Technology Assessment Activities in the Industrial, Academic, and Governmental Communities

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TECHNOLOGY ASSESSMENT ACTIVITIES IN THE INDUSTRIAL, ACADEMIC, AND GOVERNMENTAL COMMUNITIES

HEARINGS

BEFORE THE

TECHNOLOGY ASSESSMENT BOARD

OF THE

OFFICE OF TECHNOLOGY ASSESSMENT

CONGRESS OF THE UNITED STATES

NINETY-FOURTH CONGRESS

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JUNE 8, 9, 10, AND 14, 1976

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TECHNOLOGY ASSESSMENT ACTIVITIES IN THE INDUSTRIAL. ACADEMIC, AND GOVERNMENTAL COMMUNITIES

TUESDAY, JUNE 8, 1976

CONGRESS OF THE UNITED STATES,
TECHNOLOGY ASSESS-T BOARD,
OFFICE OF TECHNOLOGY ASSESSMENT,
Washington, D.C.

The Board convened at 10 :05 a.m., in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. (member, Technology Assessment Board), presiding.

Present: Representative (Charles A. Mosher; Emilio Q. Daddario, member ex officio and Director, OTA; Daniel V. De Simone, Deputy Director OTA; Ronald R. Davenport, member, Technology Assessment Advisory Council; John Davis and Dennis Miller of the staff.

Mr. BROWN. This hearing will be in order.

This morning we are beginning 3 days of hearings here in Washington and another day in Los Angeles next Monday, for the purpose of exploring what has happened to the Concept of technology assessment. I would like, without objection, to include in the record at this point a statement by the chairman of the Technology Assessment Board, our distinguished colleague, Congressman Teague, which describes the purpose of these hearings.

[The statement of Congressman Olin E. Teague is as follows:]

STATEMERT OF REPRESENTATIVE OLIN E. TEAGUE, CHAIRMAN, TECHNOLOGY ASSESSMENT BOARD

The hearings beginning this morning are designed to provide the Board with an updated view of the mission, utility, methodology, and state-of-the-art of technlogy assessment. We also hope to determine the degree to which the public and private sectors participate in technology assessment.

In the larger context technology assessment is one of the keystones of the structure of a national science policy. We now have the beginnings of such a policy, the latest ingredient of which, Public Law 94-282, the National Science and Technology policy, Organization, and Priorities Act of 1976, became effective as of May 11 this year. In addition to this law. the Technology Assessment Act of 1972, the National Science Foundation Amendments of 1968, the environmental policy laws, the energy research and development laws, and several others are all a part of the overall picture.

Science policy per se has been nurtured by our own Committee on science and Technology since the mid and late 1960's when the

Daddario subcommittee addressed both the issues of technology assessment and of science policy. It was furthered when the same subcommittee under John Davis put the Technology Assessment Act into law. And it reached an even higher level of influence when our full committee considered the new Science Policy Act during the period 1973 through 1976.

At the same time, the Senate was making similar contributions through a variety of efforts by the Muskie, Jackson, Magnuson, Moss, and Kennedy committees or subcommittees. The Kennedy committee was particularly active in pursuing new roles and missions for science and technology both through the National Science Foundation and by supporting the technology assessment concept. Without the efforts of these Senate entities, as well as those of the House, we would not be here today.

The practical application of technology assessment is still in its formative stage with many unknowns. It is anticipated that these hearings will focus on the as yet unsolved problems, and provide the light of knowledge necessary to speed their solution.

Mr. BROWN. To many of you, technology assessment (TA) is a familiar subject and a useful technique when used in planning and decisionmaking. We appreciate your willingness to share in some detail your views and experiences on this subject with us. We hope to open communication on this subject within Government and to establish a dialog with business, local governments, and other institutions. We trust that these hearings will illuminate a variety of ways in which a TA can be done.

Furthermore, if through these hearing we become aware of some of the problems other sectors have faced and resolved in conducting assessments, we may be able to help each other in resolving some of the very complicated societal issues that confront this Nation both today and in the future. Our primary concern is with the future, with the encouragement of anticipatory planning, and with the development of various concepts similar to TA that may be useful in anticipating, planning for, and managing the future.

The Office of Technology Assessment (OTA), which has been in existence for 2½ years, is still in the process of institutional development. The participation of the many distinguished witnesses in these hearings will be helpful in providing additional thought concerning that process of institutional development.

The Organic Act that established OTA is perhaps the best point of reference, and I quote from it:

> The Congress hereby finds and declares that:
>
> (a) As technology continues to change and expand rapidly, its applications are
>
> (1) large and growing in scale, and
>
> (2) increasingly extensive, pervasive, and critical in their impact, beneficial and adverse, on the natural and social environment.
>
> (b) Therefore, it is essential that, to the fullest extent possible, the consequences of technological applications be anticipated, understood, and considered in determination of public policy on existing and emerging national problems.
>
> (c) The Congress further finds that:
>
> (1) the Federal agencies presently responsible directly to the Congress are not designed to provide the legislative branch with adequate and timely information, independently developed, relating to the potential impact of technological applications, and
>
> (2) the present mechanisms of the Congress do not and are not designed to provide the legislative branch with such information.

(d) Accordingly, it is necessary for the Congress to-

(1) equip itself with new and effective means for securing competent, unbiased information concerning the physical, biological, economic, social, and political effects of such applications ; and

(2) utilize this information, whenever appropriate, as one factor in the legislative assessment of matters pending before Congress, particularly in those instances where the Federal Government may be called upon to consider support for, or management or regulation of, technological applications.

We hope that you have drawn upon examples of TA from your own experience as a focal point for your testimony. We also hope that you will provide some discussion of how your organization views TA in comparison to other policy-planning tools, such as environmental impact analysis utilized in environmental impact statements, cost-benefit analysis, future market research, and general futures research, especially as these relate to the policy and decisionmaking processes. An important question involves the role of public participation. Should the general public or selected publics be involved in TAs? If so, how?

In regard to the role of TA in the planning and decisionmaking processes, there are several questions that should be raised. For example, how does one decide to conduct a TA-and of what scope-as opposed to some other kind of analyses? This is an important decision, especially in terms of the allocation of organizational resources, the kind of the results desired, and the understanding of what level of the organization should do the actual work.

Beyond these broader questions, many specific questions arise about individual assessments. For example, what event suggested or initiated the TA ? Was the study projective, evaluative, or directive? Was the TA connected with any other TA efforts? It is anticipated that these and many other questions will assist us to better define and chart the course on which we are embarked in the Office of Technology Assessment (OTA).

While these hearings have no connection with pending legislation, we believe that they will be of significant benefit to the (congressional Board and OTA. We expect that the hearings will provide perspectives and insights into the role of TA in long-range policy-planning **in both** government and business.

This morning we have three distinguished witnesses, starting with Dr. H. Guyford Stever from the National Science Foundation (NSF). We welcome Dr. Stever here. It is particularly approriate that we start with the NSF because it was there that we probably had the earliest examples of TA, at least as specifically identified as TA, within the Federal Government. The Foundation continues to provide leadership in the development of the science and art of TA.

We are glad to have you here this morning, Dr. Stever. If you wish to bring any of your colleagues up to the table, we would be more than happy to welcome them.

Dr. STEVER. Dr. Eggers, why don't you come up ?

Mr. **BROWN.** We also welcome Dr. Eggers. Glad to have you here. You may proceed with your statement, Dr. Stever, in any way that you wish.

[The biographical sketeh of Dr. H. Guyford Stever is as follows:1

DR. H. GUYFORD STEVERj DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. H. Guyford Stever assumed the post of Director of the National Science Foundation on February 1, 1972. In addition to his duties as NSF Director, he

has been named Science Adviser and Chairman of the Federal Council for Science and Technology by the President. He also serves as Chairman of the Energy R&D Advisory Couucil; Chairman of the Technical Advisory Committee on Research and Development, National Power Survey, Federal Power Commission; U.S. Chairman of the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation; and Chairman of the Board of Governors of the U. S.-Israel Binational Science Foundation. He serves on a number of additional committees, including National Science Board and the President's Committee on the National Medal of Science.

Born in Corning, New York in 1916, Dr. Stever received his A.B. from Colgate University in 1938 and his Ph.D. in Physics from California Institute of Technology in 1941. He has received 12 honorary degrees and other honors, including the President's Certificate of Merit in 1948.

Prior to his appointment as NSF Director, Dr. Stever, had served as President of Carnegie-Mellon University and, before that, Carnegie Institute of Technology, since 1965. During his presidency, Carnegie Tech merged with Mellon Institute to form Carnegie-Mellon University with a total endowment of almost $120,000,000. Before going to Carnegie Tech, Dr. Stever served on the MIT faculty for more than 20 years, including the positions of Head of the Departments of Mechanical Engineering, Naval Architecture, and Marine Engineering. He is an internationally known expert on aeronautical engineering and space technology.

Among other organizations, Dr. Stever is a member of the National Academy of Sciences, National Academy of Engineering, Institute of Aeronautical Sciences, American Physical Society, American Institute of Aeronautics and Astronautics, and Phi Beta Kappa. He is married to the former Louise Risley Floyd and has four children.

STATEMENT OF H. WYFORD STEVER, DIRECTOR, NATIONAL SCIENCE FOUNDATION; ACCOMPANIED BY ALFRED J. EGGERS, JR., ASSISTANT DIRECTOR FOR RESEARCH APPLICATIONS, NSF

Dr. STEVER. Mr. Chairman, and members of the Board, I am pleased that you have asked me to participate in your important hearings on technology assessment (TA), and I hope that my observations of the experience of the executive branch in this area will be useful to the Board.

I would like to do two things today. First I will summarize information now being developed regarding TA activities in the Federal executive branch. 'Then I will discuss the TA activities of the National Science Foundation (NSF). I interpret the growing interest and activity in TA as indicating that a broad consensus is emerging regarding strategies for problem solving. In turn this consensus is resulting in a series of new commitments and perspectives within virtually every sector of our societ y.

Let me offer some examples:

First, our perspective of the global environment is changing to recognize the complexity of nature's ecology and the human place in it.

Second, a worldwide commitment to bring about a balance between population and food supply is growing.

Third, a realization that our primary reliance on fossil fuel exploitation for energy must be shifted to renewable resources is increasing.

Fourth, although not as strongly felt as the pressure upon energy resources, a perception is growing that material resources also must be wisely managed.

Fifth, a recognition is emerging of the necessity to make significant economic and social adjustments in response to questions of worldwide equity within a feasible time.

And sixth, underlying all of these is a realization that our success in facing all the challenges elicited by these new outlooks depends on a vast growth in human knowledge and its prudent application.

It is within this framework of new perceptions of problems of the human condition that I believe the concept of TA will prove to be an essential contribution to wise decisionmaking. Let me now give you some impressions of the extent of TA activities in the Federal executive branch. NSF, in its Research Applied to National Needs (RANN) program, is currently supporting a study designed to identify in detail the scope and content of TA activities in the executive branch. Since the study is not yet complete I will not be able to give you the entire picture, but I believe that what has been developed to date is quite informative. The study will involve up to 700 interviews, and will cover a full range of executive branch activities. The interviews are designed to reach down into individual agencies and offices in sufficient depth to obtain project-level detail.

Two years ago, I indicated in hearings before this Board, that the pace of interest in TA had accelerated and expanded throughout the executive branch. Our preliminary findings now indicate that this interest is being turned into real assessment programs and projects. While it is too early to confirm any precise measure of the extent of the growth of TA, I do believe I can illustrate by example the nature of the movement toward comprehensive TA among various Federal agencies.

Mr. Brown, I know that you are often interested in changes and comparisons, in the different ways that our society is going. TA was invented just 2 or 3 years ago when we gave our first reports on it. This Board was established a short time ago, and now we are beggining to count the TAs. One of the objects of TA was to make sure that we did not go too fast into various technologies. I am a little concerned that we may have to start worrying about whether we are not going too fast into TA. So we do have immense progress in the small number of years that we have been working.

Within the Department of Agriculture, several important new activities related to TA have taken place. A preliminary TA of minimum tillage was conducted in 1975, and in April of this year a weeklong workshop on TA was held. These TA studies are conducted in the Economic Research Service, the Forest Service, and the cooperative State Research Service. The Department of Commerce has shown an interest in the concept. I will not go into detail here since the Department is to participate in these hearings. However, it is worth noting that the Maritime .Administration (MA) has shown continuing interest and has supported assessments of ocean shipping and offshore industry. In addition, the MA also provided partial support for a Conference on Assessment of Marine Technology, Man and the Ocean. sponsored by the International society for Technology Assessment and the European oceanic Association.

The Council on Environmental Quality supported a TA of Outer Continental Shelf (OCS) oil and gas operations. In this case, the initial assessment activities by the NSF on the topic led to the follow-up work in this other agency. Although the Department of Defense (DOD) conducts a wide range of assessments. our initial impressions are that most DOD studies do not include the full range of considerations envisioned in the TA concept. An exception is the Corps of Engineers which conducts studies on the social impact of its planned projects and is applying the concept of TA, although not using the term.

Data from the Energy Research and Development Administration (ERDA) indicate that several TA studies have been undertaken. The Division of Conservation supported a TA of alternative fuels and an impact study on the use of electric cars. In addition, the Division of Biomedical and Environmental Research, the Office of Planning and Analysis, and the Division of Solar Energy, together with the Federal Energy Administration (FEA) are pursuing activities that closely relate to TAs.

Major TAs are being conducted by the Environmental Protection Agency (EPA). This Agency uses the term integrated technology assessment (ITA), for its assessment projects. The Office of Energy, Minerals, and Industry is supporting two studies: a technology assessment of the electrical utility sector, and a technology assessment of western energy resource development. The FEA is also scheduled to participate in these hearings so I will not go into detail on its activities. However, I would like to point out that FEA is partially supporting an NSF-awarded TA of telecommunications-transportation interactions.

Within the Department of Health, Education, and Welfare (HEW), several activities of a TA nature have been identified. The National Heart and Lung Institute has produced three assessments relating to heart and circulatory disease programs and the National Center for Health Services Research is currently in the process of designing a TA program. The Department of Housing and Urban Development (HUD , has conducted a TA of modular integrated utility systems and has supported an assessment by the National Academy of Sciences of the implications of an earthquake prediction capability.

The National Aeronautics and Space Administration (NASA), has been active in the area of TA for some time. Assessments of alternate transportable energy sources for aircraft and intercity transportation technologies have been performed. The intercity transportation TA is a joint project with the Department of Transportation. NASA is also participating with NSF in a -jointly supported TA of large-cargo-aircraft technologies. The U.S. Postal Service supported a study on technology forecasting and assessment of alternative modes of mail delivery. The Department of Transportation (DOT) has supported a number of TA studies, A study of the secondary impacts of highway projects for example, is an assessment of a specific highway project. It also will provide some guidelines for conducting impact assessments. Our initial data suggest that the interest in TA is growing throughout a number of individual agencies in DOT.

These are some preliminary impressions from our continuing study of TA activities in Federal agencies. The study is being conducted by the George Washington University and will be completed early in 1977. We expect that a much more definitive picture of TA will result. One of the members of the oversight committee for the project is on the OTA staff. The Office will therefore be continuously involved in the project and will receive new information as it is generated.

It is interesting to note that even though a number of agencies have not used the term '(technology assessment,'' efforts such as environmental impact studies, national assessments, future studies, planning studies, social impact analyses, the development of social indicators, et cetera, are going forward. These demonstrate a commitment and attitude toward the systematic and comprehensive examination of the consequences of technological change. I also note an important tendency for interagency cooperation in these endeavors. The joint effort of DOT and NASA in the area of interurban transportation is an example. As I indicated, NSF is currently engaged in two jointly funded assessments. And NSF is planning a joint project with OTA on future uses of the automobile.

Since I last reported to you we have established an interagency technology assessment coordination panel for the NSF technology assessment program. Currently, members from 16 agencies participate on the panel. We expect that several additional agencies will be represented during the next few months. This panel meets quarterly. It is briefed on plans and activities of NSF and it serves as a major coordinat ing body among executive branch agencies.

I.et me turn now to a more detailed discussion of NSF activities in TA. The NSF program is predicated on the belief that the assessment process is a valuable way to meet a national need to provide better information regarding our decisions and policies on the use of technology. Here I would like to stress an important dimension of TA. While there is general agreement that assessment are conducted to inform a variety of decisionmaking elements of our society, I believe we should carefully distinguish that TA per se does not make either policy or decisions. It provides information for these activities. The central question facing the purely decision situation is: “What is best to do?"' But the focal question of pure assessment is: "What if we do any one of a number of things ?" Both of these questions require comprehensive, systematic analyses if we are to deal effectively with our problems. My point is that it is the location of agency interest along this “assessment-decision" dimension that conditions the scope and focus of a given study. I will return to this point later when I discuss the NSF role in supporting TAs.

From the beginning, our TA efforts in RANN sought to accomplish three specific objectives. The first is to provide substantive policy information through support of TAs in selected areas. Here a central question for the NSF technology assessment program has been the selection of topics for assessment. In selecting research topics, we have followed a mixed approach that combines sources of public concern, government interest, and professional input.

Our Interagency Technology Assessment Coordination Panel, for example, has provided information about the concerns of other agencies and is being apprised of current and planned NSF activities. Several studies supported by the RANN program have provided professional inputs on topics that are candidates for TA. The experience gained in supporting a number of studies is currently helping us to define some larger themes and categories of concern that will shape the program in the coming years.

The scope and role of TA at NSF is being shaped to emphasize:

First, an early warning function underlining the possibility of scientific breakthroughs, for example, the assessment of life-extending technologies, which in addition to conventional disease-control methods, also considers technologies that may alter the aging process.

Second, the technologies of a cross-cutting nature that span several missions and agencies and accentuate interactive processes and cross-effects.

And third, situations where there may not be a specific agency dealing with a given problem, or where the boundaries of responsibility have not been clear. For example, we proceeded with TAs of energy options before ERDA was established, and more recently, a study of electronic funds transfer predated the creation of a commission to handle this program.

Considerations like these tend to locate NSF activity in TA more toward the "what if" of pure assessment. Since 1971, we have made more than 60 awards for TA-related projects. I would like to summarize our program activity since the first of our TA awards were made. In fiscal year 1970, the first award for TA was made with a $133,000 grant to George Washington University for a study on implementing TA. Since then, awards have been made as follows:

TABLE 1

	Number of awards	Award tota
Fiscal year:		
1971	13	$1,530,717
1972	5	421,888
1973	9	661,252
1974	13	1,996,935
1975	15	2,029,940
1976 [1]	7	861,595

[1] The 1976 data represent the awards made as of June 1, 1976, 9 new awards are being processed that will contribute to the final fiscal year 1976 expenditure of $1,400,000.

TABLE 2—TECHNOLOGY ASSESSMENT AWARDS MADE BY THE NATIONAL SCIENCE FOUNDATION (SINCE JUNE 1, 1974)

Institution	Title	Starting date	Duration (months)	Amount
Cornell University, Ithaca, N.Y.	A Technology Assessment in the Area of Mobile Communications.	July 1, 1974	30	$297,000
University of Washington, Seattle, Wash.	Technology Policy Assessment: Refinement and Evaluation of Methods.	do	18	51,500
University of Utah, Salt Lake City, Utah.	A Western Regional Workshop on Technology Assessment.	Jan. 1, 1975	18	27,300
Texas Tech University, Lubbock, Tex.	Technology Assessment: Human Rehabilitation Techniques.	May 1, 1975	18	226,600
Gellman Research Association, Jenkintown, Pa.	The Higher Order Consequences of Scientific and Technical Information as a Regulated Public Utility.	do	12	81,600
Battelle Memorial Institute, Columbus, Ohio.	Technology Assessment of Information Networking.	May 15, 1975	12	37,928
Forecasting International, Ltd., Arlington, Va.	Assessment of the Effects of Major Innovations in Scientific and Technical Information Transfer.	do	15	82,350
Xerox Electro-Optical Systems, Pasadena, Calif.	Technology Assessment of Technological Advances in Scientific and Technical Information Services.	do	17	50,490
Systems Control, Inc., Palo Alto, Calif.	Stratospheric Chlorofluoromethane (Freon) Accumulation: A Preliminary Technology and Policy Option Assessment of the Consequences.	do	12	46,200
Stanford Research Institute, Menlo Park, Calif.	A Technology Assessment of Telecommunication-Transportation Interactions.	June 1, 1975	12	271,039
International Research and Technology Corp., Arlington, Va.	Assessment of Controlled Environment Agriculture Technology.	do	18	309,500
The Futures Group, Glastonbury, Conn.	Technology Assessment of Life-Extending Technologies.	June 8, 1975	18	294,993
National Council for the Public Assessment of Technology, Washington, D.C.	Technology Assessment for the Citizen	June 15, 1975	9	50,000

TABLE 2.—TECHNOLOGY ASSESSMENT AWARDS MADE BY THE NATIONAL SCIENCE FOUNDATION (SINCE JUNE 1, 1974)—Continued

Institution	Title	Starting date	Duration (months)	Amount
George Washington University, Washington, D.C.	Retrospective Technology Assessment: Submarine Telegraphy.	June 1,1975	15	$99,700
Carnegie-Mellon University, Pittsburgh, Pa.	Retrospective Assessment of Waters and Wastewater Quality Technology, 1865–20 and 1965 to Present.	July 1,1975	15	66,300
Forecasting International, Ltd., Arlington, Va.	Retrospective Technology Assessment on the Application of Systematic Management Techniques to U.S. Industry.	July 15,1975	15	105,600
Massachusetts Institute of Technology, Cambridge, Mass.	Retrospective Technology Assessment of the Telephone.	Sept. 1,1975	15	88,900
J. H. Wiggins Co., Redondo Beach, Calif.	Risk to Structures from Natural Hazards: A Technology Assessment.	July 1,1975	18	239,500
University of Illinois, Urbana, Ill.	Hail Suppression: A Technology Assessment Study.	Aug. 1,1975	15	290,500
Gellman Research Association, Jenkintown, Pa.	An Assessment of Large Air Transport Technology.	do	12	138,883
George Washington University, Washington, D.C.	Technology Assessment in Federal Agencies, 1971–76.	Feb. 19,1976	12	75,100
University of Michigan, Ann Arbor, Mich.	Factors Affecting Utilization of Technology Assessments in Policy Making.	May 15,1976	18	274,400
Stanford University, Stanford, Calif.	Utilizing Environmental Assessments in Public Works Planning: Organizational Structures and Processes.	do	12	75,100

These awards have been made to both academic institutions and private research organizations, profit as well as nonprofit. I think it is noteworthy that the TA program is one area where small business firms have been quite successful. During a competitive solicitation last year, small business firms received 40 percent, that is 6 out of 15 of the awards totaling more than $900,000.

The second objective of our program is to develop and extend the methodological state-of-the-art. Here our efforts are focused on developing the scientific methods needed to conduct effective and efficient TAs. Many of the problems of TA challenge our analytical capabilities and often. must be dealt with by less than satisfactory approaches. The key aims of this part of our program are to enhance the tractability of the problems, develop appropriate strategies for the overall assessment process, and improve the overall validity and reliability of the results.

The final objective of the program is the stimulation and enhancement, of a comprehensive capability to conduct and utilize TA. This entails support of organizations, both public and private, that engage in TA efforts. Grants and contracts for TAs have served indirectly to improve the capability to carry out this type of work. Sponsorship of seminars, public meetings, agency briefings, and cooperative international TA projects, on the other hand, are examples of direct capability support. We also have an extensive and growing distribution list for our TA reports. In addition to more than 1,400 domestic names in virtually every State, it includes 38 persons in foreign countries, with ,Japan having the highest number. About 500 addresses are for academic institutions, with the rest distributed among individuals and organizations, profit and nonprofit.

We are keenly aware that our projects must be well-grounded in reality. In each TA award, the issue of effective final use has provided the impetus for requiring a clear linkage between the assessment activities and the potential parties-at-interest. Thus in addition to the critical appraisal of prospective awards by means of proposal review, we also make provisions for an '{oversight committed' to be associated with each assessment. This arrangement is designed to provide interaction with a set of interested parties throughout the assessment process, to increase sensitivity to the problems at hand, and to alert the research team to potential users and uses of the study findings. one of the lessons we have been learning is that a balanced and active oversight committee makes a major contribution to an effective result.

In looking toward future activities, let me reemphasize my initial remarks that we are undergoing some fundamental transformations in our outlook and activity in science and technology. These changes are being manifested in studies with more holistic analyses, taking a more comprehensive look at nature; with a new understanding of international interdependence; and with a growing emphasis on bringing the **future into sharper** focus. At NSF, the TA program will continue to support studies of this nature. We see some emerging broad themes for TA activities in the coming years. Among these are: problems of a resource constrained economy; environmental restrictions on technological opportunites; rearrangements of work and social activity patterns; technologies that affect biological systems; and questions of automation, cybernetics, and information flow.

There are a number of ways to approach both organizing categories of concern and specifying significant areas with potential or research and analysis. We have been proceeding with a combination of sensitivity to expressed social concerns and practical experience gained in doing a variety of studies, and are pursuing a flexible format that permite exploratory research with alertness to breakthroughs and potential future issues. We have also emphasized interdivisional linkages with a variety of programs at NSF, for example the other RANN" divisions: Resources; Environment; Productivity; and Intergovernmental Science.

At this point, Mr. Chairman, I would like to summarize some general insights that are further helping to shape the TA program. Technology assessments will be more credible and have more impact if a wide spectrum of alternatives is communicated to affected parties before they become committed to specific courses of action. Interagency cooperation will enhance comparability , evaluation, and integration of TAs for the use of decisionmakers. We are at present incorporating these points into current as well as envisaged program efforts.

Finally let me point to some of the problems and challenges that our program experience indicates are realistic constraints on TA: limited resources and expanding costs; availability of human resources, including apropriate talent, experience, and skills of the assessment teams; bottlenecks resulting from insufficient data and unsatisfactory methodologies; intrinsic limits in our ability to integrate all essential impacts and consequences; difficulties in involving all social groups likely to be concerned with an emerging issue; limits **and** ambiguities involved in the difficult task of communicating the results of assessments; and issues of integrating new knowledge into complex policy-making processes

These difficulties are not new. They are part of the scientific endeavor. They also express the difficult problem involved in delineating the full range of direct and indirect consequences of technological change and in equitably implementing new public policies. We believe that our program is now entering a phase in which methodological improvements, expanded capability or conducting a TA, and an enlarged pool of information will encourage and strengthen the Federal Government's ability to fulfill the mandate to carefully examine the effects of technology on society when making policy.

I believe that TA activities in the Government will become a valuable part of the larger processes for examining alternatives in the resolution of critical and emerging national and international problems; for identifying future areas of concern; and for articulating the far-reaching consequences of technological opportunities. But life, no matter how perfect we try to make it, will always contain risk, trial, and error. Although we know that we can never create a no-fault existence, I believe TA is one mechanism to help steer society toward the more desirable choices for the future.

Mr. Chairman, this concludes my prepared remarks. I will be pleased to answer any questions that you and the other members of the Board may have.

Mr. BROWN. Thank you, very much, Dr. Stever.

We are going to modify slightly our procedure this morning. We had originally thought we might ask each of the witnesses to participate as a panel after his prepared remarks, but in view of the fact that one of the witnesses has had to be rescheduled, and that there are time pressures on others, I think we will proceed in the more normal fashion of questioning the witnesses immediately after their statements. I would like to call upon our distinguishedd ranking Republican Member from the House, Congressman Mosher, to make a statement or ask any questions that he might like to ask at this time. I might point out that the Technology Assessment Board is one of the relatively few congressional organizations that is nonpartisan or bipartisan. It is equally balanced between Republicans and Democrats, and we are very happy to have members of such outstanding ability as Mr. Mosher, who we will be losing when he retires at the end of this year.

Mr. MOSHER. This is a very useful summary that we have just heard from Dr. Stever. Perhaps I can make a comment. I am aware of a study that the National Science Foundation (NSF) has commissioned with a group at the University of Michigan where they will try to determine or at least tentatively identify, those characteristics of a technology assessment (TA) that apparently are essential to the usefulness of the assessment.

In other words, assuming that there is no particular reason to do a TA unless it is effective used, what are those characteristics which will best assure that it will be put to good use and that the user will take advantage of it? This stud-y is just beginning and I have no idea of what its conclusions will be. But I understand that one of the initial hypotheses is that the producer of the assessment and the potential users shall be involved from its inception in a two-way communication with coordination and cooperation. In other words, this is just the opposite of the approach in which the producer of the study tries to keep as distant as possible from the potential user, in order that he not be influenced by the potential user in any way. This produces a pristine type of study that is then handed over to the *user* when completed. The user is then expected to immediately pick it up and make effective use of it. The supposition is that this approach to conducting a study does not work as well as when the user is involved from the very start.

This troubles me some when I think of Congress as the potential user of a TA. It is the very essence, it seems to me, of life here on Capitol Hill that it is very difficult for Members of Congress to participate in a TA. I do not think it is a matter m which you, Dr. Stever, are prepared to give us any insight at this moment, but in this audience there are many people interested in this matter. I think this is a very basic problem. Perhaps it is the most basic problem facing Congress given the nature of the job, the changes taking place in the job, the complexity and volume of information that Congress requires, and the confl icting and complex information that Congress must process as compared with. say, 20 years ago. Given all that plus the antiquated structures and procedures with which we operate here, how are we ever going to begin to develop mechanisms, and most of all the time and the chance in a Congressman's life, to consider good information while at the same time we are part of the process by which we get that information. Do you want to comment on this?

Dr. STEVER. Mr. Mosher, the rule at NSF is I speak first, while my team thinks out the right answer.

Mr. MOSHER. There is no right answer. I don't expect it.

Dr. STEVER. Let me speak and then call on Dr. Eggers. We here, this group and the others who are interested in TA, have been involved in an activity that is only a few years old. You described one instance of TA that looks to me like a two-player game. If the techniques of such a TA can be worked out, I can see many places where it would be of great value. For example, if an industrial company wants to go into a new process or a new product, and pays a group to make a TA for it with the express purpose of making sure that they do not get caught later on not having thought about something, then I think an interaction is perfectly reasonable. Provided of course, that the group with the initial interest just does not run things completely but that it is a dual mode. And in fact, I think if that kind of TA is carried out often, more frequently than is now the case, I think it is a very worthwhile process.

You are talking about something else however, when you talk about Congress being involved in TA. There I think you are dealing with more complex social issues in which perhaps not a single industry but a group of industries are moving in a given direction. The question then arises of whether the legal framework, the governmental regulatory framework, is set up to handle that? There TA would help the Congress. I think that here it is a three-player game, and in this case you would want responses from all sides. I am quite sure you are going to get them too. No TA is going to be given to you without the other sides. So I am not so sure that we should not look at both of these aspects as acceptable elements of TA.

Let me tell you about a third type, one in which NSF may be involved. This is essentially a TA that springs from the science as it develops before there is a user and before the Congress sees a purpose for it. In this case, if the scientific community is alert to the TA process, it may come up with something that society can use and adjust to more quickly and more readily. So I am not so sure that you don't have several different TA gains to consider.

Mr. Mosher. Well I am very sure that there are indeed several.

Dr. STEVER. Dr. Eggers may be able to say something about the Michigan study.

Mr. MOSHER. I welcome that. But going back to this one-to-one relationship, the producer and the potential user, the word "potential" suggests that from the very start the users may not be identified. I suppose the essence of a TA is that potential users are identified in the assessing process. If Dr. Eggers wants to make a comment, I would be glad to hear it.

Dr. Eggers. I am going to approach this matter cautiously, Mr. Mosher~ because as you have already pointed out there is no correct answer. I could perhaps make a couple of remarks, however first let me make the following observation. There are all manner of activities that we don't call TA but which in one way or another are. As a matter of fact, when I was educated as an engineer a number of years ago, good engineers were supposed to do good TA when they designed something. I mean that literally in almost the dictionary definition of engineering as the application of new technologies for the benefit of society.

When I think about this matter under discussion I am not so sure that we are always considering something new. I think maybe we are rediscovering some things. For example, I think it has been known for a very long time that there is a lot of merit in having people who are developing something new, whatever it may be, and people who are going to use whatever gets developed, being in reasonably close contact if in fact what is being developed is going to be used. There are a number of reasons why this is often true. These can vary from event to event depending on whether a new technology development will ultimately be used by somebody, or whether the assessment of such a development will ultimately be used by somebody. I think in general, history says with a good deal of consistency that the relationship between the persons carrying out the development effort and the persons Or institutions that are going to use it, should be reasonably close. As a matter of fact this was expressed by Bacon several hundred years ago.

I don't want to say too much about the Michigan study, because it is just getting underway. It is studying this issue in somewhat greater detail in terms of specific experience in TAs gained to elate. I think the point you made. Mr. Mosher, about the uncertainty of who the users are or will be is a sound one because it gets into the question of what are the second-, third-, and fourth-order effects of new developments. This in turn relates to who are the ultimate users. The Electronic Funds Transfer Study that we recently completed illustrates that point rather well.

I would like to make one last point because you are raising a fundamental issue. I don't think we are now or will ever be very smart with respect to long-range projections because of the uncertainties of the consequences of new developments. This ought not bother us too much in my opinion because it is not only true of social, economic, environmental, and other similar consequences of a new technology but it is also true of much narrower factors. What we usually learn once we recognize that we are not so smart, is not to take too big a step at any one time, or in other words to provide an opportunist to reevaluate. This means that once an assessment has been made t at indicates ways to go with their associated consequences and we choose one of the ways, then we had better be prepared to make a reassessment fairly soon after starting on the basis of what new we have learned.

I will finish my comments with this point, since this is the Bicentennial and I have always enjoyed reading The Federalist Papers. I have been struck by the fact that one of the best concepts for reassessment and feedback in decisiomaking is in the way our Government is designed. I think that the ‘Congress as well as other governmental elements reassesses yearly what has happened as a result of decisions made the previous year. I think that this is extremely important. Sometimes when I hear conversations about multi-year authorizations or appropriations to move ahead on an activity, I am very dubious because this begins to eliminate the reassessment function that is crucial on the part of the Congress. It. is one aspect of the larger issue of reassessment that I think has to be considered in evaluating technology or anything else we decide to move ahead with as a Nation.

Mr. .Mosher. Thank you.

Mr. BROWN. Dr. Stever, there are some broad questions about TA that have bothered me and I think other members of the Board. We hoped that we could explore at least some of these briefly during the hearings. One such question concerns the limits that might be drawn around the concept of TA. It may be however, that we don't want to draw hard and fast limits. I'm not trying to over-define this concept. It is a commonsense sort of idea to try to anticipate the results of one's actions, either personal, corporate, or societal. Any tools that are helpful shouldn't be beaten to death in an effort to make them too precise. In your experience, and the experience of the agency, has there been any effort to narrowly define the TA concept or to narrowly define the time frame in which an assessment shoul d be made? Should this time frame be 20 years in the future, or 10, or 50 ? Is an assessment the kind of study requiring the exploration of all options? How do you limit the second—or third-order consequences and is such a limitation necessary ?

I'm reminded of Dr. Egger's statement that TA is a commonsensc approach inherent in the definition of engineering. Did Henry Ford make an assessment when he started developing the assembly line production of automobiles? It seems like a normal engineering thing to have done. But would we expect him to have analyzed the effects of intercontinental highways, suburban sprawl, and call the other byproducts of the automobile? Is that a normal engineering function, Dr. Eggers? Do I make myself clear in this effort to try to put boundaries around the concep t?

Dr. STEVER. One of the best consequences of having an Office of Technology Assessment within the Congress is that we in the Administration can watch you go through the problems of setting priorities on these issues. This is a tough one. But let's return to the better ideas that come out of TA. If the ideas of the potential outcomes are broadly based, then if scientists in doing fundamental research give it a little thought, they will think ahead, which is in fact what they do. After all, consider what the consequences of the research on genetic change have been; how responsible many people have been, and how groups of basic researchers have been moved to ask—what will this work mean downstream ? The accuracy of their predictions way downstream may be quite wrong, 'but at least they are thinking in the right direction.

Then I think there will be some matters for which TA is very obvious. Offshore oil drilling seems to be a good example. There is high pressure on the *one* hand for energy and high pressure on the other band to preserve our environment,. I think that this kind of issue is obvious. ***So I*** am not too sure that you are ever going to put hard and fast boundaries around the TA concept. I believe that your job is to develop some ways of thinking about scientists? engineers, Congressmen, industrialists, and others, so that all of them can make these priority decisions along the way. **H**ow much TA should ***go*** into this problem? I don't think it is the kind of subject that is going to be written into a textbook or a handbook that will give you the coefficients of TA required by a given problem. I think wc are struggling through a different way of approaching this issue.

The first part of my statement lists six points. I used these also in a graduation speech recently. My object was to tell young people that the world was quite different today from what it was not so very long ago. I brought out the differences in the way society was thinking today about its life versus 10 or 15 years ago. I believe that the TA way of thinking is one of the new factors that has entered our way of life. I don't believe however, that you are going to be able to constrain it by means of a textbook. It's a way of thinking.

Mr. Brown. Well it is a way of thinking. May I sugest a parallel and get your reaction to it? I was struck by a phrase in the written testimony of the next witness referring to the newly developed procedure in the Department of the Interior that he calls the programmed decision option document. I guess option is the word that struck me, because each of us has been confronted with a changing world in which we are constantly required to make decisions among options, to make choices. The effects of these options have to be thoroughly documented. We then choose a path or make a move as in a chess game. You make a move which then gives you certain other options and a number of branches develop six moves down the road. This is similar to the way we make decisions about most policy matters. There is always the possibility that you will go down one path and reach a boundary or a limit where the purpose is no longer being served. At that point you have to rethink the options.

It seems to me that the process we are looking at is one in which we try to keep within acceptable boundaries in we proceed ***into*** the future. At each decision point we need these kinds of assessments in order to ascertain where our road is taking us. Sometimes they are not what might, be considered precisely a TA. Technology assessment is one kind of assessment however, that has to continually be made in order to develop the best possible options for making decisions.

In a democracy such as ours, the fundamental decisions on social policy have at least to be acceptable to the people. We then get involved in the question of whether the public needs to be engaged in structuring the options as well as choosing among them. Is there a role for the public in the assessment as well as in the decisionmaking process? Obviously there is. I'm attempting in this monolog to re-fleet my own efforts at clarifying my thinking about what we are doing here and also to stimulate a reaction from you on this subject.

Dr. Stever. I believe your thinking is accurate on the process. But as you know, society sometimes backs up after having taken a series of options and reached branching points. This has happened in our own time. For example, the restructuring of some of our rivers so that fish return to them. That is an instance of society backing up on some previously chosen options. Cleaning the air is another example. I agree with Dr. Eggers that you cannot look too far downstream. There are, as you know, people who derided the concept of TA when it first appeared. It was called "technology arrestment." Critics implied that its aim was to stop progress-progress as interpreted by technologists. I don't believe that it has to go that way. I think that we must make it clear that it does not have to happen that way.

Mr. BROWN. I would like to explore this at greater length, but I do want to leave time for our remaining witnesses, Dr. Stever. We have a number of other questions that we would like to submit to you, some detailed and some general. I wonder if we could ask you to respond to them in writing?

Dr. STEVER., We will be glad to.

[The following questions were submitted by Congressman Brown to Dr. Stever and his answers thereto:]

Question 1. Since The National Science Foundation (NSF) is the lead agency for technology assessment (TA) in the executive branch, would it be beneficial from a communications standpoint for NSF to publish and distribute to all levels of government a bibliography of TA reports written throughout the executive branch ?

Answer 1. 1 believe that this would definitely be beneficial. As 1 indicated in my statement, we are seeking to provide an information inventory and clearinghouse function for TA activities. As a first step in this direction, we have initiated a study to prepare analytical bibliography covering substantive T.As that have been supported by NSF/RANN. Furthermore, in conducting the survey of Federal activities in TA that I referred to. we will prepare an inventory of TA projects. Both of these activities are designed to lead to a comprehensive bibliography that should be available during fiscal year 1978.

Question 1a. Would this bibliography be helpful and cost-effective in avoiding duplication of effort?

Answer la. Since the cost of the bibliography will be modest, I believe it will be cost-effective. It also shonld be very useful in avoiding unnecessary duplication. Because of the wide differences among agencies. however, it is quite possible that some overlap of assessment nativities will occur. Thus I believe that the main benefit of the bibliography will be to facilitate well-designed assessment projects around common topics that supplement and complement studies by different agencies.

Question 1b. In this regard, what value do you see in having closer relationships between the public and private sectors and even between the State and local levels?

Answer 1b. Currently we see four general categories of organizations that have interests and activities in TA. These are: government, private industry. academic, and other. During fiscal year 1977, we will complete a series of four regional seminars begun in fiscal year 1975 that are intended to inform State government officials of the uses of TA. As currently planned we anticipate that we will be examining nativities in private industry during fiscal year 1977, find in the academic sector and other categories in fiscal year 1978. Under the category other. we include private and public foundations, non-profit activities of public interest groups, international organizations, and ad hoc assessment activities by various organizations. We see our main function as a clearinghouse activity to facilitate the communication and sharing of information among the organizations in each of the four category Thus the thrust of the program is to direct efforts toward providing outreach and linkages among organizations involved in TA.

Question 1c. HOW can greater communication between producers and users in and out of government be facilitated?

Answer le. This is a very important aspect. anti we are currently supporting a study to explicate this problem in some detail. This is being carried out by the Institute for Social Research at the University of Michigan and will explore the main elements that contribute to and define producer capabilities. And at the same time it will also explore in some depth the precise needs of TA users. We expect this project to result in knowledge that can be useful in helping to match analytical capability and decision-related information needs.

We also expect that this study will help provide better means and mechanisms for communication between producers and users of TAs. Specifically it should help to improve the situation in the user commnnity so that requests for TA are timely and well specified. And it should help the producer community to develop research that will meet the real needs of policy-makers.

Question 1d. Is there a need for some coordinating body that would encourage and develop greater communication on TA in the Government and elsewhere?

Answer Id. As I indicated in my statement there is growing activity in 'the area of TA throughout the Federal executive branch. The NSF currently has in process an Interagency Technology Assessment Coordinating Panel to help guide and coordinate activities in NSF and to assist other agencies in areas of their interest. At the present time, it is unclear whether there is a need for a separate coordinating body to *encourage* and develop communication. However, as indicated by the answer to the previous qnestion, we should soon be developing some new information in this area. At that time NSF will initiate whatever new coordination arrangements are necessary.

Question 1e. Has NSF given assistance to Federal and State agencies on methods to assess the societal impact of their technology R&D program and regulations, and any second-order consequences these might have on the environment ?

Answer le. In the fiscal year 1976 Budget to the Congress, NSF indicated that the environmental impact statement process in fact constitutes a partial TA and therefore NSF indicated an interest in assisting this effort.

Activities in NSF have involved coordination with the Council on Environmental Quality, with the National Academy of Sciences, with the Environmental Protection *Agency,* and *a* recent initiative has been taken to conduct a workshop on precisely the nature of the questions that are being asked. We expect that as a result of this workshop we will have a series of research specifications that will lead to improved methods to assist agencies in efforts to assess social and environmental impacts of their technology, R&D, programs and regulations.

Question 1f. How do you involve the public?

Answer 1f. As I indicated we typically make provisions for an oversight committee to be associated with substantive TA. This arrangement is designed to provide Interaction with the interested parties that are likely to be affected by a given technology. In addition to this, we are just completing a study on the utilization of public interest group inputs into the TA process. Since this project is not yet complete, we do not have any definitive findings.

Question 2. What are the limits that might be drawn around the TA concept?

Answer 2. As we all know, the concept of TA focuses on better understanding not only the direct but also the indirect consequences of technological opportunities. I think there are two clearly distinct functions that can be associated with this concept. First, there is an early warning function; this is the "look before you leap" issue. And second, there is the design of several options before the choice of any one specific action; this is more in the area of long-range strategic or contingency analysis. As to the limits, I believe we can look at several real-life elements. First, there is a client who provides a need limit. How much information of what nature does a client have a need for? Here, a principal dimension concerns which of the two major functions is of primary interest to the client. There are quite different needs from a private enterprise perspective than from a long-range government policy perspective. A second area would be the nature of the technology or problem at hand. This typically puts a time limit on the assessment process in terms of forecasting including forecastfng not only effects but also capabilities. Finally, there is a real-life constraint in resources or budget. How much effort can be allocated to dealing with the broad, long-range consequences ?

Question 3. At the interagency policy level, is there any formal structure for conducting or encouraging the use of TA?

Answer 3. Since the National Science and Technology Policy Organization and Priorities Act of 1976 has been signed into law. I believe some important new TA initiatives are very likely. With the establishment of the new science advisory structure in the Executive Office of the President, specific provisions have been made for conducting and utilizing TA. I believe this question will be answered in the near future as the new Office of Science and Technology Policy becomes organized and is placed into operation.

Question 3a. You state that 16 agencies are represented in the Interagency TA Coordination Panel. When was this panel formed?

Answer 3a. The panel was formed under the aegis of the RANN Interagency Coordinating Committee and the first meeting was held in February 1975. Subsequently, at approximately quarterly intervals, we have held Panel meetings.

Question 3b.. How does it function, and how often does it meet?

Answer 3b. Since its inception it has met at approximately quarterly intervals. The functioning is primarily around coordination activities in which the NSF apprises members of the panel of activities in process and planned. In addition, we try to provide briefings of completed or near-completed TAs that may be of interest to the agencies represented on the panel in their planning and research activities.

Question 3c. Do any legislative branch agencies or committees participate?

Answer 3c. The interagency coordinating function of the TA program at NSF is designed to keep only executive branch agencies thoroughly informed. However, the director of the RANN program has indicated to OTA that the panel will include them in future meetings either as members or in an advisory capacity, depending on whether constitutional issues pose membership constraints.

Question 3d. Would you supply us with a listing of the representatives to this TA Coordination Panel?

Answer 3d. The current roster of representatives as of the most recent meeting of the Panel is listed below:

Mr. Carl Gerber, Associate Assistant Administrator for the Office of Research and Development, Environmental Protection Agency, 401 M Street, SW, Room 911, Mail Code RD 672, West Tower, Washington, D.C.

Dr. Paul F. Bente, Jr., Council on Environmental Quality, 722 Jackson Place, NW., Washington, D.C.

Dr. Daniel J. Edwards, Chief, Supply-Demand Analysis, U.S. Bureau of Mines, Office of Economic Analysis. 2401 E Street, NW., Washington, D.C.

Dr. F. W. Niedenfuhr, Director, Technology Assessment, Defense Advanced Research Projects Agency, 1400 Wilson Boulevard, Arlington, Va.

Mr. Hugh Loweth, Office of Management and Budget, Executive Office of the President, Science and Energy Technology Branch, Washington, D.C.

Dr. Edward A. Brown, Harry Diamond Labs, 2800 Powder Mill Road, Adelphi, Md.

Dr. Alan R. Siegel, Director, Division of Community Development and Management Research, Housing and Urban Development, Washington, D.C.

Dr. John McKinley, National Bureau of Standards Program Office, U.S. Department of Commerce, Washington, D.C.

Mr. Robert Rollins, Study Analysis and Planning Office (Code RX), Office of Aeronautics and Space Technology, Headquarters, NASA, 600 Independence Avenue, SW., Washington, D.C.

Dr. David B. Chang, Deputy Assistant Secretary for Science and Technology, Room 3864, Main Commerce Building, Office of the Secretary of Commerce, Washington, D. Cl.

Dr. Leo S. Packer, U.S. Department of State, Code OES/APT/SA, Room 7823-NS, Washington, D.C.

Dr. William B. Back, USDA-ERS-NEAD, Room 190 GHI Building, 500 12th Street, SW., Washington, D.C.

Dr. Vincent Sardella, Office of Telecommunications Policy, Executive Office of the President, 1800 G Street, NW., Washington, D.C.

Mr. Paul Casscarano, Law Enforcement Assistance Administration, 633 Independence Avenue, NW., Washington. D.C.

Mr. Alfonso B. Linhares, Chief, R&D Policy Analysis Division, Department of Transportation, 400 Seventh Street, SW., Washington, D.C.

Mr. Richard I. Gerson, U.S. Energy Research and Development Administration. 20 Massachusetts Avenue, N.W. Washington, D.C.

Question 3e. Does the Panel publish an annual report?

nswer 3e. The Panel circulates meeting notes and abbreviated minutes of each of its meetings for record purposes but does not publish an annual report. However, each member of the panel is provided with a panel notebook that includes a compendium of information regarding the technology assessment program as well as cumulative meeting notes.

Question 3f. What has the Panel done to date?

Answer 3P. The Panel's activities to date have been advisory to the NSF program. The first meeting of the Panel was very much an organizing and orientation meeting. Subsequent meetings included panel assistance in a survey of topics of concern for assessment that would reflect specific interests of each agency. These were organized into general topic areas and recirculated to the panel for consideration and are used in program planning as we move ahead.

Question 3g. Are its meetings and records open to the public?

Answer 3g. The meetings are open to the public. The records and notes of the meetings are available on request.

Question 3h. How would you rate its effectiveness?

Answer 3h. After several meetings, the Panel appears to be moving toward becoming an effective coordination mechanism. At the last meeting, the Panel proved to be very useful in providing details of agency activities for the statement on TA in the Federal executive branch given at these hearings.

We attempt to keep each representative current on technology assessment activities initiated by NSF and are beginning to formalize procdures for apprising members of other agency initiatives in TA.

Question 3i. To whom does the Panel report?

Answer 3i. The Panel reports to the Director, Division of Exploratory Research and Systems Analysis.

Question 3j. What could be done to improve its operation and effectiveness throughout the Federal Government?

Answer 3j. As I indicated, the Panel has been quite useful in providing the NSF program with information and interests for other agencies. I believe we can improve the operation and effectiveness throughout the government by developing better mechanisms for feeding back to each of the agencies, at a variety of levels, information about TA both at NSF and from among the other agencies. We intend to attempt to do this in the future with information papers prepared by the NSF program that can be readily circulated throughout other agencies by Panel representatives.

Question 3k. Does the Panel try to interface with the private sector?

Answer 3k. As currently constituted, the Panel is a coordinating activity among Federal agencies. The interface with the private sector is not explicitly within the charter of the Panel at this time. However, as the NSF program develops its program element in capability-building, we expect that the interface activities will become an important component of the Panel's activities.

Question 3l How is the public involved?

Answer 3l. The public is not directly involved in the Panel. However, as I have indicated, in each of the substantive TA projects supported by the NSF there is an oversight committee which does represent a wide range of interested publics.

As information is developed on each of the projects, it will be fed back to the Interagency Coordinating Panel so that a mechanism does exist for including public concerns in the coordination activities of the Panel.

Question 4. How can greater use of TA in the planning and decisionmaking processes be encouraged in the Government?

Answer 4. As I indicated in my remarks before the Board, TA in a relatively short period of time has grown quite respectably. It thus appears that there is a general orientation to use TA in a large number of Federal agencies. I think the crux of the question however, is in effective use of TA in our planning and decisionmaking processes. To that end I refer to question one and the research project being conducted by the University of Michigan. The title of this project is "Factors Affecting Utilization of Technology Assessment in Policymaking." As we develop information in this project, I believe it will guide us in both encouraging greater use of TA among planning and decisionmaking activities of the Government and in enhancing its effective utilization.

Question 4a. Is its use widespread in NSF?

Answer 4a. The TA program in NSF is designed to interface with other activities at the Foundation. Particularly, the program is designed to interface with other elements of the RANN program as I indicated in my statement. As examples of this interface, let me cite two current TAs. The first is an assessment of controlled environment agriculture technology that is supported by funding from the RANN Resources Division. Another example is a study entitled "Risk to Structures from Natural Hazards: A Technology Asessment," that is designed to provide information not only useful to local and regional governments, but also closely related to activities of the RANN Environmental Division.

Question 4b. What methodologies have been developed in the last five years to give us understanding of decisionmaking under conditions of uncertainty and risk ?

Answer 4b. This is a very important area forTA. There is a large compendium of research on decisionmaking under conditions of risk and uncertainty, however, to date, this research has been only very little utilized in TA. A planned activity of the TA Program at NSF in its methodology development element is to devise ways in which the findings of this body of analytical knowledge can be incorporated into the TA process.

Question 4c. What NSF sponsored activities were designed to develop and enhance this area of TA methodology ?

Answer 4c. In fiscal year 1871 the NSF supported a colloquium on benefit-risk relationships for decisionmaking. This resulted in a National Academy of Engineering report on the TA topic. Since that time another award was initiated by the TA Program on risk-benefit analysis for large-scale technological development. This is being conducted at the University of California at Los Angeles.

Question 5. In your opinion, can we expect to measure the cost and benefits of a TA?

Answer 5. It is a difficult task to attempt to measure precisely the cost-benefit relationship for any research activity. However, I do believe there are ways to estimate the approximate return e.g. information value theory in decision analysis. Again, the TA Program in its future methodological development intends to attempt to provide ways in which such measures can be reasonably approximated.

Question 5a. Would you give US an idea of how you go about deciding how much to invest in TA?

Answer 5a. In budgeting for TA, we have proceeded on the idea that a certain fraction of the applied research program should be directed to looking out at the implications of new technologies. Thus, we have set a TA Program budget level that represents a fraction of the overall research funding available for the Directorate for Research Applications at NSF. Currently, this amounts to approximately $2,000,000 per year. As to how much to invest in a specific TA project, we have generally considered two types of projects. Preliminary TAs are those in which a technology and its implications are not well understood and for which preliminary analysis is indicated. These, typically run in the range of two to three person-years of effort. This translates to $100,000 to $150,000 per project. Our experience to date indicates that for a comprehensive TA in depth, an effort on the order of five person-years is required, this averages to about $300,000 per assessment. To date we believe that substantive useful information can be developed from both types of projects at these levels of effort. I would like to indicate that one objective of our methodology development effort is to attempt to provide better and more efficient mechanisms for conducting the assessment so that these figures can be kept to the minimum consistent with good scientific practice.

Question 6. In your testimony you seem to suggest that there will be some improvements in TA methodology. What defects in the current techniques would you expect these improvements to overcome?

Answer 6. As I indicated in my statement, I believe there are a number of defects that our TA methodology program will help to overcome. The firm has to do with the answer to the previous question. With limited resources and expanding costs, we need to improve the efficiency of conducting TAs. The second area is associated with the skills. experience, and talent required to conduct such assessments. Here our capability-building program comes to the front with its objective of encouraging the development of appropriate talent. A third area is associated with the general issue of data and methodology. While a wide range of data on many social, economic, and environmental issues are available, it is often difficult to compile, codify, and analyze such data. We are exploring methods that will facilitate this activity. In the general area of methodology, we must in many cases deal with problems by methodologies that are far from optimal.

We plan to develop, in addition to methods of uncertainty and risk analysis. structural modeling procedures, cross-impact analysis techniques, and improved methods for identifying higher-order impacts more comprehensively. A fourth area is associated with limits in our ability to integrate impacts and consequences *in* a concise and meaningful manner. Here, we are supporting research on the process of conducting TAs that seeks to identify barriers to communication among the multiple disciplines rquired for a TA Another area has to do with involvement of groups and organizations likely to be concerned with an issue yet to become visible. Here we intend to explore ways to encourage participation by a wide variety of groups. Another area of need concerns the difficult task of communicating results of complex scientific analyses. This is an area for experiment during fiscal year 1977 in which several modes of communication will be examined And finally, we are probing the central problem discussed earlier, of integrating the results of analyses into the very complex policymaking processes. As I indicated, the research at the University of Michigan is directed primarily at this question.

Question 7. Has NSF discovered ways of imoroving the quality of empircally validated information about the societal impacts of technology?

Answer 7. *Currently we* have two projects under consideration that are associated with this issue. In one of these it is proposed to explore a new technology associated with rearrangement of working conditions. It will be based on empirically derived evidence as a means to estimate validly the effect of the technology on the social system that it impacts. Another empirical study currently under consideration has to do with the examination of how a technology and a speciflc segment of society interact. This is focused on the question of changes in social arrangements that are influenced by new technology.

Question 7a. What techniques have been developed to generate this kind of data ?

Answer 7a. Since these projects are either new initiatives or are under consideration, we do not have techniques available. However, both projects are rigorous social science research emphasizing indicators of social change.

Question 7b.. Has NSF done anything to encourage the use of social impact data in TA?

Answer 7b. As previously indicated, the two projects under consideration will in fact incorporate, in a rigorous manner, measures of social change based on data, observation, and interview techniques. If successful, these projects promise to provide an improved model for integrating social impact data into the TA process. I think it is important to emphasize that the very process of TA has always attempted to incorporate general social impacts as a part of the effects that result from any technological development. Still we believe that improvements in this area are needed and possible.

Question 8. Has the NSF TA Program actually examined and evaluated the present status of the environmental impact statement process and its consequences for society ?

Answer & The NSF TA Program initiated a study of the impact statement process with a recent award to Stanford University to study the environmental impact statement process at the field agency level. This project is designed to assist in providing information on how environmental information can be effectively and appropriately used in planning. lt is focused on public works activities. In addition *to* this, as I indicated in the answer to question *one, we are* in the process of planning a workshop that will clarify and provide the indicators for future research in this area.

Question 9. Do you think it is important to support and track research on multiple impact and partial TAs ?

Answer 9. Yes, I think it is a task that should be conducted.

Question 9a. If you have any awards in these areas, how are they administered?

Answer 9a. Currently the only award in this area is the project that I indicated in my statement, in which we are attempting to survey rather comprehensively, the full range of TA activities in the Federal Government. This award is administered similarly to other TA awards, i.e., it is monitored by a program manager and has an oversight committee to guide and advise the research.

Question 9b. Are reports generated available to other agencies?

Answer 9b. A report on TA activities conducted in 1972 has been made availaBLe to other agencies. Since our current activities are still i n process, we do not have any new reports. When completed, reports will be published and made available to other agencies.

Question 9c. Does NSF still sponsor preliminary TAs? If so, how many have been done since 1972?

Answer 9c. Yes (See Question 5). There are currently three PROJECTS either completed or in process. The First was an assessMent of earthquake prediction techniques and their applications. The second is a joint project with the National Aeronautics and Space Administration on the effects of large cargo aircraft technology. A third project under consideration involves the effects of quality of work-life technologies.

Question 9d. How useful has this technique been?

Answer 9d. It appears, from our present knowledge, that the preliminary TA concept is useful when we have very little information about the technology.

Question 9e. How many have gone into full-scale TAs?

Answer 9e. The only one that involves a full-scale TA is on the topic of earth quake prediction. However, it did not stem from the preliminary TA on the subject but was concurrently awarded. The objective was to examine the differences between a TA with a very low budget and one funded at a comprehensive, in-depth level.

Question 10. How much time elapses between submission of proposals and decisionmaking on the proposal?

Answer 10. A typical time between submission of a proposal and an award is approximately six months for a TA project. In some cases however, since several major questions may be raised in peer review, this time has been extended to up to one year.

Question 10a. How does NSF identify peer reviewers?

Answer 10a. NSF maintains a file of qualified persons organized according to expertise and experience. The Technology Assessment Program has TA reviewers available as well as persons with expertise in specific topics. In addition to this file of reviewers, the program manager typically uses a procedure where experts are identified and asked to identify other experts. From a pool of such names, those most often recommended as having expertise in the subject matter are solicited for review.

Qeustion 10b. Is public participation at this juncture utilized as part of peer review?

Answer 10b. In each TA on a substantive topic, some of the reviewers are people who are likely to be affected by or who may implement the technology.

Question 10c. If so, how effective has this procedure been?

Answer 10c. Many of the insights of the users and potentially affected parties have been quite valuable in orienting the originally proposed TA in a more useful and effective direction.

Question 10d.. Has there been a noteworthy improvement in the review process as a result of pubic participation?

Answer 10d. In view of the foregoing, it seems apparent that the process has been considerably improved by increasing sensitivity to a wider range of problems as well as to potential utilization and integration of our assessments. Accordingly, we do not have any plans to modify this public input in the review process at this time.

Mr. BROWN. Our next witness is Dr. William L. Fisher, an Assistant Secretary of the Interior. We are very pleased to have you here, Mr. Fisher. I apologize for having to leave briefly, but Mr. Mosher will preside while I am gone.

Mr. MOSHER. Will you proceed?

[The biographical sketch of Dr. William L. Fisher is as follows:]

DR. WILLIAM L. FISHEB, ASSISTANT SECRETARY, U..S. DEPARTMENT OF the~ INTER1OR

Dr. William L. Fisher, Assistant Secretary for Energy and Minerals, U.S. Department of the Interior.

Born September 16, 1932, Marion, 111. ; married; three children.

B.A. geology, Southern Illinois University, 1954; M. S., 1958; Ph. D. geology, University of Kansas, 1961.

Military service, U.S. Army, Korea, 1954-56 (and inactive reserves) ; hard-mineral exploration ALCOA, 1058; research scientist, Bureau of Economic Geology, University of Texas at Austin, 1960-68; professor of geological sci-

ences, University of Texas at Austin, 19(34; State geologist of Texas and director, Bureau *of* Economic Geology, Texas State Geological Survey, 1970-75.

Frequent testimony before standing and interim committees of the Texas legislature in areas of minerals, energy, land, water, marine resources, and natural hazards. Limited testimony before U.S. congressional committees.

Approximately 250 invited lectures presented to professional and lay groups over the past five years, chiefly in areas of mineral, energy, and environmental resources, including an international tour as Distinguished Lecturer of the American Association of Petroleurn Geologists, and as lecturer as part of continuing education programs of national professional organizations.

Advisory activities include serving on numerous international, Federal, State, university, and professional committees and councils, chiefly in the areas of mineral, energy, water, marine, and coastal zone resources, as well as public policy, and education.

Elective offices in most national and several regional geological, mining, and mineral professional societies in which is a member or fellow.

Publications include approximately 80 books and articles, chiefly on energy and mineral resources, environmental and water resources, land resources, and basic and applied geology.

STATEMENT OF WILLIAM L. FISHER, ASSISTANT SECRETARY FOR ENERGY AND MINERALS, U.S. DEPARTMENT OF THE INTERIOR

Dr. FISIIER. Mr. Chairman and members of the Board; I am pleased to be here today to discuss the experience of the Department of the Interior (DOI) with regard to technology assessment (TA).

As you are aware, formalized TA, as we understand it today, is of relatively recent origin; it emerged in its present form with the passage of the Technology Assessment Act of 1972. As an analytical art, it is still evolving and subject to much more study and refinement.

Our own use of assessment techniques and our understanding of assessment concepts, have gone through a constant evolution. This began with our first chance to stand back and examine our programs, to see both, if they were meetmg our goals and how they could be improved. Since those early attempts, our techniques and understandin have matured significantly. This has been primarily due to the refinements placed upon us by the increasing complexity of our job as managers of much of the Nation's natural resources. Probably the most significant events initiating this maturation process occurred when the Department began in 1934 the series of river basin studies in which the old Biological Survey (forerunner of the Fish and Wildlife Service) made limited assessments under the River Basins Act, and in 1946 when the Coordination Act mandated the first "systematic cost-benefit analyses. With the passage of the National Environmental Policy Act (NEPA) of, 1969, we moved a major step in the direction of assessment. This legislation prompted assessments of the projected results of certain future actions.

The latest and most significant step in the evolutionary process has been in the institutionalization within 1)01 of the Program Decision Option Document (PDOD). The PDOD is a decisionmaking paper that guides the discussion before the Secretary as he makes the final decision on significant matters, particularly on matters that could have an impact on the social and natural environment. The PDOD summarizes the major options open to the Secretary. It, includes the various alternatives, analysis of those alternatives, and the implications within each option. In each case, the anticipated impacts of the options are spelled out to wide discussion. Before the PDOD itself comes into play however, briefings are held with various members of the Secretariat who analyze the results of the independent assessments that lead to the conclusions set forth in the PDOD.

I think, Mr. Chairman, the diverse missions of the Department of Interior assure that a wide range of options are presented and defined. This process is one that embraces a number of considerations and alternatives, and is actually utilizing concepts and methodologies of TA. We are very pleased with the success of the PDOD mechanism in guiding the decisionmaking process. We have found it a very effective approach for the presentation of alternatives in the very complex decisions that we and the Secretary make.

Although assessments such as these have utilize many of the elements of a formal TA, they have not systematically involved all of the steps of a modern TA, as described by Mr. Jose h Coates in the Journal of the International Society of Technology Assessment, June 1975. While the Department has never undertaken a formal TA, it has produced a number of studies, and its agencies regularly justify and develop their various projects using methods comparable to those of TA that embrace its basic methodologies and processes. I have attached to my testimony examples of departmental programs that utilize elements of TA.

[The attachments referred to above appear in appendix A, exhibit 1, of this report.]

Assessment efforts are also well-illustrated by the studies performed in analyzing the proposed Trans-Alaska pipeline. These studies, which went into creating environmental safeguards and into feasibility assessment and risk analysis, are similar to the multi-faceted investigations of a TA. The study of the proposals to deliver natural gas from the arctic is even more recent. Interior's environmental analyses, environmental impact statements, capability studies, risk analysis studies, and economic and comparability studies have all been made available to the Congress, some in formal reports. It is m understanding that they have been well-received and that they will e useful to the Congress in its deliberations on the Arctic gas delivery issue.

Over the years, the Department has built data gathering and information development capabilities in several important natural resource areas. The Geologica Survey and the Bureau of Mines have developed computerized systems covering geological and hydrological resources, mineral and energy reserves, and mining operations. Information concerning multiple use of Federal lands is available from the Bureau of Land Management, wildlife information from the Fish and Wildlife Service, reclamation feasibility from the Bureau of Reclamation, and the minerals industry health and safety data from the Mining Enforcement and Safety Administration (MESA). Analytical capability exists within each of these agencies to aid anyone interested in using these data to solve specific assessment problems. The examples of technology related activities that I have attached to my statement, Mr. Chairman, illustrate the variety of efforts to which this combination of data and analytical capability lends itself.

The Department's approach to program and project evaluation has reinforced the development of both a strong data base and a strong analytical capability. In our role as public lands manager, the DOI must take a comprehensive view of the primary and secondary results of any contemplated action. We are responsible for both protecting the public lands, and encouraging their use in a variety of ways. Decisions involving minerals production, grazing, wildlife protection, outdoor recreation, and water use often revolve the limitation of competing land uses for long periods of time. The broadest view of specific programs and projects must be taken, both for departmental decisionmaking and to assure that our NEPA responsibilities are met. Program and project ramifications are assessed on both micro and macro scales as a matter of course, with only the most trivial problems being examined as individual or isolated events. As you can see, Mr. Chairman, we believe that the DOI has developed a capability for performing the many types of analyses that are required by a formal TA and has, in fact, utilized many of the elements of TA for a number of years in performing its primary function of managing and providing policy for the public lands and for the Nation's natural resources.

At this point, Mr. Chairman I would also like to add that for the last 4 years the Department, has been conscientiously fulfilling its responsibility under the Technology Assessment Act. Last year the Department detailed Dr. Dennis Cox from the Geological Survey to the OTA. Dr. Cox has returned and Mr. Stanley Schweinfurth of the Survey is currently detailed. Also, at the beginning of this year Dr. Robert Kaplan of the Bureau of Mines was detailed to OTA. Of similar importance has been the furnishing of critical analytical data and the analysis and interpretation of that data for the Office. The particular OTA studies for which we have furnished data, interpretation, and analysis include: an Assessment of Economic Stockpile Policy; Technical Assessment of Material Information Systems; and an Interim report on Mineral Accessibility on Federal Lands. The Department has been very pleased with the results of our interface and exchange, and looks forward to the continuation of this working relationship.

Mr. Chairman, I would be happy to respond to my questions you may have at this time. Thank you.

Mr. Mosher. Thank you, Dr. Fisher. Your testimony is very helpful. In this evolving concept that you mentioned, you say that you think it actually became a conscious process as early as 1934. Has your awareness of it greatly increased in the last 4 or 5 years?

Dr. FISHER. Unqnestionably, Mr. chairman. I would say, certainly.

Mr. Mosher. You referred to a number of studies produced by DOI, and that Interior agencies regularly justify and develop their various projects using methods of comparable complexity and sophistication. In using the word justify, do you mean that you have an internal mechanism, or rather a system. by which you test the value of your Own studies and procedures ? *Is* there some formal review mechanism established within the Department that requires the justification of projects ?

Dr. FIsher. It varies from agency to agency within the Department, Mr. Chairman. In degrees of how formally this process is gone through however. some of the agencies have gone much further with this than others. At the departmental level the main process has now been institutionalized, as I indicated, with the PDOD which is very much a formal mechanism to insure that a wide range of options are defined and presented. These are usually based on some fairly expensive analyses that may have taken place within the agency. I t is a self-process. Ultimately the data, information, and analyses that lead to the decisionmakig process are incorporated into the various options. At that point they would be subject to a kind of justification and evaluation just on the strength to which they support various alternatives presented.

Mr. Mosher. I suspect there would be some people in the public and certainly in the Congress who would be skeptical of all this sort of folderol, which for instance they might call your PDOD system. Obviously such a system takes time, energy, and manpower. My prejudices are all in favor of it. I am assuming that it is worthwhile. But, what if you had a Congressman sitting here who thought that in relation to cost, it was a lot of nonsense. Could you really justify it?

Dr. FISHER. **I think so. Mr. Chairman. Primarily because of the kinds of complexities that Dr. Stever mentioned just a moment ago, such as the exploration and {Development on the Outer Continental Shelf, which it had foreseen from a variety of concerns, all the way from rapid development to nondevelopment. The kinds of complexities** that now get into natural resource issues I think compel 1 an examination of the alternatives and their implications. I can t perceive that we could go ahead with any kind of sophisticated process without a very thorough examination of these options. This takes both time and effort. But it assures that all of the facets have been considered, and evaluated, and that they are a part of secretarial decisions. So I would say that we probably could not even move forward on a decision and take a defensible position on that decision, unless we did expend the time and effort to go through this process. Although it takes time and effort, it is still the most expeditious way of making decisions that we have. I think we have to do this now with the kinds of complexities we are facing.

Mr. MOSHER. I suspect you are right. However, I cannot help being aware from da -to-day of the increasing number of people in this country, and they are reflected in the Congress. who represent a rather persistent and profound strain in America. They are skeptical about sophisticated procedures, intellectual expertise, articulation of ideas and so forth. I think there are still a lot of us who believe that seat-of-the-pants instinctive decisions are perhaps better.

Dr. FISHER. **I think definitions are involved in this, Mr. Chairman. Obviously we do not apply the PDOD process to every decision made in the Department. Major decisions, such as a decision to hold a lease sale or the adoption of major regulations, would go through this particular kind of process. If you carried this on to a ridiculous point of course? then that would Perhaps be the kind of reaction some people would have, that you analyze to death before you ever make a decision. Yet I believe that the gravity and the Complexity of many of the elements that go into decisions mandate and require this approach. I would argue that it is probably the most expeditions way to get through the decisionmaking process, as well as being the most direct way to do it.**

Mr. MOSHER. Well I think -you are right, and I hope so. What about people from -your Department who were on loan to OTA? I suspect that Mr. Daddario and others would testify that they have been very helpful to OTA but has there been a mutual value? Since being employed for awhile at OTA and then returning to the Department are they considered to be more useful because of that experience!

Dr. FISHER. Very much so. Some of the people that have been involved are at the present time trying to evaluate what is the state-of-the-art of the more formalized TA going on within their agencies. So this is helpful. I have met with and carried on discussions with Dr. Cox of the Geological Survey since he spent time detailed to the OTA. So yes, I think it is a mutual exchange and helps us appreciate in a much better way what OTA and the Board are try" to do. I think by the same token it aids the Office's appreciation of what we are tring to do in this process and I think we have reached a great deal o commonality, largely because cornmonsense leads you in that direction. Whether we produce reports that have TA in the title is less important than whether these reports embrace the fundamental issues. This kind of interchange that gives us a better appreciation of both sides is, I believe, very helpful.

Mr. MOSHER. I have been one of the Members of Congress, and there have been quite a few of us, who have had the privilege and the very useful opportunity to have in our offices on our own staffs, and in some cases on committee staffs here, very competent people on loan from various executive agencies. They have come as fellows for sometimes as long as 10 or 12 months. It is an extremely useful device from our standpoint. I ho e and expect that these people go back to their agencies with a better understanding of the congressional process and the decisiomnaking process in general. I am a believer in these exchanges.

Thank you very much for your testimony, Dr. Fisher. Congressman Brown has some additional questions he would like to have you reply to in writing for the Record .

[The following questions were submitted by Congressman Brown to Dr. Fisher and his answers thereto:]

Question 1. You state that technology assessment (TA) in a formal sense is not utilized by the Department of the interior (DOI), but that several kinds of analysis similar to TA are used. How then would you define TA's use in the Department? How do the results of this kind of TA enter into the planning and decisionmaking processes at Interior? How has it changed the decision process in the last 5 years? What are you doing differently now?

Answer 1. We have yet to find a generally accepted definition of TA. There is a divergence of opinion within the DOI about its definition and its use. For example, the staff who prepare the Environmental impact Statements (EIS) do not distinguish between TAs and EISs because they believe that EISs are a form of TA. (See answers to questions 9 and 10.)

Question 2. You mentioned that at the Department level you make use of some elements of TA. What elements do you use and which elements do YOU not use? In regard to the missing elements, how do you think these missing elements affect the Department's decision and policy making and planning processes? Has the use of TA affected the way you do business?

Answer 2. Without a generally accepted definition of TA it is a little difficult to determine which of its elements are missing.

The DOI has produced about 500 draft EISs. The Council on Environmental Quality recently released a year-long study of the experience of Federal agencies with EISs. (Environmental Impact Statements-An Analysis of Six Years' Experience by Seventy Federal Agencies, March 1876). We have not attempted a thorough analysis of all EISs for this request. By one definition of TA, we believe that many of our EISs are relatively complete TAs. That definition is as follows:

"Technology assessment evaluates all the significant impacts, both beneficial and detrimental, of a technology. This systematic analysis will usually require

Illuminating secondary and tertiary effects. For some technologies, TA might include an analysis of psychological impacts. "

However, if we take one set of components of a TA, such as presented on page 6 of the June 1975 Journal of the International Society of Technology Assessment and referred to in our testimony, we may be able to illuminate some areas for improvement.

"COMPONENTS OF A TEOHNOLOGY ASSESSMENT (SLIGHTLY MODIFIED FROM COATES)

"l. Definition of the problem, technology, issue or project to be assessed (proper focus for study).

"2. Examination of decision apparatus relevant to the problem or technologies involved.

"3. Identification of alternative programs, strategies, or systems to be assessed (system alternatives).

"4. Identification of parties of interest and their goals or values.

"5. Identification of possible impacts of alternative strategies.

"6. Evaluation of the significance of impacts in terms of parties of interest.

"7. Development of policy options for decisions apparatus.

"8. Identification of exogenous factors or events which might affect 1-7. Exploration of macro system alternatives.

"9. Formulation of conclusions and recommendations."

Our impression, without the advantage of a detailed analysis, is that items number 4 and 8 might need improvement in some EISs. Even with a thorough analysis of these possible areas for improvement it would be close to impossible to know how our decision, policy-making and planning processes would have been affected, if some specified definition had been adhered to.

Question 3. Do you probe TA studies that are not in accordance with the Department's position? What specific methods have you used in assuring length, breadth, and depth in your TA and related studies? How do you generate dissent and alternative and conflicting points of view? How is it presented to management ?

Answer 3. We attempt to evaluate as full a range of alternative views as possible. As far as we know, our staff has reviewed any TA study that was both available and relevant to a departmental issue. The production of our EISs is generally considered to have included length, breadth, and depth. By evaluating as full a range of relevant alternative views as possible we attempt to generate dissent as well as alternative and conflicting points of view. These alternative points of view are part of the creation of a Program Decision Option Document (PDOD).

Question 4. How do YOU obtain the participation of private industry? Do you involve the public, and advisory panels in planning your TAs? Do you see any value in the Department having closer relationships with the private and public sectors and with state and local governments? How do you advise the public ahead of time about impacts?

Answer 4. Again, the Department is not conducting any studies considered to be TAs at the present time. Knowledgeable experts are sought from the private sector to participate in our EISs and similar projects. The Department continues to develop closer relationships with private and public sectors. For example, the Bureau of Mines developed a State Liaison Program just a few years ago. Alerting the public to specific impacts depends on the subject under consideration. For some issues involved in this area, see recent "Environmental Impact Statements—An Analysis of Six Years' Experience by Seventy Federal Agencies," Council on Environmental Quality (CEQ), March 1976.

Question 5. How does the Department generate and analyze assumptions about the future state of society? How does the Department analyze such studies and how are the results used ? Please give an example.

Answer 5. The Bureau of Mines (BOM) Publishes "Mineral Facts and Problems" at about 5-year intervals. This publication includes forecasts of sources and uses of mineral and energy commodities through the year 2000. The Bureau's Division of Economic Analysis evaluates alternative scenarios for economic conditions through the year 2000. These evaluations are both presented to and discussed with commodity experts. The Office of Mineral Policy and Research Analysis also evaluates alternative scenarios in monitoring their contracts and for use in their staff evaluations. Departmental staff members belong to various organizations such as The World Future Society and the International Society for Technology Assessment.

Question 6. When conducting TAs, do you have a mechanism for coordinating and exchanging TA information with other agencies, particularly with those in the DOI? What about communications and exchanges of information with the National Science Foundation (NSF) and the Office of Technology Assessment (OTA) ? Of the many TA studies generated at NSF that were mentioned by Dr. Stever, has the DOI made use of any of them? Is TA activity published in any of your reports?

Answer 6. When conducting TA-type studies, there is no formal mechanism for coordinating and exchanging TA-type information. Nevertheless the informal channels are quite open. Staff members belonging to organizations such as those mentioned in question 6 alert and cooperate with each other. The DOI recently had a member join NSF's Interagency Technology Assessment Coordination Panel. As stated in our testimony, we currently have 2 staff members detailed to OTA. Another staff man was selected to follow the current BOM staff man when his assignment is completed. It is likely that some of NSF's technology assessment studies have been used by staff members, because these studies have been read. However, no tracking system exists to list how they have been used. The BOM's, "Mineral Facts and Problems", was one of the first U.S. Government publications to evaluate and report systematically and routinely on technology. Although these are not full TAs, they were unusual when introduced, in their discussion of technology.

Question 7. You state that Interior has benefited from having people at OTA? Has the Department made any attempt to utilize the experience of those who worked at OTA by having them, for example, give seminars, briefings, etc. ? How has this kind of TA training been done at Interior? How successful do you think this has been?

Answer 7. Both the BOM and Geological Survey staff are discussing the possibility of having TA seminars and briefings. Besides on-the-job training at OTA with our detailed staff, staff has attended TA courses. No evaluations are available on the degree of successful feedback from these courses or from staff participation with OTA. It should be noted in passing that OTA is requesting, and we are complying with their requests, to continue to detail selected staff members to them.

Question 8. How does your use of TAs and EISs compare? What features of the EIS process are not handled well at Interior that would be dealt with much more effectively if you used TA? How do these deficiencies relate to the TA process? Do you see a difference or similarity between the two processes? How do they relate to the PDOD? How were the results of the EIS on the Trans-Alaskan pipeline related to the PDOD?

Answer 8. We do not distinguish between TAs and EISs since EISs are a form of TA. Moi'cover, the scope of EISs covers most if not all of the probable consequences of proposed actions in natural resources management. On the other hand, there are two areas that we generally believe are outside of the scope of an EIS; these are the economic justification of a proposal, i.e., the public and private investment criteria, and the national security analysis of a proposal. Where these are important considerations to a decision, separate analyses are performed. Under present procedures the results of all related studies including the EIS are summarized and integrated into the PDOD. At the time of the Trans-Alaskan pipeline decision however, the PDOD included only the non-environmental factors, and the decision process reviewed the results of both the PDOD and the EIS.

Question .9. What lessons were learned from the work that went into the EIS on the Trans-Alaskan pipeline? Are there monitoring EISs on its progress? How do such results feed into the decisionmaking and planning processes in the Department ? Would you say the EIS process has affected decisionmaking and planning in the Department? Please explain how.

Answer 9. Notwithstanding the Department's desire to keep proposals within existing management channels, we recognized in 1969 that the Trans-Alaska pipeline proposal was so large and complex that a special management arrangement was necessary. This arrangement allowed the immediate high-level consideration of study results as they came available. This arrangement is currently under review to determine whether it will continue to be necessary upon completion of the construction phase of the pipeline. EISs are only prepared on major proposed actions having significant environmental impact. Thus there are no EISs monitoring the pipeline's progress. The EIS process has had significant effects on the Department's planning and decisionmaking. Although impossible to quantify, we believe that the greatest effects are at the field level in initial planning stages of proposals. Some of the more obvious effects have been in our Outer Continental Shelf (OCS) activities, master planning for parks, Private initiatives on public land, mineral leasing on public and Indian land, and in implementing Section 17(d) (2) of the Alaska Native Claims Settlement Act. These have been reported to the CEQ in its questionnaire of last year.

Question 10. Will your newly created Office of Program Development and Evaluation and its division of planning and evaluation be in fact an institutionalization of TA in the BOM? Is this function separate from Your EIS activities? How will the results of TAs provide input to the policy and decision-making process in the Bureau? How will they have an impact on policy-making in the Department?

Answer 10. The Office of Program Develomnent and Evaluation and its Division of P1anning and Evaluation do not represent an institutionalization of TA in the BOM. Bather, they represent a determination by the Bureau management to make better use of relevant Bureau expertise on mining and minenals problems and technologies. This includes TAs, in developing plans for future Bureau programs, and evaluating the results of ongoing programs to assure that the Bureau is making the best use of its resources to effectively and efficiently address the most important problems within its area of responsibility. The function of this Office is separate from the Bureau's EIS activities.

Technology assessments will highlight emerging problems and promising new technologies in the minerals area, enabling the Bureau to direct its attention to the emerging problems in time to alleviate them before they reach crisis proportions, and to investigate promising new technologies for solving existing or emerging problems. The problem as we see it, is not a lack of knowledge or foresight within the Bureau, but rather a need to focus that knowledge and foresight into the development of clear, coordinated, and comprehensive Bureau-wide efforts to solve major national minerals problems. That is a major role of the new organization. It is expected that improved planning and evaluation activities within the BOM will provide better information to guide policy decisions in the DOI, many of which must address minerals problems beyond the scope of Bureau responsibilities as well as those within the Bureau's mission areas.

Question 11. How is TA defined in the *Office* of Biological Services, and the Fish and Wildlife Service?

Answer 11 The Office of Biological Services (OBS) has not adopted a formal definition of TA. However, a key responsibility of the OBS is to develop methods for assessing the impact of various technologies, such as coal extraction and conversion or stream channel alteration, on fish and wildlife resources and their supporting ecosystems. In order to accomplish this, we must understand the characteristics of the ecosystem concerned, the characteristics of the develop mental processes involved, and how these processes effect the ecosystem. The program's emphasis is on the ecological aspects, but In order to understand and predict the impacts we must understand the nature of the technology as well.

In developing such analysis, we are concerned with second- and third-order effects as well as with immediate impacts. For example, in the case of coal mining in the Western United States, we are interested not only in the impact of surface disturbance and the rehabilitation potential of strip-mined lands; we are also concerned with identifying changing transportation and population patterns and their ecological impact.

Question 12. Is there a TA Team?

Answer 12. There is no TA Team as such, but there are four National teams associated with specific environmental problems. These are the National Stream Alteration Team, Power Plant Team, Coastal Ecosystems Team, and Western Energy and Land Use Team. TA as described above is an important function of each of these teams.

Question 13. How does this activity differ and/or compare to the EIS activities of the OBS ?

Answer 13. This activity differs from EIS activities in that it focuses on developing insights and information upon which more effective environmental analyses can be used, as distinguished from EIS drafting or review. Participation in the drafting or review of EISs is a small part of the OBS's responsibilities for the Fish and Wildlife Service. The principal responsibility involves improvement of the information base and analytical capability. This will be useful in environmental decisionmaking, including the EIS process.

Question 14. How many *TAs* has the OBS conducted?

Answer 14. We cannot isolate individual TAs as a separate activity because they are an integral part of the overall work as described above. We do have activity underway in the following problem areas, each of which involves some elements of TA:

Activity	Fiscal Year *1976 dollars*
Coal extraction and conversion	$2,170
Outer Continental Shelf development and coastal modifications	1,500
Powerplants	1,001
Stream alterations	861
Geothermal development	200
Oil shale development	800
Western water allocation	350
Total	6,882

126 in-house full-time positions are involved in administering these activities However, a substantial portion of the work is done by contractors. Some examples of individual contract studies that we would consider TA-related are:

Activity	Title	Organization	Amount (thousands)
OCS	Analysis of the onshore estuarine, and marine effects of coastal and OCS oil and gas development.	Conservation Foundation	$222
Oil shale	Oil shale development impact on 4-Corners Region.	University of New Mexico	189
Geothermal	Geothermal development ecological implications.	RFP	
Western water allocation	Instream flow strategies	RFP	

Question 15. How are the results fed into the DOI decisionmaking and planning processes?

Answer 15. The results are fed into the Department's decisionmaking and planning processes through direct Fish and Wildlife Service participation in these processes. An important functions of OBS has been to improve the Fish and Wildlife participation in these decision processes at both Headquarters policy and field levels. Examples of recent institutional improvements are Secretarial Order No. 2974, which provides for Fish and Wildlife Service participation in the OCS development process; a Memorandum of Understanding with the Bureau of Land Management and the U.S. Geological Survey concerning implementation of Fish and Wildlife Service responsibilities in the OCS development program; and a Memorandum of Understanding with Bureau of Land Management and the U.S. Geological Survey concerning Fish and Wildlife Service participation in the geothermal leasing program. We also have a formal information transfer activity to assure that the results are disseminated to users as widely as possible. This is being done through information transfer specialists located at our Headquarters and national teams.

Mr. MOSHER. Mr. Monte C. Throdahl is our next witness.

Mr. THRODAHL. If I may, I would like to have two associates join me please.

Mr. MOSHER. will you please identify yourself and your associates?

[The biographical sketch of Mr. Monte C. Throdahl is as follows:]

Monte C. THBODAHL, GROUP VICE PRESIDENT, MOONSANTO COMPANY

Mr. Monte C. Throdahl, group vice president-technical staff, a member of the Board of Directors of Monsanto Company, and a member of the Corporate Administrative and Executive Committees. Member of the board of directors of Monsanto Research Corporation, St. Louis; and vice president and a member of the board of directors of Monsanto Triangle Park Development Center, Inc. Durham, N. C., both subsidiaries of Monsanto Company.

Born March 25, 1919, Minneapolis, Minn.; married; two children

B.S. chemical engineering, Iowa State University, 1941.

A research chemist Monsanto Company, Nitro, W. Va., 1941; subsequently management positions in the former Organic *Chemicals* Division, i.e., director of commercial development, 1956; director of research, 1960; and director of marketing, 1962; elected a corporate vice-president and transferred to Monsanto's European headquarters in Brussels, Belgium, as general manager of the International Division, 1964; elected a member of the company's Board of Directors, and to its Executive and Technical Committees with responsibility for worldwide technology and research, Monsanto Company, St. Louis, 1966; and appointed to present position, 1973.

Director of the Boatmen's National Bank of St. Louis, director and executive committee member of Webster College; board member Salzburg Seminar in American Studies, and the St. Louis Symphony ; and a commissioner of the Museum of Science & Natural History; a member of the State Mental Health Commission (Me.).

Other memberships include: American Association for Advancement of Science; American Chemical Society; American Institute of Chemical Engineers; Society of Chemical Industry; Commercial Development Association; the Patent and Trademark Office Advisory Committee; and a fellow of the American Institute of Chemists.

Numerous technical articles authored, and patents held from the United States and five foreign countries.

STATEMENT OF MONTE C. THRODAHL, GROUP VICE PRESIDENT AND A MEMBER OF THE BOARD OF DIRECTORS, MONSANTO CO., ACCOMPANIED BY FRED D. WHARTON, JR., AND J. KENNETH CRAVER, MONSANTO CO.

Mr. **THRODAHL. Yes,** I am Monte Throdahl. I am a group vice-president of technology, and a member of the Board of Directors of Monsanto Company, headquartered in St. Louis, Mo. With me, on my ri ght, is Mr. Fred D. Wharton, Jr., who is manager, environmental affairs Cycle-Safe@ container group, and on my left is Mr. J. Kenneth Craver, who is manager, futures research, corporate plans department. They are here to support me in any line of questioning that might come later. We will shift gears a bit. We are here to present our observations on the practice of technology assessment (TA) in industry. We propose to use two specific examples within our own corporation; the Cycle-Safe@ container, and the use of chlorine in the synthesis of organic chemicals.

I would like to start by pointing out that the enterprise system, and particularly the chemical industry from its earliest beginnings, has been attuned to providing the market with what the consumers wished. This has been the strength of the industry, and it has also been its success. Intelligent suppliers in the chemical industry have been able to anticipate shifts in market demands, and position their products and services. They position their products and services in time to satisfy these newly emerging market requirements. This is how suppliers keep their customers, and grow as the market grows.

Implicit in these statements is a concept of TA. We are a technology based company. We began in chemistry many years before chemistry was a familiar American production technique. As the American chemical industry grew, we grew along with it. We built engineering strengths, developed new areas in materials science, have one heavily into both pure and applied mathematics, and have branched out into electronics, medicine, and veterinary science. Over the world we have more than 6,000 employees who are occupied full-time in various science-related careers. We were doing a form of TA as a result of market needs that I spoke of earlier, and scientific curiosity, even before this term had been coined.

As Dr. Stever mentioned the scientific mind begins by asking questions that begin, "What if . . ." These range from, "(What properties would a chemical product like this have?" to, "What will happen when this product reaches the garbage dump ?" I cannot stress enough what a powerful force this scientific conscience has been within Monsanto over the years. Our young people coming in with new knowledge have challenged our senior people time and again on matters of this kind. Members of our technological community, and particular the younger members, support the TA concept. At their request I have formed what we call a Young Turk Committee within the company, so that there is some mechanism through which to forward their sugestions and ideas to top management.

I should add here that one member of the Young Turk Committee is in his early 60's and another is in his late 50's. Both of these individuals are as young in heart as anyone else on the committee, and both have been taking constant advantage of our tuition refund program to keep their knowledge up-to-date. The Young Turk Committee has found out that it is unusual for to management to accept their ideas. When that does happen, it tends to build a number of credible responses.

In recent years we have witnessed ***a*** new dynamic in the areas of what have been referred to as second- and third-order effects. The commercial development arms of firms such as ours are in close and constant touch with their markets as they seek to develop new products and improve existing ones. The commercial development groups compete with each other in anticipating future market needs. They learn to live 5 to 10 years in the future since it may take that long to build a major product change into the productive machinery of our system.

So for over a decade our commercial development activities have detected the emerging trends of environmental protection, of consumerism, and of energy conservation. In terms of providing products to meet market requirements, these three forces have all pushed in the same general direction. At times some of these forces seem to be in opposition, but these differences can be resolved. We have found that TA is a technique both for resolving the differences and for measuring progess.

We have actively participated in the professional activities of the TA movement almost from the very beginning. Our people, particularly Mr. Craver, have organized programs, contributed papers, and encouraged other individuals, both private and public, to employ TA methodologies. The First International Technology ("conference in The Hague, the Engineering Foundation Research Conferences on Technology Assessment, the First International Conference on Marine Technology Assessment in Monaco, and the forthcoming Marine Technology Conference at Texas A. & M., are a few of the major meetings where Monsanto has contributed professional support.

So here we have the three elements of what we feel is a winning combination: First, a growing market need as perceived b what we call commercial development; second, an in-house mechanism to channel energies to meet the same objectives; and third, the active professional support of both public and technical organizations dedicated to TA. It is my opinion that TA at Monsanto is hereto stay.

Now turning from the general to the specific, I would like to briefly review how we responded to all these forces that I described in reparing to introduce the Cycle-Safe@ container that is now available in arts of New England as the new Coca-Cola “Easy-Goer” bottle. The development began with the discovery in a Monsanto laboratory of the excellent barrier properties of a class of polymers with a high nitrile content. Without going into some of the finer points of container ruirements for carbonated beverages, these high nitrile polymers keep oxygen out, which is good, and keep carbon dioxide in, which is also good. It appeared that at long last we had found a way to make a major contribution to the beverage container business, a market of several billion dollars in the United States alone. We knew that organic polymers could be produced with the aesthetics and the transparency of glass. We also knew that these polymeric containers would be lighter than lass and offer a safety factor of better break- and shatter-resistance. It was the lack of barrier properties that had thwarted our earlier efforts in this direction.

This development of what we now call Cycle-Safe@ began back in the 1960’s, when the cam uses were in ferment, and when the environmental movement was beginning to take form. Responding to both the external and the internal concerns that I described earlier, the Monsanto management decided to subject Cycle-Safe@ to an examination, which at that time went far beyond the technical aspects of the matter. We knew that in a soft drink container we were placing a new object directly into the hands of the general public, and we believed that the public would expect us to have the answers to any potential problems before they arose. The manner in which we did this has been detailed in man papers and presentations, and we now submit to the committee a full text of all the test data that we have publicly reported.

Mr. BROWN. Without objection, that will be made a part of the committee record.

[Information on where to obtain copies of the material referred to above is found in a p. A, exhibits 2,3, and 4 of this report.]

Mr. THRODAHL. Thank you, Mr. Chairman. To begin with, we subjected the Cycle-Safe@ project to three successive cross-impact studies. Cross-impact analysis is a technique that we at Monsanto use extensively, and which we have helped to develop. Let me explain.

Cross-impact analysis tries to identify interactions among events or developments by specifing how one event will influence the likelihood, timing, and mode ofimpact of other events in associated fields. It is useful in uncovering not only direct impacts, but also secondary and higher order effects as well. We consider it a highly effective TA technique, and have used it rather extensively in perhaps more than 35 other large projects comparable in nature to the complexity of the Cycle-Safe® case.

We even went to such lengths in Cycle-Safe@' as assuming that some people would find that the empty bottles were flammable and would use them to spice up a barbecue fire. So for 4 weeks we fed rats a 100 percent hamburger diet with the hamburgers cooked over a fire of cycle-Safe@ bottles, and the test data showed that the rats suffered no ill effects. Finally when we had completed our TA of the product, we scheduled a symposium to which we invited over 70 potential critics. We paraded our suspicions and our test results before this qualified audience, and asked them if we had overlooked anything. We did this in Hartford, Corn., and again before audiences in Chicago, New York, and Washington. The results can only be described as flattering.

I do not want you to get the impression that we only use TA when a highly visible product such as Cycle-Safe@ is involved. We even extend the method of self-analysis to our chemical processes and we take action based on our conclusions. Here is another exam le. The element chlorine must be handled with care. It does a good job of killing germs in drinking or swimming-pool water, but when It gets loose in the environment it can cause problems, especially when it is combined in an organic molecule.

Following more than a year of TA of all Monsanto recesses involving chlorine, and we have a lot of them, a review of the subject was presented just 2 weeks ago to the company's top administrative committee. That committee voted that from now on new Monsanto production units involving the chlorination of organic materials will not be located solely on the basis of production economics. Instead these new units will be located at those plants where the best waste-stream control, and chlorine recovery techniques are available. This also implies more of a critical mass than if they were scattered about only on the basis of production economics These plants are in four locations; Illinois, Louisiana, Missouri and New Jersey. We have a total of some 50 plants in this country. So we may pay a rice in extra transportation, raw material, or labor charges as a rasult of this decision, but we think the environment will be protected, and we should recover additional elemental chlorine for re-use in our own system over time. We are also searching for alternative processes in a number of cases so as to bypass the use of chlorine itself as a reactant.

This is the sort of responsible corporate decision that many in industry are making today. We believe that it is in harmony with the new climate that exists. n many companies, including Monsanto, this sense of corporate responsibility is formalized through policies that are approved at the highest levels of the corporation, an procedures to carry out those policies are developed at the working levels of the firm. I think my presence here today would testify to that.

Turning now to the last point we wish to make, the Office of Technology Assessment (OTA) has played a definite role in helping us make these decisions by bringing the subject to the attention of the Congress and the State legislatures and by alerting the thinking public to the complexity of the situation. Policy decisions have to be made in which the demands of the ecology, consumer protection, and energy problems must be balanced against each other. TA provides the thought process through which these difficult value judgments can be made. Your Office is to be commended for its work in the frontier of this effort. At the same time, we feel you face a challenge in the political process itself. as determined by the questions you gentlemen have asked this morning. The subject is so complex and the competing values so charged with emotion that TA could be a fertile field for those who would like to distort, subvert, and confuse. You will have to guard a against this. I sincerely hope your Office can remain strong, lndependent, and staffed with capable people. There is a great deal to do in this area and little time in which to do it.

For each member of the Board we have a kit containing the statement that I have just made, and a copy of the procedures of the symposium on the environmental and societal impacts of the Cycle-Safe@ container. There is also a paper describing in detail how TA was applied in directing the development of that container. So Mr. Chairman, If I have moved too quickly in covering either the approach to TA or the Cycle-Safe@ issue, my two associates are here to help me answer your questions.

Mr. BROWN. Thank you very much, Mr. Throdahl. Your testimony is extremely useful to the Board and we hope to find other corporate entities which have as forward-looking a position as our company has in this field. I was struck by your comment that a "Young Turks" committee has been created in your operation. It reminded me of a paper I read by a sociologist, who described his view of how corporate change occurs. Basically, the picture he presented was one of younger executives coming into a company imbued with a new set of values, similar to some of the points you made, who would rise in the hierarchy and transform the company from within. This model is in contrast to some of the more radical or destructive models that are advocated from time to time. I am wondering whether this "Young Turks" committee has been valuable to you in decisionmaking or in getting new insight into policies that ought to be followed. From the fact that you mention it at all, I infer that you consider it a useful device within your company.

Mr. THRODAHL Let me illustrate with an example. Four years ago we knew that the medical clearance procedures for our new products wasn't as good as it should be. Some of the more conventional wisdom felt that a change would not be appropriate I had the same assignment as I currently have and had been privileged to work with a number of fellows under 30--over 30 you know, you never get a new idea. I went to a group of people themselves in their 30's with whom I had worked on another project just to sample their thinking. I asked them what they would do to provide an appropriate medical clearance for every new product we intended to market, and what they would do to make sure that everything we were doing could meet those criteria ?

I did not say an-y more than that, but told them to come back when they thought they had some responses. I did not tell them who should be chairman. They selected the man from among themselves, five in all, I believe. Their first thought was to shut down everything. Then they realized that this action would benefit no one, not the customers. not society, and least of all, not themselves. After several weeks of wrangling they finally came back with a proposal. The proposal was tempered only to the extent that one of them who was slightly older had said in effect that if we really want to sell something we will have to put a little sugar on it, which they did. Much to their amazement we accepted their recommendations almost verbatim and installed the new policies with the approval of the appropriate administrative committees. They were taken aback that it was so easy. It wasn't actually that easy because they had worked very hard. Also, what they had to say was very worthwhile.

We have since subjected a similar but different group to similar kinds of questions. Surprisingly enough they responded. The reason we think they did is that they knew we would listen. But more importantly, a young man coming out of the scientific graduate fields these days has been exposed to kinds of thought processes and has knowledge that those o us who are much older do not have. We are trying to listen to him without subvertin our entire existing organizational structure.

Mr. BROWN. I notice that you list a futures research operation within the corporation.

Mr. THRODAHL. Yes sir, that is correct.

Mr. BROWN. You have Mr. Craver here who is manager of that program ?

Mr. THRODAHL. Yes he is.

Mr. BROWN. I am interested in how futures research relates to the TA process. In a sense they are similar, since they have similar goals. How would you distinguish between them ?

Mr. THRODAHL. Let me ask Mr. Craver to respond to that question, but before he does, let me tell you that the ideal size of any group is one. After that everything goes downhill. Ten years a o we assigned Mr. Craver to a committee of one to do futures research , I would like him to describe it briefly if he would, please.

Mr. CRAVER. This job grew out of a technological forecasting operation, It very quickly had to encompass all kinds of forecasts-societal, economic, and legislative—in order to begin to consider the future business environment that Monsanto would have in the next decade or so. This is the simplest statement of what futures research is about. What is it that we will be facing? What are the opportunities and threats that we will have to face 10, 12, 15 years ahead. We do this not because we want to make an accurate forecast of the future, but because we want to bring to our decisionmakers the kinds of options and threats that they have about making decisions now. Our purpose is to affect the decision in such a way that we will proceed into the future in as orderly as possible a fashion.

Along the way we have had to explore ***a*** variety of forecasting and analysis techniques. It was during this time that we developed cross-impact analysis as a tool that was particularly well-suited to our needs. We also began to perceive that the TA movement was something that we should pay attention to, one that Monsanto should be involved in. I took it upon myself to play a part in this movement. Futures research is a very flexible operation, much is left to my decision, but a great deal of lt is influenced by my ‘management.

Mr. THROAHL. Mr. Chairman, we started this when Mr. Craver was part of a corporate research organization that was at that time a central research group. We put it there because it would perhaps have a less hostile environment in which to operate. For about the last 3 years he has been part of a corporate group called Corporate Plans. So now he is a, functioning entity that the senior management utilizes on a frequent and regular basis. It is not an activity we have to be very careful to keep well-hidden. It is very accessible.

Mr. BROWN. I have one further question before I turn to Mr. Mosher, on your Cycle-Safe® container development. You went through a rather unusual public participation process apparently in order to get outside input. You indicated that the results seemed to be entirely favorable. Are you telling me that you got no adverse response in this highly critical period? That nobody could find any fault with what you were doing?

Mr. THRODAHL. No? sir, we received constructive responses. If you don't mind, I would like to have Mr. Wharton answer this. He was the creator of the symposium that produced this result.

Mr. BROWN. May I say that we are interested in the symposium model as a way of getting input into the TA process. The Technogy Assessment Board is interested in how we can get a reasonable, reliable cross-section of views about particular types of TAs that are being undertaken.

Mr. THRODAHL. We honestly were trying to make a case for credible behavior. Since it was really Mr. Wharton's idea to do it this way, I would like to have him describe it very briefly. If you would please, sir.

Mr. WHARTON. Frankly, Mr. Chairman, what we did was to first go through the internal operation of the TA of the impact of the container. Having done that, we developed research and set guidelines, priorities, and criteria for the research effort. In other words, the type of container that was developed was to some extent determined by e potential impact it would have on the environment. We wanted to assure that the adverse effects would be minimized if they could not be entirely eliminated. When all of this information had been collected we felt that it should be exposed to review by the scientific and environmental community that was qualified to judge and make judgments. Since we are not infallible we wanted a critique that would point out impacts we had minimized, had not attached sufficient importance to, or that we might have totally overlooked.

What really was meant by saying that the results were flattering is that we did get responses. There were criticisms of some of the things we had done, there were instances where people pointed out that we ought to put more emphasis on certain aspects of the research we had conducted, and there were areas that we had not considered which were brought to our attention, and have been subsequently looked into. These procedures were current and up-to-date as of 1973 when the symposium was held. As a consequence of the symposium additional studies were conducted, and we now have more data beaning on the environmental and societal impact.

Mr. BROWN. Did your analysis or TA of the container include such factors as changes in job structure, displacement of certain skills, creation of additional job needs and so on that might result from the introduction of a new kind of container. This is an issue that comes up when we talk about the container industry switching from glass to tin or tin to glass or whatever. It seems to be a matter of considerable importance to the unions that organize the industry. To what extent were these factors considered ?

Mr. WHARTON. We looked primarily at the impact on Monsanto's employment in terms of the employees that would be required to execute this project to produce the container. I don't believe our evaluation looked into the total effect on employment in the container industry. I am not sure that this is appropriate for a co oration such as Monsanto to look into inasmuch as new technology always makes old technologies obsolete. This competition is the way progress is made.

Mr. BROWN. I would tend to agree with you that this kind of impact goes beyond your immediate corporate responsibility. It may, however, be the kind of issue that an organization such as the OTA needs to look at from the standpoint of public policy. I am not saying that it should, but I imagine that it would in some circumstances where the public policy implications are extremely broad. Mr. Mosher.

Mr. MOSHER. Mr. Chairman, when Mr. Throdahl be an his testimony, I was somewhat concerned because he was emphasizing that private enterprise, and the chemical industry in particular had been attuned to providing the market with what the customers want, and had been able to anticipate shifts in market demand and then position their products and services in time to satisfy newly emerging market requirements. He commented that TA was implicit in this process. I was fearful that he was going to define TA as merely satisfying what consumers want. I am delighted that the rest of his testimony indicates a far more extensive understanding of what the term means. I am impressed.

At the end of your testimony, sir, you said that the subject is so complex and the competing values are so charged with emotion that TA could become a fertile field for those who would like to distort, subvert, and confuse. I would like to have you say more about that. You are suggesting I judge, that perhaps all of us have to guard against being used. Is that what you mean, or do you mean something else?

Mr. THRODAHL. No, sir, I mean exactly that.

Mr. MOSHER. Do you mean that the OTA Board and Office must guard against being used ? Do you want to say more about that?

Mr. THRODAHL. I think that in some other areas of the public domain that very kind of thing is occurring. If I may say so, It is occurring over the issue of toxic substances. There is t merit in much of what is being done. But the inconsistency will benefit no one. Some of the inconsistency is caused by very well-meaning and sincere groups that apply intense pressure to achieve only one objective at the expense of almost everything else. The whole idea of TA is to weigh an balance without distortion and without subversion of the truth, insofar as is humanly possible. It seems to me that you have a group that has been assemble for a very brief time, who are verty able people that have done very able work, and you are saying, "Great, let us make sure that we do not get under the same pressures that EPA is under." It is that simple.

Mr. MOSHER. I think that is a wise warning. Congress is always faced with choices of various options. More often than not Congress responds to crises or to strong fashionable impressions that distort our decisions. We tend to swing back and forth in distorted **ways.** Hopefully, this new emphasis on systematic analytical procedures when considering our choices will keep us from making such distortions and the cycles we go through of overemphasis and readjustment.

Mr. THRODAHL. If I may say so, sir, I think that you just gave another answer to the question you asked of Dr. Fisher, about colleagues who are either derisive or fearful of the kind of approach typified by the TA concept. Decisions are sometimes made based on very fashionable but false ideas. The record is replete with them. Here is an opportunity at least to begin to turn it around somewhat.

Mr. CRAVER. One of the main strengths of TA is that it assumes some standards of value, some objectives. Certainly within Monsanto these objectives are made eminenty clear to us; we now the directions that the company wants to go, and the policies that we are to follow. When strategies, tactics, directions, and policies are weighed against established objectives, you tend to take a longer—rather than a shorter-term view of them. This is a real strength. You do not make a quick decision. You tend to take a longer term attitude.

Mr. MOSHER. To re-emphasize the warning in your closing remarks, you are suggesting that these new systematic, analytical processes can be extremely useful, and the are necessary. However you suggest that we must all guard against their being manipulated to do just the opposite of what we would like to have them do.

Mr. THRODAHL. I think we are on record with Mr. Daddario that upon our knowledge of his appointment to this office, and the formation of the OTA we have followed the whole idea. We look to the OTA to spearhead and lead in the development of better methodologies, for example. We are proud to stand ready to be of any assistance we can, insofar as our resources permit.

Mr. BROWN. If I may follow up for a moment along that line. Congress is a little sensitive about the point that Mr. Mosher has brought up about political influences that develop. They are very strong here. One of several devices that the OTA has tried to use is t e creation of external panels to review the work that might be done, and in many cases to actually do the work. Of course the problem becomes one of securing a panel that is properly balanced to appropriately represent the various points of view. I gather that this same sort of thinking is what led to your use of the symposium.

Mr. THRODAHL Absolutely.

Mr. BROWN. There is a great deal more that we would like to explore with you and your colleagues, Mr. Throdahl, but we will be interrupted: now by the House, which has gone into session. I would like to ask if some additional questions could be submitted to you in writing. The answers would help us complete the record.

Mr. THRODAHL. It would be our pleasure.

[The following questions were submitted by Congressman Brown to Mr. M. C. Throdahl and his answers thereto:]

Question 1. Do you have a formal structure for technology assessment (TA) at Monsanto? How does it relate to the planning and policy process? What steps have been taken to integrate TA in your company's activities? Has TA affected your way of doing business? Please explain and illustrate with a few examples.

Answer 1. Not in the sense that all projects and businesses are subjected to a TA. Those projects that have major funding and that can have large impacts on the Corporation's future and its environment are assessed as a part of our long range Corporate Planning process. This service is available to any business manager who cares to use it, however. Over the past 6 years we have done formal TAs on more than 35 projects or businesses, large and small. Based on these assessments, in conjunction with other studies (i.e., economic, technological, and strategic) we have made decisions and commitments that have had and will continue to have major effects on our business.

Question 2. How is TA activity incorporated into reports?

Answer 2. TA is not considered an isolated activity. It is part of our overall continuing planning process. The contribution of TA appears in our long-range planning documents along with other inputs of an economic, financial, or strategic nature.

Question 3. You mentioned a high degree of success with symposia while explaining the Cycle-Safe@ 1'A. Have there been any further attempts to involve the public in the TA process?

Answer 3. As a community service we have made our TA capabilities available to Webster College, a small liberal arts college located in Webster Groves, Mo. Over the years the Administration of Webster College has been able to define a policy and a posture for their institution that has brought new vitality and growth to them. Dr. Leigh Gerdine would be pleased to discuss it in detail, if requested.

Question 4. How do you handle impact statements? How do you discuss impacts to the public ahead of time and educate it about the meaning of impacts?

Answer 4. Impact statements that are not a part of the public record are for internal use at Monsanto. However, the data they contain are used by public relations people of the firm in compiling preparedness material used in making major announcements. In this way, through the investigative activity of the press, the information is made available to the public in an interesting and therefore enlightening manner. The material is also used in speeches, by-lined articles, and other public statements by company executives. Raw data are rarely employed because these documents are suspect in the public mind as corporate propaganda and without the mediating influence of the media, they may miss the public concerns that the media can voice.

Question 5. What value do you see in having closer relationships and improved communications between the public and private sectors? Do you see any difference between executive and legislative branch agencies? What about the value of Monsanto having closer relationships in the area of TA with State and local governments?

Answer 5. Monsanto feels strongly that improved communications between all sectors of society is essential to progress. In the government-private business interface however, it is important to maintain on both sides the check-and-balance relationship that litigation can provide when either corporate or agency abuses occur.

There are differences between executive and legislative branch agencies that reflect the different objectives of top officials. This is again a part of the check-and-balance mechanism of the American system. We strongly favor a continuation of this system.

TA is a powerful tool. It involves the use of logic and cost-benefit analysis for varying parts of the ecosphere. Unfortunately, not every individual is capable of following such a complex thought process. Wherever possible, we use TA data and findings in our relationships with local, State, and Federal Governments as well as with various segments of the general public.

Mr. 13 BROWN. Thank you very much gentlemen, all of you, for being here this morning. The hearing will be adjourned until tomorrow morning, June 9, 1976, at 10 a.m. when we will return.

[The hearing was adjourned at 12:02 p.m.]

TECHNOLOGY ASSESSMENT ACTIVITIES IN THE INDUSTRIAL, ACADEMIC, AND GOVERNMENTAL COMMUNITIES

WEDNESDAY, JUNE 9, 1976

CONGRESS OF THE UNITED STATES,
TECHNOLOGY ASSESSMENT BOARD,
OFFICE OF TECHNOLOGY ASSESSMENT,
Washington, D.C.

The Board convened at 10:08 a.m., in room 2318, Rayburn House office Building, Hon. George E. Brown, Jr. (member, Technology Assessment Board) presiding.

Present: Emilio Q. Daddario, member ex officio and Director, OTA; and Dennis Miller of the staff.

Mr. BROWN. The subcommittee will come to order. The Technology Assessment Board is entering the 2nd day of a 4-day series of hearings on technology assessment (TA) with the purpose of analyzing and exploring t e ways in which As are conducted in governmental, academic, and private industry operations; how TA fits into the general program of policy formulation and decisionmaking within Government and private enterprise; and how it is conceived of or defined to the extent that this is possible to do here. Our expectations are that as a result of these hearings, we will be able to more effectively plan and carry out the program for the Technology Assessment. Board and the Office of Technology Assessment (OTA), which is a relatively recent creation of the congress for the purpose of assisting it to make better policy judgments than it has been able to in the past.

We are grateful for all the witnesses who have participated and cooperated in helping us to achieve this purpose. This morning we have four witnesses. Due to the exigencies of executive branch policy with respect to giving testimony, we are going to proceed in the following fashion. Our first witness will be Mr. J. W. Davison, vice president, research and development, Phillips Petroleum Co., who will give us some insight into how his company perceives problems in this area. Then we have three witnesses representing various offices within the executive branch. I am going to ask all three of them to come forward at the same time to make their statements and then be questioned as a panel, if that is satisfactory to them. I think this approach may slightly speed up our activities.

The House is in session as of 10 a.m. It is my intention to carry through until we have finished with all the witnesses. even though it may be necessary to go slightly beyond 12 noon. With that brief introduction, I would like to ask Mr. Davison to come forward.

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Mr. DAVISON. Mr. Chairman, with our permission, I would like to have Mr. Emil Malick, who is President of Provesta, a Phillips Petroleum Co. subsidiary, 'join me at the witness stand.

Mr. BROWN. We are happy to have him and certainly welcome him here. We are happy to have you also, Mr. Davison. You may proceed with your statement in whatever fashion suits your convenience.

[The biographical sketch of Mr. J. W. Davison is as follows:]

J. W. DAVISON, Vice PRESIDENT, PHILLIPS PetroLEUM COMPANY

Mr. J. W. Davison, Vice President, Research and Development, Phillips Petroleum Company.

B.S. chemical engineering, University of Kansas, 1943.

Military service, U.S. Navy, 1944-1946.

Professional experience at Phillips Petroleum Company: refining department "1943; research and development department, 1946; in that department: manager, process evaluation branch, 1956; director, process evaluation and optimization, 1934; director process development, 1965; director, chemical and polymer process, 1988; director, rubber, carbon black, and polyolefins, 1969; vice-chairman of the operating committee, 1971; chairman, 1973; manager of research and development, 1975.

Numerous articles published in technical journals; author of 21 U.S. patents.

Advisory activities include memberships in: the board of directors of the Coordinating Research Council; the U.S. national committee of the World Petroleum Congresses; the executive committee of the Frontiers of Science Foundation of Oklahoma; and the business advisory committee of the National Association of Conservation Districts; also Phillips representative to the Industrial Research Institute.

Professional memberships include: registered professional engineer in Oklahoma, member and fellow of the American Institute of Engineers, and American Men of Science.

STATEMENT OF J. W. DAVISON, VICE PRESIDENT, RESEARCH AND DEVELOPMENT, PHILLIPS PETROLEUM CO., ACCOMPANIED BY EMIL MALICK, PRESIDENT, PROVESTA, A PHILLIPS PETROLEUM CO. SUBSIDIARY

Mr. DAVISON. Thank you, Mr. Chairman, members of the Board and staff of the Office. My name is Joe Davison. I am vice president of research and development of the Phillips Petroleum Co, I want to tell you today the philosophy and approach of my company in planning, assessing, and implementing technologies. My remarks will apply to almost any company working with private capital that depends for its existence on extensive research; on upgrading technologies; on finite sources of energy and other natural resources; on the need to make them compatible with social, environmental, and economic factors; and on the need to choose from among technologies those that can make the best input to the public.

The interrelation of these and other determinant factors is complex as is shown on this chart. (See fig. 1.) Referring to the chart, going around clockwise, it involves technology present and future, U.S. Government and public policies, the economy, social needs and trends, and so on.

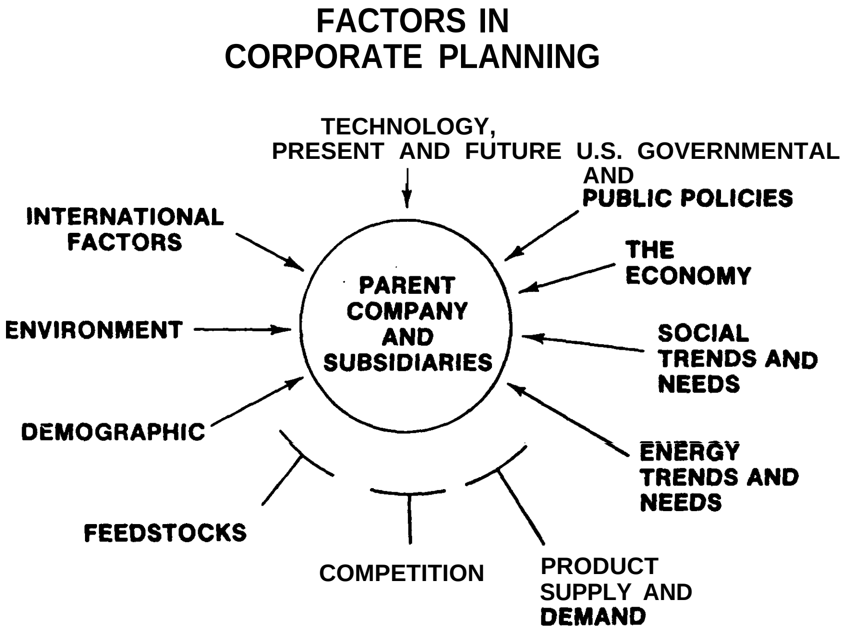


FIGURE 1

The assessments are never one-shot decisions but involve many reassessments from the cradle of the idea to the grave of a technology, in the light of changing conditions. In our company overseeing all such planning and implementation worldwide is a full-time organization reporting directly to our chief executive officer. Branching out of it are satellites or divisions in our operating groups in R. & D. These divisions make long-range alternative strategy studies or what man of us call scenarios. Cofunctioning in environmental assessments we have a full-time staff to assure that all phases of operations safeguard and preferably improve the environment and conserve natural resources. The total effort in our company applied to environment is the equivalent of approximately 600 full-time employees.

The final key to whether a given technology is of value is simply how well the public receives it and benefits from it. The measure of this is whether the input can be made to the public in a manner that is economically and competitively self-sustaining and rewarding. In competitive enterprises this of course is the bottom line, the make or break.

We have studied your 1975 report to Congress and agree that everything we in industry do affects society and Government in one way or another. The other side of the coin is of course that everything Government does in the regulatory actions that it takes vitally affects society and industry. In this sense our relationship to each other is clearly bilateral, an equation containing two mutually dependent variables, Government and industry, in which each is affected by and must be responsive to the other. Our philosophy is that what is good must be good for both parties, Government and competitive enterprise, to maintain the well-being of those that both are intended to serve-the public.

The Office of Technology Assessment (OTA) could help to stimulate in Government a better understanding of this bilateral relationship. We compliment you on an impressive job in setting up your objectives anfin putting control over your expenditures and we say this as a major company with many international technological firsts and a highly inventive team that has ranked first for each of the last 8 years in the number of U.S. patents assigned to U.S. oil companies. However, while we look upon the OTA with hope, it is at the moment also with bated breath. The question in our minds is in just what manner you will actually implement your mandate. We are anxious that you do well, and we stand ready to help.

Now let me take you through my company's version of project planning or TA. (See fig. 2.)

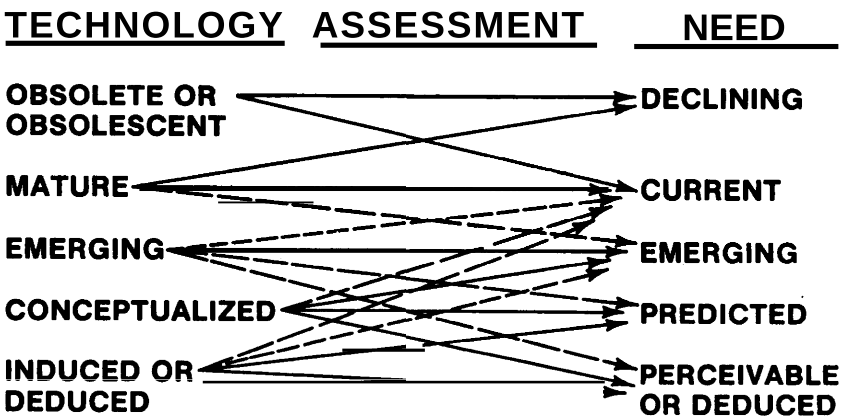


FIGURE 2

Technology assessments pose a chicken-and-egg situation. One must either first have something to assess, some conceptual, embryonic, or mature technology, as on the left side of the chart, or one must be able to perceive an existing or future need for a new technology or one adapted from an existing technology, as on the right side, the need side.

This sensing and measurement of public need involves many factors such as the anticipated growth or decline in public demand for products that would employ the technology, opportunity to improve the products needed or thought to be needed by the public, opportunity to better adapt to societal needs, obsolescence of a current technology or emergence of better ones, changes in corporate organization and facilities, trends in sources of raw materials and feedstock, ability to better complement other lines of business, and discernment of long-range societal trends and needs.

The TA then proceeds as shown here (see fig. 3), through searches of literature, conceiving a process, review of applicable past now-how, resources study, and so on clockwise around the chart, with, of course, close attention to societal compatibility.

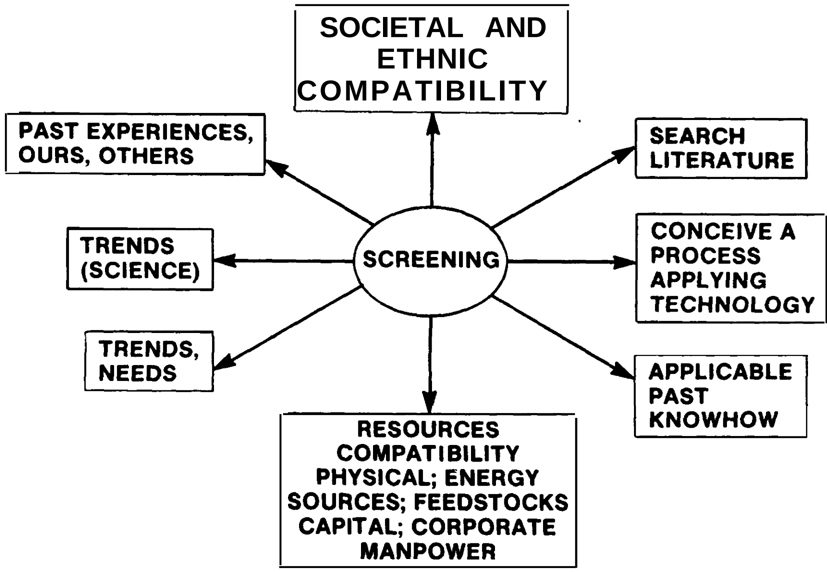


FIGURE 3

"Guesstimates" are then made as to the degree to which the technology can satisfy or improve response to present or future public need in terms of performance life, economics, chances of success, time to develop, safety, health, and environment. (See fig. 4.) As can be seen, there are many complex factors and the public is involved in most of them. Throughout there is progressively greater effort in consumer

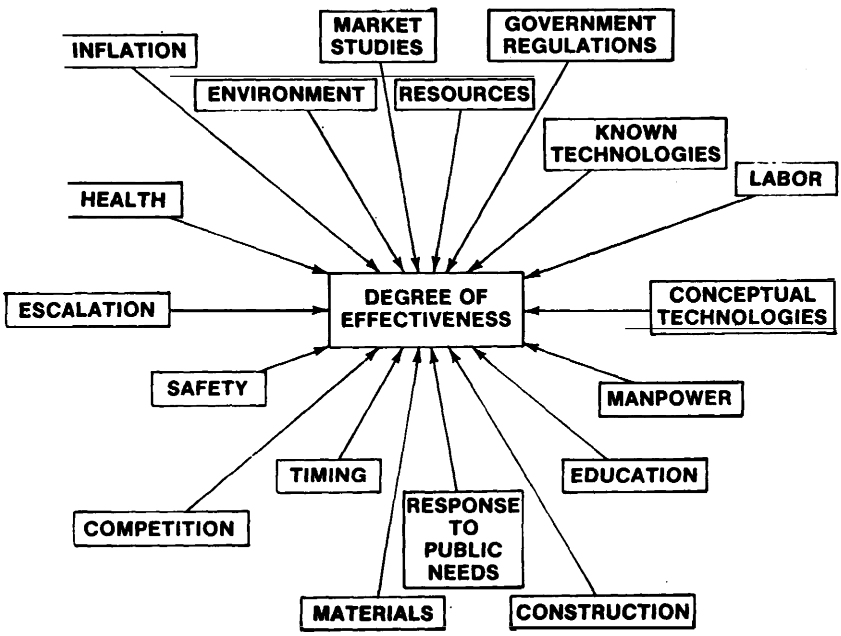


FIGURE 4

research, compatibility with existing or possible future regulations, appraisal of competitive technologies, estimates of costs of plants, materials, labor, escalation, inflation., and so on.

Assuming the assessments indicate a favorable balance (see fig. 5), we would then enter a more advanced phase in which previous assumptions would be checked in greater depth using more laboratory, literature, market, and small-scale plant studies as shown here.

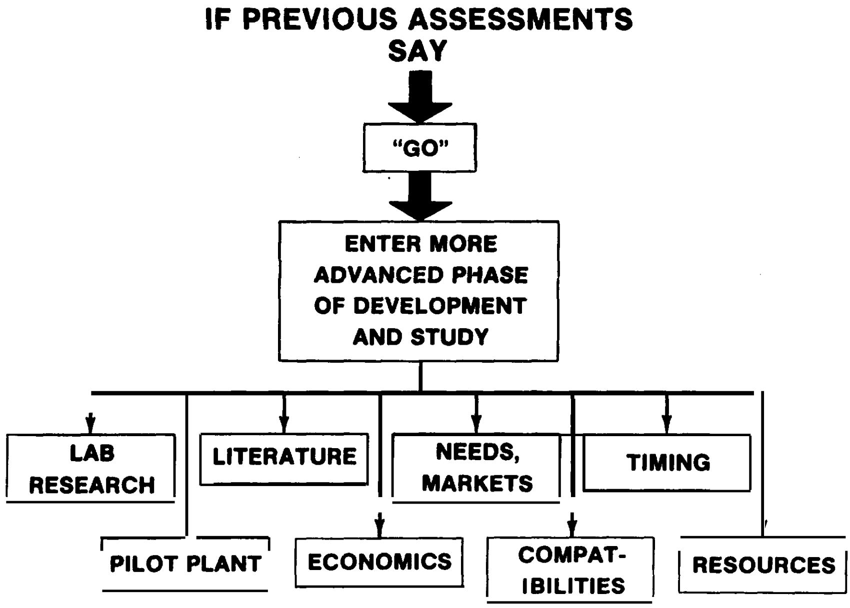


FIGURE 5

If the assessments still say go (see fig. 6), we would then pin down hypothetical processes that would employ the technology and make still more refined assessments of the probability of success and the costs in translating technology into a production, using past inputs, economics similitude comparisons, and prototype product performance.

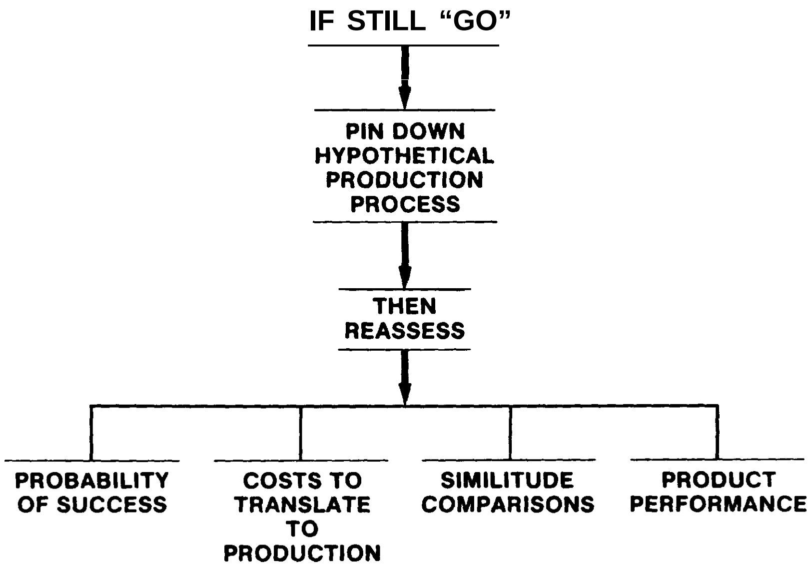


FIGURE 6

Next we would decide whether the present technology is OK, a new technology is needed, or a combination of old plus new would do the job. (See fig. 7.) Also whether the new undertaking can survive; be self-sustaining, and yield returns that would justify the capital put into it. At this stage optimistic thinking is essential because undue conservatism would prematurely destroy the prospects of ever creating anything new.

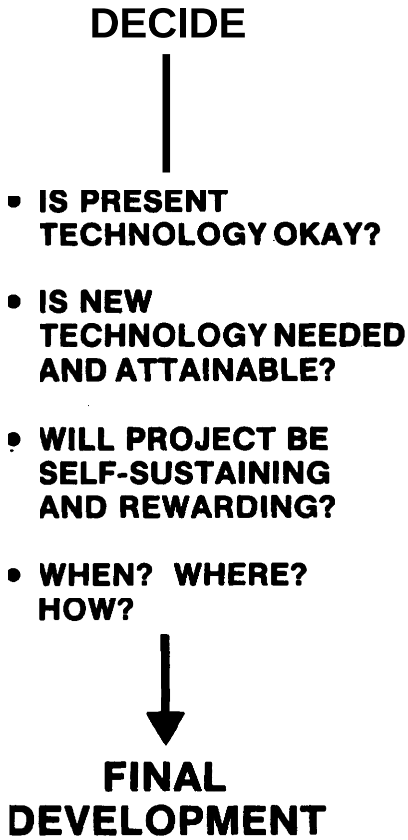


FIGURE 7

If it appears that the candidate technology would satisfy all criteria, the program would then enter final development. (See g. 8.) At this stage the costs normally far exceed earlier phases. Thus the reassessments become very hardheaded. During this phase there is often the need to design and build the pilot or prototype plant that might obtain process data, or verify product quality and get product samples for lab and field testing. If problems appear, they are again assessed in terms of the need to modify the technology, to develop a new one, or to cancel the entire effort.

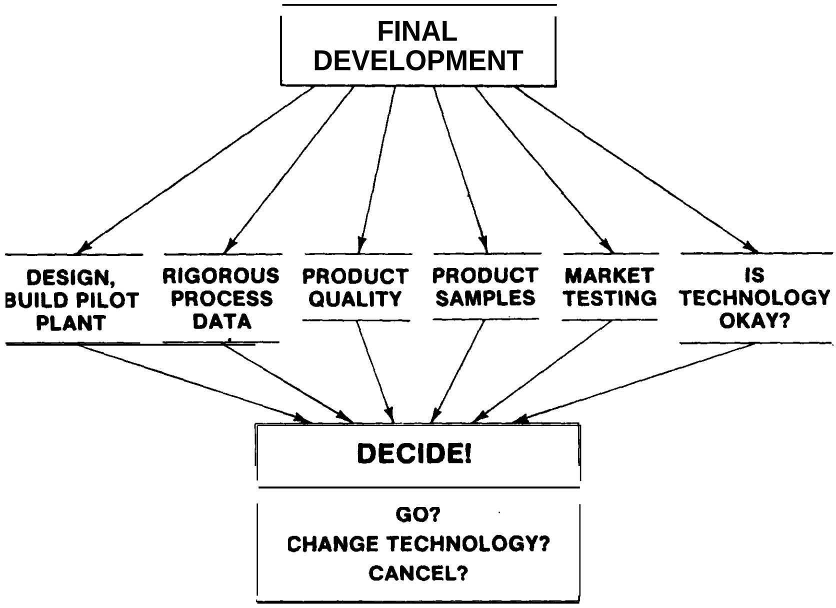


FIGURE 8

If the signals are still go, we then freeze and the effort expands into full, detailed plant design, process flow sheets, drawings, specifications, staffing, and other considerations that attend commercialization. (See fig. 9. Then we make a final check with still tougher reassessments to check the probability and degree of confidence of suc-

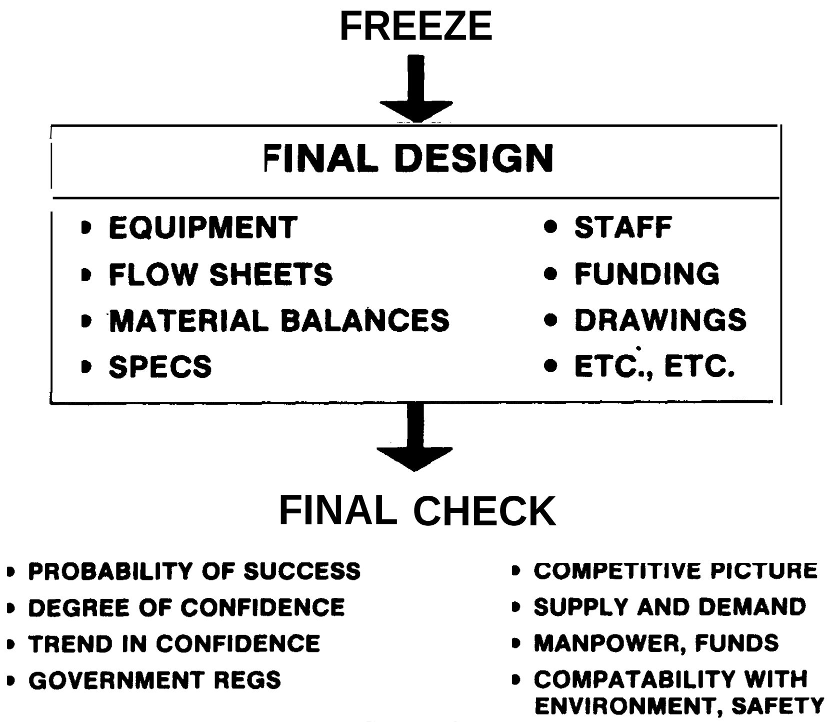


FIGURE 9

cess, the trend in confidence, competitive developments, supply and demand, manpower, operating funds, scheduling of funds, capitalization needs and sources, and a host of other considerations. The "go" decision is now made, or the total effort is again remodeled or rescheduled, or in the most hopeless cases it is canceled with the least expenditure of further funds. (See fig. 10.)

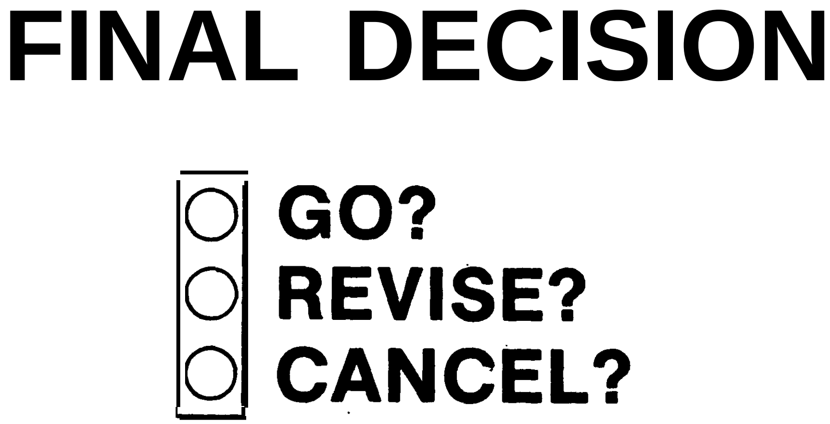


FIGURE 10

Gentlemen, please do not conclude that through such rigorous evaluation we somehow achieve that happy state where we hit a winner every time. We still have losers just as you do at times in your decisionmaking. As a rule however, when we do it is not because of faulty technology but rather because of the influence of unexpected changes in societal, regulatory, or other factors. We must of course come up with more winners than losers, so that on balance we are self-sustaining and rewarding to those who have invested money in us with the expectation of good returns. Otherwise our sources of capitol will withdraw and dry up.

On the other hand, we do not expect every technology to be a winner from inception every time. Before some can generate a self-sustaining capability, a great deal of money has to be poured into them speculatively and without, offsetting current income. From a fiscal standpoint, such money is in a very real sense a loss. Often in such technologies much of the life of new patents is eaten up before manufacturing even begins. Sometimes the technology may continue a loser during its first years of commercial operations because we guessed wrong about how well the public would receive it, or about the cost effects of unexpected changes in regulations, or other factors influencing mananufacture.

Ho&ever, in some cases we deliberately accept in advance that on balance the commercial implementation of the technology will be a loser in its early stages, especially if it is highly innovative in concept, form, or marketplace. In such cases we turn our backs to short-term economics and speculate through faith that the technology will in time help fill some important societal needs. In such cases we attach greatest weight to those technologies that would simultaneously allow us to conserve energy, or to make wiser use of it, or to upgrade it to a greater degree into forms that would fill more critical societal needs.

Let me tell you now of an example that has all of these attributes, plus many major secondary and tertiary societal implications. It IS one into which we have put much research, development, and funding over a period of years with no offsetting income as yet, and it has now passed through all of the developmental phases that I have described. (See fig. 11.) It is known as single cell protein or SCP for short, and its assessment is now underway by governments and

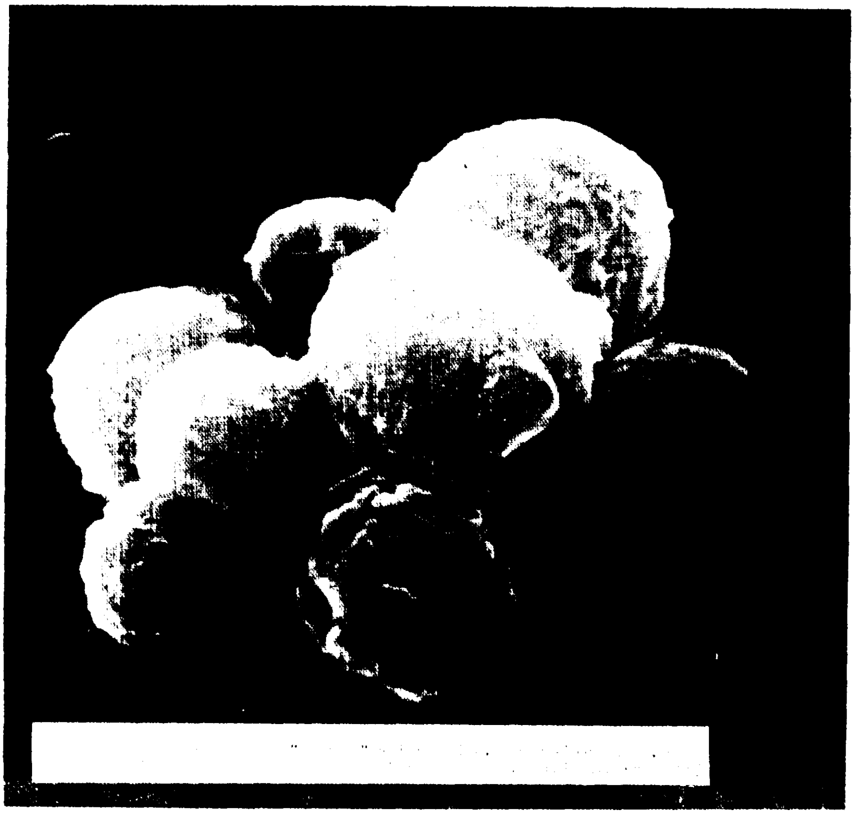
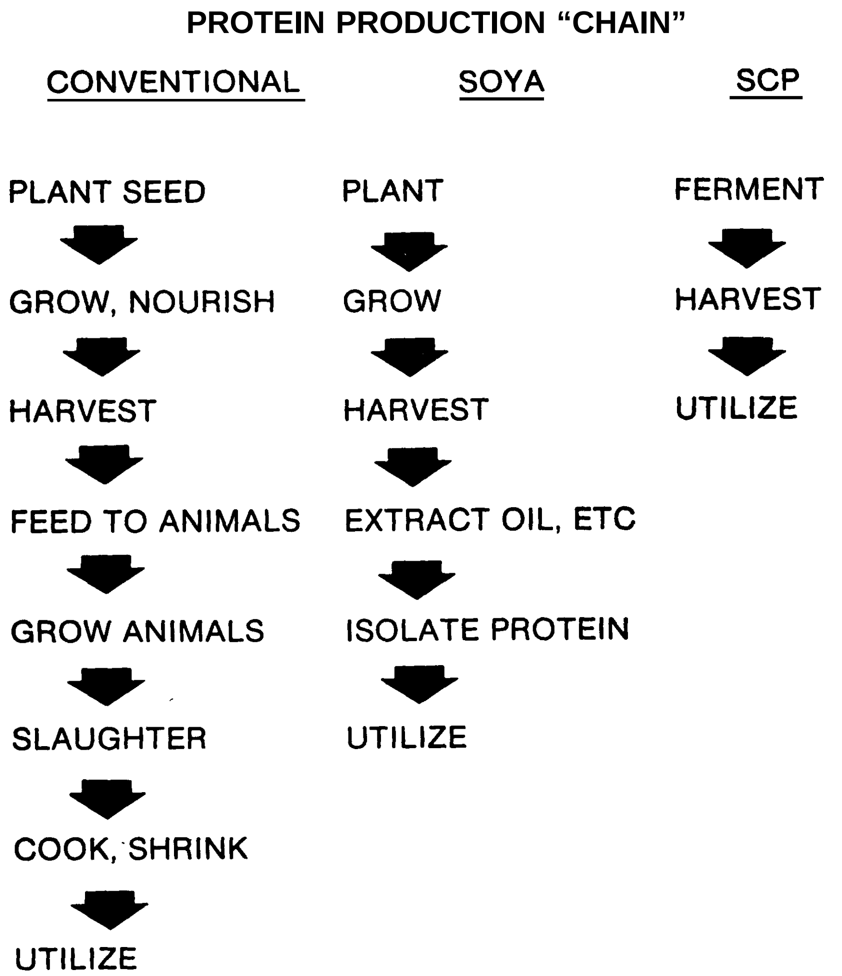


FIGURE 11

private concerns here and abroad.

It is potentially a giant stride, forward in simplifying, improving, and speeding up the protein production chain for getting massive new sources of protein to relieve the world's critical and ever-growing food shortages. (See fig. 12.) As shown on the left in this chart, SCP shortens the chain from the conventional agricultural cycle-as compared to the soybean cycle as shown in the middle—to the vastly shortened cycle, as shown on the right for SCP. Besides shortening



FIGUBE 12

the chain, at the same time it greatly increases the efficiency of energy utilization. As part of my presentation, I am providing for your record a recent paper on SCP by Provesta Corp. along with related statements in the Journal of Commerce and the Congressional Record.

Mr. BROWN. Without objection, that will be made part of the record.

[The material referred to above is found in appendix B, exhibits 1, 2, and 3 of this volume.]

Mr. DAVISON. Thank you. Some have asked us what a petroleum company is doing getting into the food business. Actually what we and others have been getting into here is much broader in scope. In this instance, we started our learning tree by assessing the basic scientific truth that some species of organisms can use the energy contained in petroleum derivatives to perform a host of functions; some are useful like SCP and some are not. SCP, of course, is only one of these functions. Some organisms break down petroleum derivatives into their elements, hydrogen, oxygen , and carbon and then use the elements along with growth minerals and nutrients as building blocks to proliferate greatly, as shown by the checkmark on this chart, to create useful protein and other products. (See fig. 13.)

MICROBES UTILIZE ENERGY FROM HYDROCARBONS, GASES, ALCOHOLS AND OTHER SOURCES

FAVORABLY

— ECOLOGICALLY AND ENVIRONMENTALLY, BY BREAKING DOWN AND ELIMINATING UNDESIRABLE PRODUCTS

✓— BY PROLIFERATING GREATLY IN A USEFUL MANNER WHILE BREAKING DOWN THE ENERGY SOURCES

— BY FORMING NEW SECONDARY PRODUCTS WHILE BREAKING DOWN THE ENERGY SOURCES

— BY "RESTRUCTURING" THE ORIGINAL ENERGY SOURCES INTO NEW USEFUL PRODUCTS

UNFAVORABLY

- BY CREATING MANY UNDESIRABLE SIDE EFFECTS AND PRODUCTS

FIGURE 13

In this same way other organisms perform still other functions. (See fig. 14.) Some are unfavorable, as shown on this chart. Here

MICROBES UTILIZE ENERGY

UNFAVORABLY

— POLLUTION (AIR, WATER, ETC.)

— CONTAMINATION

— DESTABILIZATION OF OTHER PRODUCTS

— GUM FORMATIONS

— PLUGGING (FILTERS, LINES, MEMBRANES, ETC.)

— DAMAGED PROTECTIVE LININGS

DAMAGED PIPELINES

— CORROSION

— DESTRUCTION (ASPHALT ROADS, CONCRETE, ETC.)

— "SOURING" OF OIL

— COOLING TOWER DAMAGE

— INDUSTRIAL DERMATITIS (CUTTING OILS, ETC.)

— RUBBER DETERIORATION

— DRILLING MUD BREAKDOWN

(— AND MANY MORE)

FIGURE 14

technology tries to find corrective products and measures. The checkmark shows an example where a bacteria plugs filter lines in jet aircraft. Coincidentally Phillips worked on a technology for a solution that is now used in all U.S. military aircraft and NATO aircraft to solve this particular problem of detrimental organisms. It should go without saying that these organisms are not, of course, the ones for making SCP.

In other cases, the reactions of the organisms are of value ecologically and envmonmentally in breaking down and eliminating undesirable products or situations. (See fig. 15.) This chart shows

MICROBES UTILIZE ENERGY

FAVORABLY

— — — ECOLOGICALLY AND ENVIRONMENTALLY, BY BREAKING DOWN AND ELIMINATING UNDESIRABLE PRODUCTS: — — —

OIL SPILLS	**— REMOVAL OF PLASTICS, SOLVENTS, ETC., IN OTHER CARRIERS**
WASTES IN WATER	
SLUDGE	**— PHENOLS**
CHEMICAL WASTES	**— DETERGENTS**
REMOVAL OF HYDROCARBONS FROM ATMOSPHERE	**— OTHERS**

FIGURE 15

examples of how microbes can dispose of wastes in water, sludge, or the atmosphere. In still other reactions certain micro-orgartisms form desirable secondary products such as vitamins and enzymes while breaking down and consuming the elements of the original petroleum derivatives. (See fig. 16.) And in still others, certain species can

MICROBES UTILIZE ENERGY

FAVORABLY

— — — BY FORMING NEW SECONDARY PRODUCTS WHILE BREAKING DOWN THE ORIGINAL PRODUCTS — — —

— VITAMINS

— ENZYMES

— AMINO ACIDS

— ANTIBIOTICS

— CERTAIN ACIDS
(CITRIC, GLUTAMIC, ETC.)

— MANY OTHERS

FIGURE 16

77-495 O - 77 - 5

chemically restructure petroleum derivatives into new useful products such as those shown here. (See fig. 17.) There are many of these. We've only shown a few on the chart.

MICROBFS UTILIZE ENERGY

FAVORABLY

— — BY "RESTRUCTURING" ORIGINAL PRODUCTS INTO NEW USEFUL ONES

- **LONG CHAIN FATTY ACIDS**
- **MANY OTHER ACIDS**
- **KETONES**
- **ALCOHOLS**
- **AROMATICS**
- **SIDE CHAINS**

FIGURE 17

Finally, and here is where SCP comes in, certain select organisms can be made to proliferate> in a useful manner, while breaking down the original energy sources, thereby producing new sources of biomass or protein, as shown by the checkmark on this chart. (See fig. 18.)

MICROBES UTILIZE ENERGY

FAVORABLY

— — BY PROLIFERATING GREATLY IN AN USEFUL MANNER WHILE BREAKING DOWN THE ENERGY SOURCES — — —

✓— FORMING 'BIOMASS' (PROTEIN, ETC.)

— HELPING TO RECOVER OIL

— LOCATING OIL

— CAUSING NEW OIL 'GENESIS'

— LEACHING OF ORES, ETC.

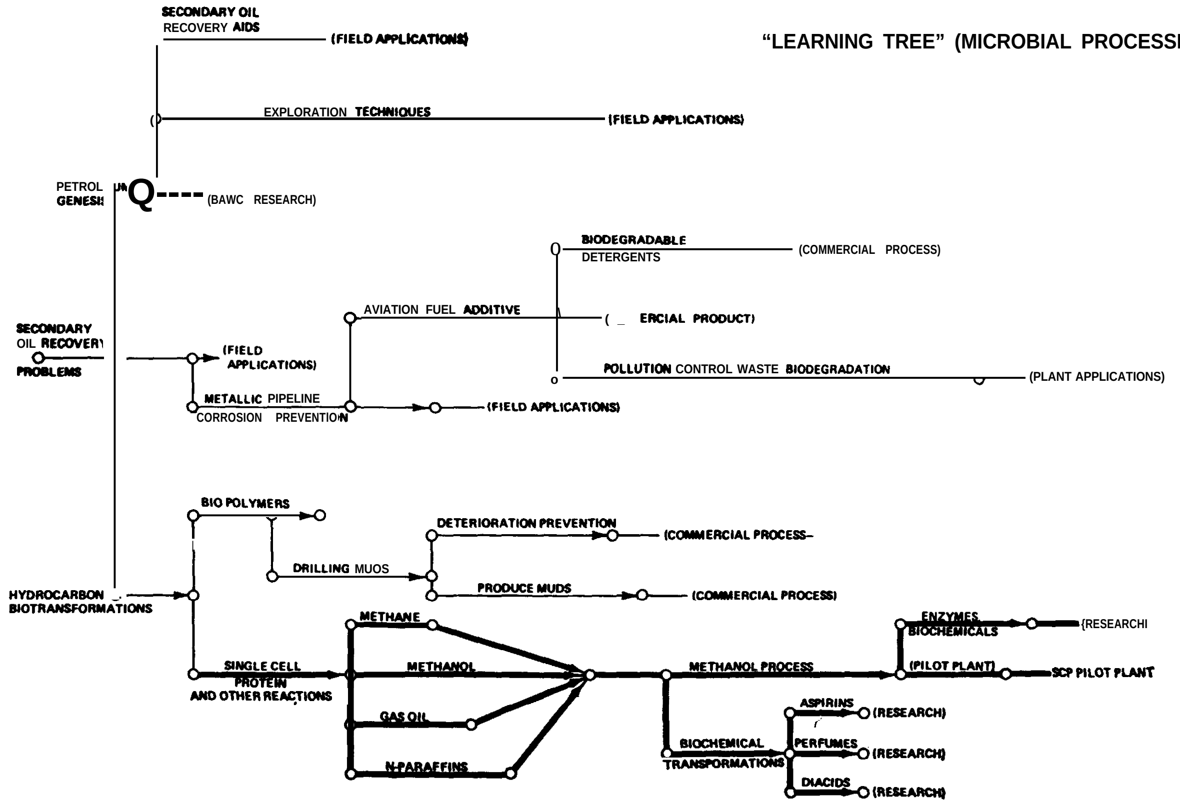
— EXTRACTING AND 'REFINING' USEFUL COMPONENTS FROM THE ENERGY SOURCE

FIGURE 18

The variety of such reactions and their applications is so great that a conventional learning tree visualization of them in chart form would be a maze of complexity. So we have chosen to show instead only that part of the learning tree in dark lines on this chart. (See fig. 19.) I do not expect you, Mr. Chairman, to read all that. But it

FIGURE 19

"LEARNING TREE" (MICROBIAL PROCESSES)



SCP "CRITICAL PATH"

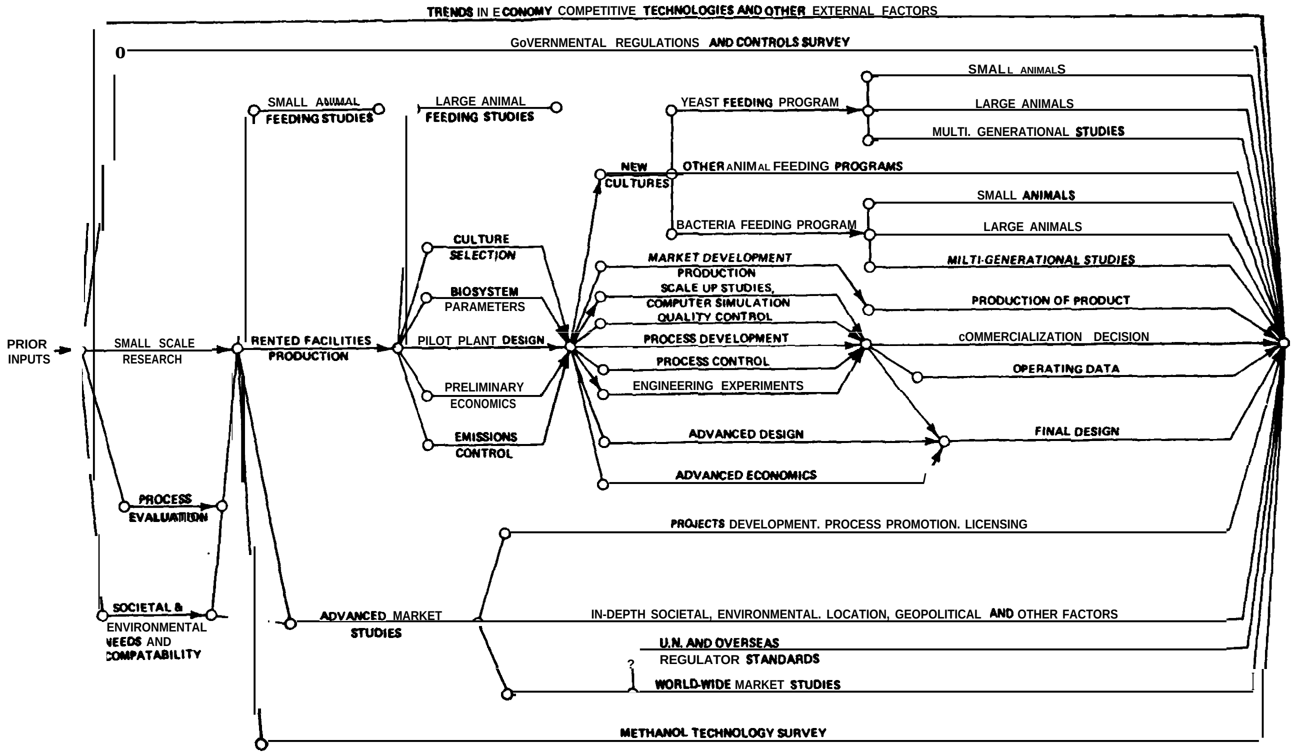


FIGURE 20

portrays some of the aspects that apply more immediately to some of our assessments. This branch of the tree of course includes SCP, some of the feedstocks that can be used, etc. From this one branch we can now make a project plan of SCP’s critical path. (See fig. **20.)** As seen, it is complex with numerous intermediate decisionmaking points. If you were able to read this chart from where you are sitting, you would see the large diversity of factors such as animal feeding tasks and emissions control—including if possible the recycling of water.

Actually SCP is nothing new. It has been around for billions of years in a variety of life forms. It consists of highly select micro-organisms whose body mass is made up mainly of rotein. In the case of SCP the final products can be the whole dried organisms or extracted parts. Mankind has eaten some micro-organisms for many, many years in the form of cheeses, yogurt, and other products.

Here is a startling figure that reveals SCP’s potential impact. A cow weighing 1,000 pounds can add about 1 pound of effective protein to its body mass per day. In contrast, 1,000 pounds of SCP could within 1 day begin producing as much as 1 million pounds. This is a theoretical rate, of course. The potential productivity of SCP staggers the imagination. Just one large SCP plant could produce about as much protein as might be isolated from 300,000 acres of so beans or from beef grown on about 5 million acres of good grazing land.

The first reaction of some to whom these figures have been cited has been, “Good Lord, is SCP going to knock the chicken ranchers, the cattle growers, and soybean farmers out of business?” Actually the exact opposite, we think, should take place. The secondary and tertiary societal effect would be many but positive. Extensive animal feeding tests have shown that SCP helps animals gain weight and makes more efficient use of the total feed given them.

In addition, the use of SCP as a protein supplement in animal feeds could displace soymeal now used in such feeds. This would create a positive domino effect because the protein in soymeal could then be extracted and used much more efficiently “energywise” as high-value textured vegetable protein for direct human consumption. Millions of pounds of such protein are today being sold as meat extenders for mixing into hamburger and other products, and billions more could be produced and exported by the United States through this SCP domino.

SCP is not a panacea that will displace agricultural and animal sources of protein. Conventional sources will continue to be needed to an increasing extent despite their much lower energy use efficiencies. They employ far more people and thus have greater infrastructural societal value than SCP. The old ways and the new would thus work hand in hand complementing each other, thereby serving mankind in its urgent quest for more protein.

The reason we chose SCP as a case history, in our remarks to you, is that from a TA or a project-planning standpoint, it is one of the most complex that we have ever seen, not only in its conventional parameters and their influence but also in its exceptional array of secondary and tertiary factors—societal, ethnic, psychological, novelty, regulatory, evaluatory, food policy restraints, political, geopolitical, educational and others. The leverage these factors exert on implementing decisionmaking is great, What makes it even tougher is that many of them are subjective andabstruse, thus difficult to quantify in their TA.

The manyfactors influencing SCP commercial timing and viability could in their aggregate be overshadowed by one alone, and that is the nature of (government regulations here and abroad that will control SCP manufacture, sale, and usage. Aware of this danger, the Protein Advisory Group of the United Nations evolved and issued a series of advisory guidelines for use by regulatory bodies here and abroad. These were prepared under the capable direction of Dr. Max Milner, who we are pleased to learn is now a staff member of OTA. The guidelines appear workable and seek to create commonality among regulations of all countries to allow unimpeded export-import trade and to give planners of commercial SCP enterprises a firm, consistent handle on regulatory aspects in assessing the viability of new projects.

How does one make reliable TAs under circumstances such as this when the make or break depends so greatly on regulatory decisions that have yet to be made? The answer may be to have a vehicle in our Government, namely OTA, which working with other Government agencies and private enterprise, will make informed, thorough, and unbiased assessments that will later serve as guidelines to cogizant U.S. agencies as well as to Congress.

As I have said before Mr. Chairman, ladies. and gentlemen, we are anxious that you do well and stand ready to help. Thank you.

Mr. BROWN. Thank -you very much, Mr. Davison. I find your testimony to be not only valuable but extremely interesting. It appears to me that you have a broad concept of technology assessment (TA) in your company, one that is interwoven with the entire formulation process, and serves as a major adjunct to your policy decisions. I am not entirely clear as to the degree to which you isolate this function as a separate organization. I might say that this is not necessarily good or bad. We have a tendency in the Government I think, to overbureaucratize functions. Sometimes this becomes counterproductive. Could you describe again briefly how you handle this function?

Mr. DAVISON. Yes, I would be happy to, Mr. Chairman. At the beginning of my remarks when I mentioned the overseeing body that is titled “Corporate Planning Group,” I certainly did not mean to imply that we compartmentalize this function. Quite the contrary, this full-time staff that reports directly to the chief executive officer of Phillips then branches down through satellite groups, which are divisions in every operating group of the corporation and in R. & D. These groups have many other functions, but the gist of it is that they function throughout the whole fiber of the operating groups and R. & D. in assessing technology. It is very much of an ongoing activity along with the functions that I have described in total.

Mr. BROWN. You say it is integrated with your overall corporate planning activities.

Mr. DAVISON. Very much so. As a matter of fact, in preparing our remarks we thought that in some aspects perhaps these remarks and the sequence of slides that I showed you might be considered trite. someone might say, "Well you know. that’s just project evaluation.)’ In a broad sense it is, it is true. but I think the important thing is to try to read back into that project evaluation from the very inception the environmental, the ecological, the societal impacts so that you are considering them hopefully. And I must say we are not always successful but we are learning.

Mr. BROWN. Of course, you have a slightly different need in private enterprise, which does not occur quite so much in public entities, and that is the market viability aspect of it. In fact, you can have a very successful technology resulting in the development of a product, service, or what have you with which as a result of market competition, you might fail. You not only have to make sure that the technology is viable but that you can produce the end result of that technology in a competitive fashion with all other enterprises that might be involved in the same endeavor. I cannot quite see a comparable situation in Government. We have a little bit of difficulty of course in the concept of planning in Government, making long-range policy determinations. The general assumption is that it is something Government ought not to be involved in. Although as a practical matter it is absolutely necessary, and it is being done in many different areas.

I might say that in other areas of Congress we are looking rather fully at the overall problem of long-range planning. This hearing and its results I think complement and fit into that. Your testimony indicates how closely they are identified in your own organization. I am very much interested in the example you gave of the single cell protein (SCP). Could you give me an indication of how close the development of this product is getting to the point at which there would be large-scale marketing—before it becomes an important aspect of our economy

Mr. MALICK. Mr. Chairman, before I answer that question, with your permission I would like to go back and make a brief comment on the rather important remark you made a moment ago. This distinction, this philosophical conceptual distinction that you mentioned, between the motivator in industry, that is that the measurement of viability is in terms often of economic parameters, whereas from a societal standpoint you in Government have to be mindful and conscious of the broader implications exclusive of how it might affect, one particular company or another. We really don't turn our backs on those technologies that do appear to be viable from a functional standpoint societally. If they do not fit our operations, quite often what we do if they are functionally useful, societally useful, but for some reason or other we do not have the feedstocks or we do not have such plant operations, or if it would cost too much to build a plant, then what we do, sir, is to license those technologies.

Let me give you a prime example. Air Force aircraft were crashing in the United states and other countries because micro-organisms were growing in the fuel tanks and clogging the filters. As part of the schemata Mr. Davison just described, one of the objectives in our studies is not just to proliferate micro-organisms for such products as SCP but to get rid of the unpleasant ones that cause undesirable effects in other situations. We discovered a technology to do the latter, that is to kill undesirable organisms. However, the chemical components of the product monomethyl ether of ethylene glycol, for one, were chemicals that we were not lined up to produce. so, what we did was to license companies all over the world, in the United States, Japan, and elsewhere, to let that technology be applied and move forward.

And again in still another case, the short-term viability of this matter that you asked us to address at this point, SCP, has not been a pivotal consideration at this stage of development. We have been working over 7 years, as the dates of the articles that we have submitted to you indicate, without 1 cent of return, on the assumption that in time the societal value of protein is going be be literally staggering the way the demand is growing now.

Now if I may, I will answer the question you addressed to me, namely, how close the development of SCP is getting to large-scale marketing. It is in some cases in its inceptual stage and past this stage in others. The awareness that organisms could proliferate and produce large masses of protein has existed for many years. Just to give you a point of reference, milk contains about 4 percent protein, meat anywhere from 20- to 30-percent perhaps, whereas these organisms contain 50- to 80-percent crude protein. And the knowledge that their body structure is made up that way has existed a long time, Mr. chairman. The question w-as one of developing efficient processes that would yield SCP products that nutritionally and toxicologically would be useful in one or another application. one of the applications is as animal feed, as Mr. Davison mentioned, the other ultimately is possibly for direct human consumption.

With respect to the former use, as soon as an awareness developed that certain hydrocarbons would grow protein-rich SCP, some companies abroad assumed, as we all sometimes do in science, that they had discovered a really major breakthrough, and they immediately proceeded to build plants with what we call first generation technologies. Two have just been completed in Italy, each of 100,000 tons, by two competitors of ours, We elected to pass up first generation technologies because of this concern that you are attentive to, the societal implications. There was a possibility that with certain feedstocks some problems might arise from the standpoint of consumer interests. We opted instead to go on to a more advanced technology that would eliminate such problems. Our judgment was correct. For as we understand it from the press and reports, at this moment those brand new plants are shut down because the Government of Italy has prohibited putting the products on the market until such time as certain additional quality criteria or measurements are satisfied.

So you could say that SCP in general is on the verge of being commercial if some resolution of the problems is arrived at momentarily. We ourselves are now addressing a number of locations around the world, examining the parameters of each of these prospective projects to see where, when, and how suitable projects applying our technology could move forward. With respect to animal feeds in the United States, the economics and the need are both rather uncertain. Soymeal as you know, has been rather low in price. It does provide a good protein supplement for animals, and we have plenty of it in the United States. For that reason, I do not see the entry of SCP in the animal-feed market very quickly.

Let me digress and say we are not the only company working on SCP. There are a number of companies all over the world each with its own particular technology and proprietary processes. One company in the United States is now marketing a form of SCP that is in fact a yeast, Torula yeast. It has been eaten by people for generations. The difference is that now the yeast is made using alcohol produced from gas. It is being marketed as a supplement to be added to different foods as a protein reinforcement.

As to progress beyond this point, we have this rather strange anomalistic situation. There is a tremendous need for protein in certain parts of the world. We know that extreme protein deficiencies affect brain functions, gestation in mothers, and health. But those areas that have the greatest intrinsic demand have the least capability to buy any products. In contrast, here in the United States we have a large production of other protein products for human consumption, as we have mentioned in our paper. When the advent of SCP overseas will be will de end a great deal on how Government and industry work together, and what priorities they set on its commercial rogress. That was a rather long-winded way of answering you, but I thought it might be helpful.

Mr. BROWN. It is quite obvious to me that this serves as an almost classic example of the importance of TA and its integration with market assessment, cost-benefit analysis, and the whole range of policy tools that you would have to apply. For example, you face a problem of declining availability of petroleum resources and higher prices. How is this going to affect the desirability of using petroleum resources for the manufacture of protein?

Mr. MALICK. There are several ways of doing this, Mr. Chairman. With one, you start with a liquid hydrocarbon fraction; with the other you start with—

Mr. BROWN. Is this a fraction that would not have minimum economic value otherwise?

Mr. MALICK. In certain a placations it would have a negative value. For example, normal paraffins have a very low octane number, and they have a high waxing point at which they cause the pour point of materials to be raised to a point where they might clog up something at low temperatures. In other situations, those components as chemicals are useful in making certain other products. So it really varies. Now, the other way of doing it, the way we have gone to what we call our second or third generation technologies, is to take gas—just gas-and make an alcohol out of the gas, that is oxidize the gas into an alcohol. If you take methane and oxidize it, you get methanol, which is methyl alcohol. There is a lot of methane around. This methanol is used as the energy source for growing the SCP. As for the extent to which you dip into the hydrocarbon resources, the best perspective I can give -you is this. There is a world protein gap that has been measured by the World Health Organization. I have a chart if you would like to see it, that shows what the deficiency is below the U.S. recommended level of daily protein intake for good nutrition, health, and mental development. The amount of this gap in the world daily diet is such that with less than 1 percent of the total current proven reserves of petroleum in the world, that gap could be completely filled on a projected future basis as well as a current basis.

With less than about 6 percent of the total world petroleum and gas reserves—this is theoretical of course because it will never happen—100 percent of the world's protein requirement for direct human ingestion could be satisfied. So it really does not hit the world petroleum resources that hard. Yet it has a tremendous impact.

Mr. BROWN. That is a very important point. If the SCPs can be developed from alcohols such as methanol, then the methanol could be produced from a wide range of wastes. Even in India it could be produced from agricultural waste, all those cows that are not being eaten and leaving a lot of manure around that could be converted into protein. Your assessment has taken into account all of these factors, I presume.

Mr. MALICK. Yes, sir, it has. "

Mr. BROWN. What about adverse side-effects, the possibility that there would be carcinogenic effects or other effects on human health? Has this been subjected to analysis also?

Mr. MALICK. First of all, just like people, all SCPS are not alike. Some are potentially questionable in character and repute, and others are rather spotless and virginal in these aspects. You have to discriminate and not generalize. One does have to discriminate.

As far as toxicology is concerned, some toxicologists feel that with certain substrates, that is with certain forms of hydrocarbons, there is a possibility that a residual chunk of the hydrocarbon might be left trapped in an organism. This in turn might theoretically cause a carcinogenic response in whatever the host is of that particular material. The fact is that to the best of my knowledge, there has been no evidence that this has happened. But the theory does exist. other substrates such as alcohols do not pose this question at all. The alcohol approach is not the same as the hydrocarbon approach. An alcohol is an alcohol and not a hydrocarbon even though it may be made from a hydrocarbon. Thus you cannot leave a trace of a hydrocarbon in there. We have run animal feeding tests for over 4 years. Others have for that length of time and even longer, and the responses of the animals have been excellent. There is no evidence of any difficulty.

Mr. BROWN. One of the big problems with carcinogenic effects is the long time delay.

Mr. MALICK. For that purpose you have to run multigeneration tests with these substances, Mr. Chairman, that is right.

Mr. Davison. And those are in progress, as a matter of fact.

Mr. MALICK. Yes.

Mr. BROWN. I think this is fascinating. Mr. Davison, in your testimony there comes throuqh this concept of the difference between public and private enterprise and the need for cooperation between them. You do stress however. the degree to which your company, and presumabl,v the forward-lookirw **portions** of private enterprise, takes as a sort of trusteeship responsibilitv with regard to what they are doing. Your testimony emphasizes this to a great extent. Governrment on the other hand, which is supposed to exercise a trusteeship role, sometimes neglects the importance of what you miqht call the enterprise role, the necessity to operate in a profitmakinq mode in order to survive. I am interested in the role of OTA. which you point out, as possibly making a bridge between these two by improving the understanding on the part of Government of the economic impacts of what might be proposed, and possibly helping private enterprise through the widespread dissemination of-its results and techniques and so on to understand the importance of the trusteeship role. The-y need to consider second- and third-order effects on human beings. which is a trusteeship function. Would -you care to comment a little further on how you see OTA meeting this role or the process of TA meeting this role?

Mr. DAVISON. yes, Mr. Chairman, I would. I thought our remarks some minutes ago were certainly perceptive of the differences that exist between industry and Government. My testimony as you have noted, refers to specific products and specific processes. It is true that industry does deal with these and it is a very important difference in that we are trying to get such commodities, such products and processs, viably to the marketplace. Whereas Government-and I must confess I sympathize with you in this role—is attempting to look very broadly at bodies of technology. It is a most difficult problem to bring these two concepts together satisfactorily and carry on a dialog about them in a way that will be meaningful in serving the public interest.

I believe though in taking consideration of the trust aspect and how we can come together and be helpful. I think the start you are making right here and will in Los Angeles with further testimony and discussions is most useful. You brought—and I think this is to the good-you brought certain industry people into your advisory boards. hey are giving input. And to that extent I can only again compliment you, and I hope that this trend will continue. We want to help. Any time we can be of help on a given project or technology. we will.

Mr. BROWN. **I think this process of involving through various panels a cross-section of competent people from private enterprise and from other sectors of the economy may be one of the most significant contributions that** OTA and the Technology Assessment Board can make. But I am interested in getting reactions to that.

The problem that results in a lot of Government regulation, which is the bane of your existence in private enterprise, is the apparent desire of private industry, in some cases, to market a product almost regardless of its effect upon society as long as it makes a profit. This can extend all the way from something relatively harmless like making hoola-hoops—and who am I to say that hoola-hoops are not valuable-but they do use scarce resources-to something far more serious such as a failure to anticipate the carcinogenic effect of some product that has a great deal of use in a special application but far more importantly has adverse effects in the long range. That results in, as I say, a great deal of effort on the part of Government to do what it thinks is necessary to protect the public, but which the company probably could have done and done more efficiently in going through some processes you have so ably described both in your testimony and with your charts. I do not like to suggest this, but maybe a wider attention to TA on the part of private enterprise might succeed in reducing the regulatory role of Government. a highly desirable result if it. should come about.

Mr. DAVISON. I think those again are good remarks, and I am not going to sit here and say that there is not some form of regulation or some sort of overview in which Government will play a part. I just cannot be critical in that respect. But I certainly agree with you, and I would like to think that we are learning. We are all learning. We are learning more about TA. I think that perhaps a number of years ago there was more of a tendency for private enterprise to produce something, to put it, into the public sector with more exclusive attention to the profit motive. But I honestly believe, as I remarked before, that the fact that out of 30,000 Phillips employees we have the equivalent of 600-and I do not mean 600 full-time but on call for a percentage of their time-the equivalent of 600 people involved in environmental work, that, I think, is outspoken testimony to the emphasis that we are giving it. We are not alone in that respect. There are many other competent companies that are doing the same thing. Monte Throdahl I know, spoke to you yesterday about Monsanto's efforts in these regards.

Mr. BROWN. Gentlemen, I again want to thank you for the contribution that you have made to our hearings. We would like to keep in touch with you. If there are any additional questions to help clarify The thrust of your testimony, I hope that we can communicate them to you and have you respond at an appropriate time. Thank you very much for your testimony.

[The following questions were submitted by Congressman Brown to Mr. Davison and his answers thereto:]

Question 1. Compare the process of TA in The Phillips Petroleum Company with the concept and utilization of TA in OTA. Contrast the strengths and weaknesses.

Answer 1. In concept and utilization we both seek the same end result: the capability of reaching sound decisions on future actions. In formulations we differ. Ours comprise a series of TAs, each of which affects the course of effort and substance of the final TA, and those made during the gestative process (often years) may not characterize the final one. Yours appear to be one-shot, and if made at interim stages in the gestations would in effect be speculating presciently and perhaps erroneously on the final stage. This means that OTA will be unable, in some instances at least, to provide valid TAs to Congress et al. until the technology is a fait accompli. This poses a dilemma since Congress seeks sound inputs before the active interface between society, environment, and technology.

The strength of our approach to TAs is that they are at all times current and thereby representative of the true state of existing knowledge. Its weakness, inherent in evolutionary processes, is that the final stage often cannot be accurately measured in form, timing, and impact until it is actually evolved.[1] In theory the strength of TAs made by a body such as OTA stems from their implied potential for greater societal and environmental objectivity because of their greater emphasis on these aspects (as Chairman Brown observed) than on industry's "bottom-line," economic viability. However, emphasis or bias in either direction could lead to distorted decisionmaking, possibly damaging from the standpoint of one or the other party. Recognition of this by both parties will offer an excellent opportunity for creating a system of constructive checks and balances in TA "points of view," government vs. industry. All that is needed is open-minded and frequent coordination between the parties. Among other things, this would safeguard against making premature "package" TAs of emerging lines of technology in all of their potential forms [2] that might severely penalise individual technologies falling within the package. Similarly, it would guard against specious TAs, representative of only one or another embodiment of a broad line of technology, that would lack true relevance to other embodiments.

If in policy and practice government and industry coordinate closely throughout the period that OTA is evolving each TA it will insure that as evolution takes place it will always accurately reflect the current characteristics of the topic under study. It would still be impossible to give Congress a final-status TA until the final attributes of the technology are evolved. But OTA would at least be able to do the next best thing, to give Congress sound current advice and interim guidelines on what may be emerging—in effect, interim progress reports in fields in which Congress has expressed interest, One must hope of course, that Congress would make prudent use of such interim inputs and not jump the gun.

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[1] Exceptions include government-sponsored technology-oriented contracts whose end objectives and characteristics (specifications) are often presumptively predefine by the buyer.

[2] This approach, frequently used by government, 1s known as the "least common denominator" principle in specification or regulation writing, intended ostensibly to protect restrictively against the worst embodiment that might be offered by anyone within the scope of the regulation, often at the expense of the best.

Properly sed, both parties would benefit from them. This is, in effect, what we recommended in our testimony and it reflects the concurrence expressed by Chairman Brown in his response to us.'

Question 2. Does information about your TA activities appear in any Phillips Petroleum Co. reports?

Answer 2. Yes. During formative stages our reports sometimes contain highly proprietary data and are given internal distribution only. Frequently however, TAs or their counterparts are published prior to commercialization of the technology. An example of the latter is the paper on single cell protein submitted to OTA as part of our testimony. In other instances we issue informative releases on impending actions and in still others special descriptive reports are sent widely to public, government, environmental, private, and academic sectors. An example of the latter is the booklet "The Casebook, Examples in Environmental Protection" given to OTA as part of our testimony. (See appendix B, exhibit 4, on how to obtain copies of the report.) Such "Casebooks" are updated and reissued periodically. Additionally, special brochures explaining our individual TA efforts and their implementations (prospective and actual) are at times issued. We also prepare and make wide release of information movies.

Question 3. Do you see any value in having close relations and better communications between your organization and Federal and State governments?

Answer 3. Emphatically yes.

Question 4. How do you decide how much time, effort, and money should be allocated for a particular TA or EIS?

Answer 4. As explained, allocations change during evolution of the technology. Those initially made to highly innovative technologies having little precedent simply reflect a priori judgment. The allocations are then readjusted periodically as data are acquired, based on parameters described in our testimony. In contrast to TAs, the scope of EIS processes is usually well-defined at the outset through prior knowledge of the criteria by which the EIS will be measured by EPA.

Question 5. Do you see any relationship between the TA and EIS processes?

Answer 5. EISs employ TA methodology but measure some, not all, of the parameters of TAs. TAs include EIS factors but not in precisely the same format as EIS-related assessments prepared specifically for submittal to EPA and other agencies.

Question 6. How has TA affected your way of doing business? How do you involve the public in your TA processes?

Answer 6. To one degree or another TA has always been intrinsic to everything we do in conceiving, planning, developing, and implementing technologies or changes therein that affect the public and the primary, secondary and tertiary attributes of whatever we bring to the public. The weighting of the many factors involved in TAs varies depending upon the nature of the technology, its novelty, methods of production, choice of feedstocks, markets, timing, societal, environmental, and other factors. Common to all, is consideration of the impact of the technology on the public and the environment. As explained elsewhere above and in our testimony the measurement of this impact employs methodology modelled to fit each case and including market research, studies by independent consumer testing laboratories, sample consumer group evaluations, test marketing in selected areas, study of the experiences of others in similar lines of effort, external and internal compatibility, and many other factors.

Question 7. How do you handle impact statements and how do you inform the public of the requirements and your efforts? How do you discuss the impacts and educate the public ahead of time?

Answer 7. Industry does not itself prepare EISs. What it generally does is to apply for permits to discharge effluents of one type or another. Normally public hearings are held before such permits are granted. Frequently we inform the public in advance of what we are thinking of doing and then allow and measure public response. In the case of new installations, we prepare environmental assessments, then submit these to EPA. It in turn assesses our data and then itself prepares the EIS. For major new projects we often hire competent third parties and firms to prepare the environmental assessment, to give it greater utility and neutrality. Generally, where we seek EISs from EPA we release no publicity until EPA gives us its EIS. However, we do at times in the interim publicly announce our projected plans, if this appears to be in the best interests

[3] Mr. BROWN. ". . . I think this process of involving through various panels a cross-section of competent poeople from private enterprise and from other sectors of the economy my be one of the most significant contributions that OTA and the Technology Assessment Board can make . . ."

of all concerned, then hold discussions as needed with interested or affected outside groups. Additionally, we prepare special reports, brochures, and other communications for dissemination to many outside groups.

We now have three governmental witnesses and if I might, I would like to ask all three of them to come forward. I would like to conduct their part of the hearing in a way that would be most convenient to them. Dr. Sidney R. Galler, who is Deputy Assistant Secretary for Environmental Affairs, Department of Commerce (DOC) ; Mr. Bruce Pasternack, Deputy Assistant Administrator for Policy, Federal Energy Administration (FEA) ; and Mr. John S. Barron, Assistant to the General Manager of the Tennessee Valley Authority (TVA).

Gentlemen, do any of you have time pressures that require you to leave in the next hour? If not, then I would like to ask each of you to present your testimony one after the other, and then we will have some discussion with all three of you after that is over. If there are no objections, we will take them in the order that I listed. First, Dr. Sidney R. Galler, who is from the Department of Commerce. We are very pleased to have you here.

[The biographical sketch of Dr. Sidney R. Galler is as follows:]

Dr. Sidney R. Galler, Deputy Assistant Secretary, U.S. Department of Commerce

Dr. Sidney R. Galler, Deputy Assistant Secretary for Environmental Affairs in the Office of the Assistant Secretary for Science and Technology, U.S. Department of Commerce, with responsibility for developing, coordinating, and evaluating the Department's environmental affairs.

Born November 9, 1922, Baltimore, Maryland: married; four children.

B.S. 1945; M.S. 1947; Ph. D. hydrobiology, University of Maryland, 1948.

Military service U.S. Army, World War II; head of the Biology Branch of the Office of Naval Research, 1950-1965; Assistant Secretary (Science) of the Smithsonian Institution, 1985-1971; appointed to present position by Secretary of Commerce, 1971.

Professional activities include: establishment of the U.S. Navy Hydrobiological Research Program, which served as a foundation for the later development of U.S. national research programs in biological oceanography; and development of the first U.S. program of animal orientation research which has contributed to improved high altitude aircraft operations and manned space flight; also pioneering work in bio-instrumentation which led to the development of the first U.S. satellite biological experiment launched from Cape Kennedy on February 4, 1958.

At the Smithsonian, initiated the Smithsonian Center for Short-Lived Phenomena—the first international early warning system for scientists to facilitate early investigation of major natural catastrophes, e.g. earthquakes, volcanic eruptions, pest infestations, etc. Also, helped develop the Smithsonian Center for Environmental Studies, a research facility for discovering scientific solutions to environmental problems such as the protection of watersheds in areas of rapid industrial and residential development.

Author of numerous scientific and technical publications. A member of: the American Society of Limnology and Oceanography; Society of Sigma Xi; The Research Society of America; and the American Institute of Biological Sciences; and a Fellow of the American Association for the Advancement of Science, a Founder member of the Marine Technical Society, and a Fellow of the Washington Academy of Sciences; also a member of the Cosmos Club, and listed in *Amcrican Men of Science* and *Who's Who in America.*

Awards received include: the Navy Civilian Service Award, several Outstanding Performance Awards, and the Navy Distinguished Civilian Service Award. (This award is the highest civilian award of the U.S. Navy.) Special Achievement Award received from NASA in 1971; and for advancing international scientific collaboration. Letters of commendation awarded from secretaries of the navies of Mexico, Argentina, Chile, Peru, and Brazil.

Honors received include the Smithsonian Exceptional Service Award, the highest staff citation awarded by the Smithsonian; and in March 1975. a Special Achievement Award by the Secretary of Commerce.

STATEMENT OF SIDNEY R, GALLER, DEPUTY ASSISTANT SECRETARY FOR ENVIRONMENTAL AFFAIRS, U.S. DEPARTMENT OF COMMERCE

Dr. **GALLER.** Thank you. Mr. Chairman, it is a privilege to be invited to appear before the Technology Assessment Board and provide you with information about one aspect of the U.S. Department of Commerce's (DOC) activities in the area of technology assessment (TA). I would like to focus my presentation on the National Environmental Policy Act (NEPA) and specifically on section 102 (2) (c), which, in my view, provides an important mechanism for assessing the impact of technology on the environment.

Up to a point, the subject of TA like beauty, is in the eyes of the beholder. I would like therefore, to provide you with the context for my perspectives on TA that follow. Let me quote from section 101(a) of the Declaration of National Environmental Policy:

> The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment . . . and new and expanding technological advances . . . declares that it is the continuing policy of **the** Federal Government . . . to create and maintain conditions under which man and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations of Americans.

Next let me quote briefly from section 102 of NEPA:

> The Congress authorizes and directs that to the fullest extent possible: . . . (2) all agencies of the Federal Government shall include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the human environment, a detailed statement by the responsible official on the environmental impact of the proposed action. . . .

It is my considered opinion, Mr. Chairman, that NEPA, including the requirement to prepare environmental impact statements (EISs). whenever appropriate, provides for assessments of the impacts of proposed technology based actions on the environment. It is especially interesting to note that section 101(a) addresses the need for man and nature to exist in productive harmony and fulfill the social, economic, and other requirements of Americans. It is also noteworthy that section 102(2) (c) addresses the need to prepare EISs on proposals for major Federal actions significantly affecting the quality of the human environment. Obviously then, NEPA encourages the development of an information base to facilitate assessments of the impacts of technology on the life-support capacity of the natural ecosystem—that is, the environment as we know It—as well as on the supply of materials and energy for the delivery of food, shelter, clothing, and the amenities that determine in the aggregate the quality of the human environment. In summary then, I am suggesting that NEPA, and specifically the requirement to prepare the EIS under NEPA, for the first time in our Nation's history institutionalized a process for projecting and assessing the effects of technology-oriented decisions on the quality of the total environment. so much for the context of my perceptions on TA.

On December 8, 1970, the Secretary of Commerce established the post of Deputy Assistant Secretary for Environmental Affairs to assist the Department in complying with the spirit as well as with the letter of the NEPA. I assumed my post on January 11, 1971, just in time to take part in the preparation and review of what is now known as the Trans-Alaska Pipeline (TAP) Environmental Impact Statement, whiCh was at that being prepared by the Department of the Interior (DOI), with collaboration from other Federal departments, including our own. Since that time. our department has gained considerable experience and insight, b@ in the preparation of. and in the review and comment on, the EIS.

Because of the nature of our missions and programs in the DOC, the number of EISs that we have prepared has been relatively small, averaging about 12 or more a year. However, we have reviewed many thousands of EISs over the last 5 years, and have commented on about half of the number that have come in for our review.

The question is frequently asked, "Is the environmental impact statement an effective technology assessment tool?" Let me respond as follows; that since the advent of NEPA local, State, and Federal Governments, as well as business. industry, and the public at large, have become increasingly conscious of the need to predict and assess the technological impact of proposed major actions on the total environment, prior to reaching a decision, rather than making the ex post facto assessments that typified our pre-NEPA activities. Indeed, in my opinion, the EIS requirement provides an extraordinarily interesting and important challenge and opportunity to improve the TA process. At the &me time, our experience with the EIS as a TA tool points to the need to reappraise that process toward insuring that it indeed meets the intended requirements to identify and assess the impacts on the human environment of a proposed major Federal action before and not after the primary decision—thnt is, the go-no-go decision—is made. Also that regard, I think it is necessary to examine closely the connotations of the term, “major Federal actions,” because in my view. the most serious and chronic defect in the w-hole EIS assessment process continues to be its largely ex post facto nature, notwithstanding the earnest and sincere efforts on the part of all Federal agencies, including our own, to inject the EIS ***process*** into the earliest stages of project planning.

One major obstacle that militates against optimum utilization in the decisionmaking process of the information document we call the EIS, is that the implementing guidelines fail to take into full account the fact that many of the so-called major Federal actions are basically actions that are derived from earlier decisions made in the non-Federal sectors of the community before the formal EIS process was actually initiated. I have estimated that over the last 4 -years approximately 80 percent of all the projects for which Federal EISs have been prepared, originated outside of the Federal sector. I estimate further, that during that same period more than 50 percent of those projects requiring EISs could be identified as originating in the private and local sectors. For example, if the XYZ electrical generating utility conducts a market survey that projects a market demand for electrical energy well beyond its current capacities, it must by law take whatever action is deemed appropriate to increase its capacity in order to meet that demand. In point of fact, the local XYZ utility is under societal-generated statutory pressures to initiate projects to increase capacity for societal good.

Ironically, and notwithstanding well-intentioned efforts on the part of the utility to factor environment into its early project planning, it

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rarely possesses an adequate in-house capability for doing so. Most frequently, it depends on outside consultants or contractors to gather and package the available environmental information in the form that corporate management can use in arriving at the primary decision—that is, whether to go nuclear, fossil fuel, et cetera. That first or primary decision is made by corporate management largely based on its perceptions of its legal and social responsibilities to the community that it serves, as well as to its stockholders and to the lending institutions. Once the utility decides. on the basic energy source, it has, in effect, made the first and most Important decision. From that time on, environmental factors, while still very important in developing actual project implementation plans, come to be looked upon as hurdles to be overcome before the utility can meet responsibilities to serve the community.

From the moment of the first decision, the project begins to unfold. It takes on a life of its own, as it were, as it travels through the successive levels of local, county, and State governments, meeting the various legal, social, and financial requirements imposed by the communities and their governmental agencies. As it proceeds, the project may develop a tremendous socioeconomic and political momentum. So when it finally enters the Federal sector, seeking the necessary Federal subventions, It has become, for all intents and purposes, an irresistible force.

Thus, some 2 or 3 ears after the first decision was arrived at, and with thousands of miles frequently separating both the impact site and the local community's exceptions of the project, from Washington, D.C., and the lead Federal agency's perceptions of the project, the lead Federal agency is required to undertake the development of an EIS. It is small wonder then that the current process often generates more purple prose than dialog, and exacerbates rather than ameliorates the differences in perspective between the local, State, and Federal communities; since neither the private sector nor local and State governments, can be expected to view the TAs inherent in the EIS in the same way as the Federal sector.

In our view, another equally distressing weakness in the current EIS recess is the lack of clear requirements for the inclusion of what I call an economic dimension in the EIS. Most EISs are largely devoted to discussions of possible impacts of technology on the physical, biological, and ecological elements of the environment; for example, the impact on the life-support capacities of the biosphere. With few exceptions, the presentation of information about economic factors is nonexistant, or at most cursory, under current guidelines for the preparation of EISs. This is the case despite the fact that the decision-making process in the United States almost invariably depends on the availability of an adequate body of information both on the economic and on the environmental dimensions of a proposed action.

An additional area where progress can be made is to increase the amount of assessment that occurs in the EIS. Too often, an EIS consists of a partly digested compendium on everything that is known or can be predicted about a particular development, with little assessment of the significance of the impacts and the trade-off relationships between values, public and private. In my opionion, EISs like TAs must be evaluative, not just predictive or encyclopedic. Furthermore, the EIS, in my view, was intended to be an objective assessment report, not the advocacy document that it unfortunately has become in too many cases.

Fortunately, we believe that the likelihood for improving the EIS process in the problem areas just mentioned is very good. We have developed a preliminary plan in our Department for an experimental project to establish a standardized methodology for developing, evaluating, and displaying information in the EISs; as weIl as developing a procedure for restructuring the final EIS into a more useful informational document for decisionmaking.

We would like to apply the results of this effort to actual projects as a test on a retrospective or current time-frame basis. Since this effort could have significant benefits for other agencies, we would be delighted to collaborate with the OTA, the National Science Foundation (NSF), and other agencies concerned with TA or its close kin, EIS. I am certainly aware of the leadership role that NSF has played in both the development of TA techniques and their application.The insights that NSF has gained from its experience could be invaluable. By introducing these innovative approaches decisionmakers would be provided with more useful information in the EISs.

Deciding what a TA should consist of is in some respects like peering into a prism. What is encompassed within the scope of vision and its arrangement is dependent, in large measure, on which facet it is viewed through. We, in the DOC, are keenly interested in the effects governmental regulations have on the development and application of technology and the innovative technological process. For example, when Congress or a Federal agency specifies directly or indirectly the aplication of a certain technology or class of technology, such as the best available technology under the Federal Water Pollution Control Act requirements, we In Commerce, wish to assess the impact of those regulations on the development and and application of new treatment technologies Further, we wish to evaluate the economic as well as the environmental effects that may follow from the application of those technologies. The Office of Environmental Affairs is conducting several industry TAs that are identlfying and evaluating the energy. economic, and environmental consequences of mandated pollution-control levels and associated waste-treatment technologies. I might add, Mr. Chairman, we are ding this in very close consultation with our brother agencies, the Federal Energy Administration (FEA), The Energy Research and Development Administration (ERDA), as well as the Environmental Protection Agency (EPA).

In summary, I believe that the techniques for TA are sufficiently developed to find useful application in the preparation of EISs, and the development and review of governmental regulations. We should move ahead in applying these technique toward projecting the broad implications of technology in environmental rotaction programs, and so provide the policymakers in the Federal Government with the best possible information on major national issues and programs. Thank you.

Mr. BROWN. Thank you very much, Dr. Galler. Your testimony raises the important question of the relationship between EISs and

TAs. I want to explore that more fully with you after the other witnesses have also presented their statements.

The next witness is Mr. Bruce Pasternack, Associate Administrator of. the Federal Energy Administration, Mr. Pasternack.

[The biographical sketch of Mr. Bruce Pasternack is as follows:]

BRUCE A. PASTERNACK, ASSOCIATE ADMINISTRATOR, FEDERAL ENERGY ADMINISTRATION

Mr. Bruce A. Pasternack, Associate Administrator for Policy and Program Evaluation, the Federal Energy Administration (FEA).

B.S. engineering, the Cooper Union, New York; M.S. systems engineering and operations research, University of Pennsylvania; Ph.D. course work completed, environmental management and public administration, Drexel University.

Systems designer and project manager for environmental analyses and information systems, General Electric Company; staff member for energy programs, Council on Environmental Quality, where coordinated a Presidential study of the environmental impact of potential oil and gas production on the Atlantic Outer Continental Shelf and the Gulf of Alaska, and also worked on the Council's strip mining study conducted for the Senate Committee on Interior and Insular Affairs, drafted environmental legislation, and was responsible for environmental monitoring and solid waste activities at the Council; Deputy Assistant Administrator for Policy and Director of the Office of Policy Evaluation, FEA where was responsible for policy development and analysis for the President's Energy Program, and also served as Deputy Project Manager for the *Project Independence Report*, for which coordinated all policy, technical review, and administrative matters, and developed legislative initiatives for data, analysis, and conservation.

Additional activities at FEA include: directing the preparation of the *National Energy Outlook*, the analytical framework for development of a national energy policy; chairman of a Federal planning effort to relieve the Nation's natural gas shortage; directing an interagency review of liquefied natural gas policy; and as a member of the Agency's Project Review Board for new contract proposals, and the Senior Review Committee for exceptions and appeals cases. Currently responsible for development and analysis of energy policy proposals and legislation and evaluation of FEA programs and budget.

STATEMENT OF BRUCE A. PASTERNACK, ASSOCIATE ADMINISTRATOR FOR POLICY AND PROGRAM EVALUATION, OFFICE OF POLICY ANALYSIS, FEDERAL ENERGY ADMINISTRATION

Mr. PASTERNACK. Thank you. Mr. Chairman, members of the Technology Assessment Board, and staff: I am very leased that these hearings are being held at this time, and particularly that the Federal Energy Administration (FEA) has been asked to appear. With your permission, Mr. Chairman, I would like to submit my written statement for the record and offer some remarks in summary.

Mr. BROWN. Without objection, that will be the order.

[The complete statement of Mr. Bruce Pasternack is as follows:]

FULL STATEMENT OF BRUCE A. PASTERNACK, ASSOCIATE ADMINISTRATOR FOR POLICY AND PROGRAM EVALUATION, FEDERAL ENERGY ADMINISTRATION

Mr. Chairman, members of the Board, I am pleased to be here today to discuss with you the role of technology assesement (TA) in the operations of the Federal Energy Administration (FEA). As such, I will confine my remarks to those efforts within the agency whose purposes are the anticipation of impacts, both now and in the future, of the various policy, regulatory, and program alternatives developed In response to the energy situation now confronting the Nation.

As this Board is well aware, the ongoing debate over various energy issues clearly illustrates the difficulties involved in making policy decisions in the face of countless conflicting values and interests. In this type of environment, the concept and approach of TA is a valuable tool.

Technology assessment is often used to refer to a policy study that examines the fullest range of the impacts resulting from the introduction of a new technology, or the expansion of a present technology in a new or different way. For the purpose of this presentation, I shall use the term technology to refer not only to new physical inventions or processes but also to new regulatory patterns, distribution patterns, or patterns of consumption-in short, to new "soft" as well as "hard" technologies. Furthermore, I shall use the term TA to refer not only to analysis of the impacts of a single technological change, but also to the analysis of the impacts of multiple technological changes taking place concurrently-that is, changes in broad scenarios as well as changes of a more limited nature.

Although the term TA cannot be found in any of FEA's functional statements, the methodology has been an integral part of this agency's workings since its inception shortly after the Arab oil embargo began in the fall of 1973. In the period immediately following the embargo, our energy management programs were primarily regulatory in nature as we sought to distribute equitably a reduced volume of energy supplies throughout the country. Our objective was to lessen, to the greatest extent possible, the adverse social and economic disruptions caused by the embargo.

Since the embargo, both the Congress and the Administration have recognized the crucial need to develop an in-depth understanding of the domestic and international energy situation in order to develop an effective national program to limit future vulnerability to embargoes. Our own authorizing legislation (the Federal Energy Administration Act of 1974) directed as, among other things, to develop and implement a comprehensive national energy data system, to develop an analytical capability to forecast and estimate short- and long-term energy problems, and to implement policies to meet energy needs. Thus, the Agency was given a broad mandate to perform TAs as previously defined, and to act on the basis of those assessments. It should be noted here that another agency, the Energy Research and Development Administration, Is primarily responsible for decisions regarding energy research, development, and demonstration activities related to new scientific and engineering technologies. Complementing this effort, the focus of FEA is on the economic and operational aspects of the various components of the energy system

To achieve an understanding of the energy situation, FEA first established a comprehensive information data base composed of supply, demand, production, and import statistics that would form the foundation for techniques to forecast our energy future. Then using various econometric models and judgment. FEA developed both the Project Independence Report of November 1974 and the National Energy Outlook of this year that report to the American people on our energy outlook and the factors that will affect our future energy situation. With the help of the Project Independence Evaluation System (PIES) developed for the Project Independence Report and refined since then, a set of national energy objectives and policies was formulated. The PIES model evaluates technologies, lead times, costs, and geographical locations that affect energy commodities from the point of discovery, through production, transportation, conversion to more useful forms, and ultimately consumption by all sectors of the economy. While its advantages in projecting the broad impact of alternative policies are obvious, we recognize its limitations in evaluating specific projects. The Federal Energy Administration has built upon the PIES model and reinforced it with other economic, environmental, and consumer impact evacuation tools.

Much of the work that might be classified as TA is performed within the FEA's Office of Policy and Analysis. This Office is primarily responsible for the evaluation, analysis, and coordination of energy-related policies and programs that will culminate in a national plan to meet the future energy needs of the Nation. This includes managing the decisionmaking process for all policy, program, and regulatory options; providing statistical and analytical studies of the economic and social impact of the options; and developing short- and long-term energy supply and demand forecasts.

Environmental concerns are centered in the Office of Environmental Programs under the Assistant Administrator for Energy Conservation and Environment. This Office ensures that FEA is in compliance with the National Environmental Policy Act, reviews environmental impact statements prepared for specific energy-related projects, examines the environmental issues surrounding the development of our energy resources, and analyzes existing and proposed environmental regulations with the aim of achieving a more perfect balance between energy and environmental concerns.

In another area within FEA, the Office of Energy Resource Development, a Project Operations System has been developed to provide assistance in expediting site-specific energy projects throughout the Nation This system attempts to identify energy facilities that are encountering serious roadblocks to their development determines the nature of the problems involved, and makes an assessment as to whether the Federal government can have a positive impact by helping reduce causes of project delays and offering assistance as needed. Projects here include coal mines, gas, oil, and coal slurry pipelines, railroads, synthetic fuel plants, and utility facilities.

The formulation of a national energy policy is a complex task that requires the close cooperation of Federal, State, and local government bodies, and the public-at-large. Our Intergovernmental, Regional, and Special Programs Office provides a daily liaison with State and local government officials, national associations of elected officials, and business, consumer and other interest groups on a wide range of energy issues of particular concern to the States and the public. As an example, this Office directs the Intergovernmental Coordinating Committee of the President's Energy Resources Council (ERC).

Prior to the development of FEA energy policy initiatives, the views of consumers and special interest groups are made through a variety of mechanisms. A total of 14 advisory committees representing such groups as Consumer Affairs/Special Impact, Food Industry, Environmental Interests, Energy Financing, and so forth, meet regularly to air their specific concerns to the Administrator. In addition to these meetings, public hearings are held as a matter of course in the issuance of regulations and when such major policy issues as the importing of liquefled natural gas, industrial conservation, electric utility rate reform, etc. are being considered. The Office of Intergovernmental, Regional, and Special Programs is thus closely involved in reviewing and analyzing the actual and potential impact of the FEA policies, programs and energy-related problems on the public sector. It advises the Administrator of the results of these reviews and analyses as well as about the concerns of the public, so that he can consider those factors in the development of FEA policies and programs.

Finally, the Office of Policy, under the Assistant Administrator for Policy and Analysis, provides the focal point for the refinement of energy policy initiatives and has a close working relationship with the Offices mentioned previously. This Office utilizes the various analyses, forecasts, and data provided by the other Offices, in the development and evaluation of energy policy options. Various policy alternatives can be evaluated, in part, through the use of the quantitative, economic, and social impact analyses performed by these Offices.

All of these activities have, for example, beep necessary during the past year in the coordination and development of policy proposals concerning fuels allocation, oil decontrol, and natural gas curtailments planning, and are being utilized now in planning for the Strategic Petroleum Reserve, outer continental shelf development, liquefied natural gas imports, and Western energy supply development.

I would now like to review briefly some examples of the kinds of TAs that are undertaken by FEA. It is the responsibility of the FEA's Office of Energy Conservation and Environment to identify and encourage the widespread adoption of existing commercially available technologies to conserve energy. To fulfill this responsibility, the Office has funded numerous studies to determine the energy savings potential and economic attractiveness of energy-conserving practices and techniques, as well as the environmental impacts of energy programs. Several examples of such TA studies funded by this Office include:

> The projected impact of anticipated changes in energy supply technologies on various industries identified as key energy consumers. These include steel, copper, aluminum selected chemicals, paper, glass, and cement. The studies concentrate on changes in energy supply mix, in production processes, in pricing of inputs and outputs, and other factors directly relevant to these industries.
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> The potential impacts, beneficial and otherwise, of substituting telecommunications for travel. Two means of energy-saving are being explored: (1) decentralization of work forces, which would reduce commuter travel; and (2) the increased use of telecommunications by existing work forces, in their current organizational structures.

A socioeconomic impact study of coal and oil shale boom towns. This would identify socio-ecomomic and fiscal problems associated with the development of oil and coal reserves between 1975 and 2000 in Colorado, Montana Wyoming, and Utah. In each community, in the four states under analysis, the capital needs for public and private services are being identified. The implications for Federal and State policy wonld be evaluated with a detailed examination of financing options for both the energy development projects themselves and for the related socio-economic infrastructure changes they are likely to require. I am presently assisting the Environmental Protection Agency's Technology Assessment of Western Energy Development by serving on its advisory committee for this study.

The Office of Policy and analysis, in another example, is currently leading the ERG interagency task force evaluating liquefied natural gas (LNG) import policies, as directed by the President in his February Energy Message to the Congress. The Task Force is presently assisting in the development of criteria for a national security economic review of LNG import ventures beyond those already unconditionally approved by the Federal Power Commission. Recognizing that this issue has important implications beyond national security, public hearings have been held to consult with consumer, environmental, regional labor, industrial and other groups in order to assess the potential impacts of various alternative policies. Of particular interest are considerations related to pricing, government financial assistance, domestic regional supply dependence, international sources of supply, and possible reassessment of import target levels if natural gas deregulation is not achieved.

As can be readily seen therefore, Mr. Chairman, the concept of TA is an integral part of the FEA's operations. I do not mean to imply that its application is simple or universally acceptable. There are many important problems for which either the scope or time for addressing the issue is too limited to apply TA techniques. Nevertheless, it is an important tool to be used in achieving viable solutions to the energy problems that confront the United States.

Mr. PASTERNACK. The ongoing energy debate that we have seen over the last couple of ears clearly illustrates the importance of considering the innumerable values and conflicting interests that occur in making policy decisions. Technology assessment (TA) by that or any other name, and I think the name itself is less important than the concept, is a valuable tool. Its value is equally great or what I would consider the soft technologies such as regulatory decisions, pattarns in consumption, and broad changes in policy, as well as the hard technologies discussed earlier in these hearings.

The term, technology assessment, does not appear anyplace in FEA's official organization chart. That might be a good thing as opposed to a bad thing, for its methodology has been a vital part of our agency since its inception. I would like to spend a few minutes talking about what was probably the first major TA activity in our agency. That was the Project Independence report which we produced in November of 1974. That report was done in a rather short period of about 6 to 8 months. It was a first attempt to look at the overall energy outlook for the 10 years following the embargo. And while we were particularly concerned about assessing our future supply of and demand for energy, we also recognized the need to do more than just look at supply and demand.

Thus, while we produced an encyclopedic set of volumes of resource-supply reports that look at the supply potential of each energy source from coal and oil to solar energy and geothermal at different prices and under different regulatory environments and that describe the technologies that would be used in developing these resources, we also for the first time looked at a whole series of what we called cross-cut studies. We called them that because they basically went across all the disciplines. These included studies such as assessments of the availability of water to supply our energy needs in the West, in parts of the Midwest, and in the East; the transportation requirements that will be placed on an industry to move coal, oil, natural gas, and other sources of energy across the country, very often in areas that were untapped before; possible labor shortages and the requirements for labor when you develop areas such as the northern Great Plains, which were previously rural and basically undeveloped, and the migration patterns that would result; the possible shortages and bottlenecks in supplying material, equipment, and the construction facilities that will be needed to develop the large amount of energy we will need over the next 10 years and beyond; the environmental impacts of this development on both air and water quality as well as land use and solid waste; the financing and capital problems that would be faced not only by the energy industry but by the investment community; and a whole range of conservation options to look at whether or not in fact, the energy was needed over the next 10 years and beyond.

We developed a very sophisticated forecasting and impact assessment tool to evaluate these alternatives. But, in the context of doing that we were very careful and continue to be careful to recognize the limitations of any model or any computer simulation in looking at as tough an issue as energy. We held a series of regional hearings during that study at over a dozen sites around the country, focusing on the impacts of alternative policies in that particular region. So, for example, in Denver we held hearings relating to the impact of oil shale and Western coal development in that region. In San Francisco we held hearings on energy conservation and its possible impacts.

The final report of over 20 volumes makes no policy recommendations. It was deliberately done that way. However, it evaluates alternative policy directions and tries to assess the impacts of going one route versus another. The Project Independence report was updated last winter, and we also released a report on the national energy outlook this year. This is a further look at the energy problem, and considers new issues such as regional concerns that we did not get into as much the previous year.

The Office of Policy Analysis in FEA directs many TA-related activities. It prepares the policy papers and analyzes and directs the FEA issue process. This attempts to insure that the views of all senior FEA officials, whether in resource development, in conservation, in the Office of Consumer Affairs, or in intergovernmental programs, that all the views of these officials reach the administrator before he makes any decision. This is not the only office in FEA that practices TA. My written statement goes into some of the other areas. I will just highlight a couple of them.

In our resource development area we have made a very strong effort in the last several months in building an activity to evaluate the roadblocks to energy development and to understand what it is in local areas that is causing energy development to slip.

We have also looked at the question of solar energy and have a basic memorandum of understanding with the Energy Research and Development Administration that we signed recently. This divides some responsibilities in the solar area. Our Solar Office is responsible for working with other agencies in the Federal Government to commercialize solar energy to set an example, and to understand the impacts of solar energy. This Office is also working with other agencies in a cooperative venture to see how we can improve the use of solar electric generation in the Southwest.

Our Conservation and Environment Office basically has a major responsibility in looking at changing consumption patterns in industry, households, transportation, and utilities. It funds and has funded several special studies to deal with the attractiveness and the impacts of energy-conserving practices. Among these are included a series of studies, many of which were done with the Department of Commerce, on the projected impacts of changes in the energy supply technologies on the major consuming industries. So we have looked at the steel industry, the petroleum refining, chemical and other industries from the standpoint of what will be the impacts of introducing new technology to conserve energy.

We have also looked at the potential impacts of substituting telecommunications for travel on the decentralization of work forces. This is a joint project with the National Science Foundation, which I think Dr. Stever mentioned in his testimony yesterday. We are carrying out right now, a major socioeconomic impact study of coal and oil shale boomtowns. This is something that certainly the people in the West are very concerned about.

Our utility demonstration projects across the country are designed to evaluate the effects of new rate structures such as peakload pricing or lifeline rates on not only the consumers but also on utilities, on industry, and on the whole regulatory environment under which utilities have to operate; and also to ass&s the impact of new load-management devices, some which have very wild-sounding names like ripple-ccmtrol systems.

Finally, I would like to offer a personal note, if I might. I have been involved in what is very similar to TA techniques for several years now. My training before coming to Washington was, I think, in many ways a predecessor to TA. That was the systems or systems analysis approach. I have been fortunate to work in both environmental and energy agencies in government, and at the Council on Environmental Quality (CEQ) to participate in one of the first ma-or TAs. This was the one done by the University of Oklahoma on offshore technology and Outer Continental Shelf development. I also worked on a major strip mining study done for the Congress, on the impacts of strip mining regulations on the economy and social structure of Appalachia. And of course, in CEQ I had a very close involvement with the National Environmental Policy Act and environmental impact statements (EISs).

At, FEA I have been fortunate to direct the preparation of the "Project Inclependence" report and the "National Energy 0utlook," as well as to oversee some major policy formulation activities. These include some current work on Alaskan development and the possible impacts on the State of Alaska as well as on the lower 48 States. I am sure you have heard about some work we have been doing recently on Alaskan oil distribution from the west coast. We just recently held a set of hearings in Los Angeles to look at liquefied natural gas policy and its impacts not just on supplying natural gas but also on environmental problems, and problems of alternate fuels. We are looking at the role both of natural gas and of electricity in the future, again not from just the energy standpoint but also from the environmental and economic standpoints.

I have recently been asked and am now serving on an advisory committee to the Environmental Protection Agency and the University of Oklahoma. This has a major 3-year TA of Western energy development going on. I believe in these approaches, whether discussing energy or other subjects such as food, health, and some of the others that are the concern of your Office. I think that energy is a fertile area for TA. As we see the massive structural and societal changes resulting from what has happened since the oil embargo a couple of years ago, I think that TA will be even more important in the future.

I would caution however, that the application of TA is neither simple nor universally acceptable. There are many important problems-and it seems to me as if we see them every day—for which either the scope or the time allotted for analysis is not enough to permit a very good TA to be done. Nevertheless, I think the energy problem lends itself very well to TA, and if we ever ho e to solve this problem we are going to have to work with these techniques. Thank you.

Mr. BROWN. Thank you very much, Mr. Pasternack. I think your paper illustrates another aspect of the TA process; that is, its relationship to the policy analysis needs of the government, which is an extremely important aspect, of course.

Our last witness this morning is Mr. John S. Barron, who brings us a perspective from his role as Assistant to the General Manager of the Tennessee Vane Authority (TVA). Mr. Barron.

[The biographic sketch of Mr. John S. Barron is as follows:]

MR. JOHN S. BARRON, ASSISTANT TO THE GENERAL MANAGER, TENNESSEE VALLEY AUTHORITY

Mr. John S. Barron, Assistant to the General Manager (Planning, Budget, and Systems), Tennessee Valley Authority.

Born July 10, 1932, Montgomery, Alabama; married, two children.

B.S. forest management, Alabama Polytechnic Institute (now Auburn University), 1954.

Commissioned Ensign in the U.S. Naval Reserve, 1964; forest technician for pulpwood procurement, International Paper Company; partner, Dixie Timber Company, Grove Hill, Ala.; assistant forester, Fulton Land Management Company, managing 170,000 acres forestland Alabama State Parks, first forester on staff, 1959, (third professional forester in State parks field in United States) ; subsequently Acting Chief and Assistant Chief of State parks; planner on Recreation staff, Tennessee Valley Authority (TVA), 1962; Chief of Recreation Section, TVA, 1904; represented TVA on the interagency task force to draft the Executive Order implementing the Land and Water Conservation Fund Act, 1965; Acting director of TVA's Office of Tributary Area Development, which is concerned with the unified resource development of subareas of the Tennessee Valley, 1966; Director, 1967; Assistant to the General Manager (Planning and Budget), 1973, aiding the General Manager in the development and administration of TVA's budget program and in guiding the development of related planning activities by offices and divisions.

Course participation at the Civil Service Commission's Executive Centers in Berkeley, California, and King's Point, N. Y.; and lectures given at the Center in Oak Ridge, Term., as well as at the University of Tennessee.

A member of Xi Sigma Pi forestry honor fraternity.

STATEMENT OF JOHN S. BARRON, ASSISTANT TO THE GENERAL MANAGER, TENNESSEE VALLEY AUTHORITY

Mr. BARRON. Thank you, Mr. Chairman. I would like first to introduce my associate, Mr. William E. Dickenson. Mr. Dickenson is the Coordinator of Research and Development Activities in the Tennessee Valley Authority (TVA). We are pleased to have the opportunity to appear before this Technology Assessment Board, and we hope that TVA's experience in assessing the benefits and the impacts of some of our programs will be of interest to you; and that we will be of some assistance in the future.

As you know, Congress created the TVA in 1933, directing it to aid in—"the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and adjoining territory." This work has resulted in a diverse organization. The agency has staff members involved in many areas—developing fish and wildlife, protecting air and water quality, working with farmers to improve production, developing new fertilizers, reclaiming eroded and surface-mined coal lands, working with citizens organizations, State and local agencies to help make economic progress, and of course as we are best known, in producing an ample supply of electric power to serve the needs of about 7 million people in areas of 7 States.

I might digress here for a moment and point out that our power program in particular makes us an exceptional Federal agency in that a 1959 amendment to the Tennessee Valley Authority Act charged us with the responsibility for operating a power system that is self-financing and self-supporting. We do not rely on appropriations to operate the power system. It is totally independent in that it is required to be financed strictly from revenues and borrowings against future revenue.

Our work is not completed, nor has it been easy. The process of trying to balance economic opportunity with an improved environment has given us numerous occasions perhaps without using the exact term, to use TA in examining the many ways, expected and unexpected, in which our technology affects people's lives. This has been a part of TVA's method of operation since the beginning.

Since Congress, the Nation, and the Office of Technology Assessment (OTA) are vitally interested in the benefits and impacts of energy, I would like to focus on TVA's electric power program and some of our efforts to reduce the impacts of producing electricity for the home, farm, schools, businesses, and industries of our region. But before I do, let me take just a moment and give you a brief example of how TA entered into some of our early decisions. When we were first building the water-control system in the valley, it became evident as we practiced our form of TA that a product of the reservoir construction program would be a vast breeding ground for mosquitoes. This was not only significant from the point of view of the nuisance of the mosquito, but malaria was a rather prevalent disease in the Tennessee Valley region at that time. Consequently, we entered into a program to modify first the shoreline, the anticipated shoreline of the reservoir, and then, second, a program that would manipulate the reservoir levels in a way that has essentially precluded the breeding of mosquitoes and, as a consequence, our reservoirs are essentially mosquito-free.

In the 1950's, TVA began building large coal-fired generating plants as the region% use of electricity outgrew the hydroelectric output from our dams As a results TVA became a large user of coal, and a considerable amount of this coal was surface-mined. Recognizin the impacts of unregulated strip mining, TVA supported the efeffortfor State regulation of strip mining. It worked on cooperative studies to show the extent of strip mining and to publicize the effects on land and water. I might add that our 1963 report, “An Appraisal of Coal Strip Mining in the Tennessee Valley," has been use nationally as a reference source. The Tennessee Valley Authority surveyed mining and reclamation methods throughout Appalachian and Midwestern coal fields, and carried out a series of demonstration projects to show that reclamation could be workable and effective in valley strip mining.

As early as the 1940’s TVA began to encourage reclamation in strip-mined lands, and in 1965 we began including reclamation requirements in our term-coal contracts whenever the coal was to be produced by stripping. This was recognized as only a limited approach since TVA buys only about 15 percent of the coal stripped in the major States where we purchase coal, but it was a start. Our provisions have been strengthened as experience has indicated that changes and improvements are needed. Over 35,000 “acres have received reclamation treatment under these provisions. Meanwhile, the States involved have adopted reclamation laws of their own, and we have also supported sound reclamation efforts on the national level.

As early as the 1950's, TVA incorporated design features in our coal-fired plants to minimize their impact on air quality. **In** the rnid-1960’s, extensive improvements such as the use of tall stacks and improved electrostatic precipitators were begun. These efforts continue today.

For example, in fiscal year 1975, TVA invested about $180 million in construction of facilities to protect the quality of air and water as part of our long-range program for environmental protection at powerplants. Even larger expenditures are expected in the current fiscal year.

Again in 1975, TVA continued its program to install high-efficiency precipitators at all of its coal-fired. plants. Additional precipitators, and improvements on those already installed, were under construction at seven steam plants. The cost of this current program in precipitator installation and updating is expected to be about $300 million.

A full-scale sulfur dioxide scrubber is under construction on a 550,000 kW coal-fired unit at Widows Creek steamplant in northern Alabama. The estimated cost is $54 million. The limestone scrubber is one method to remove sulfur dioxide from stack gases, but the process has not been commercially proved on units as large as the Widows Creek unit, and it possesses many technical and economic problems. The Widows Creek installation is a demonstration project undertaken by TVA to gain firsthand experience and to contribute to this important technology.

To comply with the Environmental Protection Agency (EPA) and State water quality requirements. and to protect aquatic life from the effects of warm water discharges at our steamplants, TVA is installing cooling towers at all of our nuclear plants. The estimated cost of cooling towers for the seven nuclear plants now under construction is $640 million. Extensive changes are also being made at existing coal-fired plants at a cost of about $75 million, to comply with recently announced EPA limitations on nonthermal discharges. TVA continues to assess new energy technologies with the goal of providing clean, economical, and reliable electric power supplies.

In fiscal year 1975, energy research and development activities paid for by TVA totaled $21 million and included contributions to both the Clinch River breeder reactor project and to the Electric Power Research Institute (EPRI). An additional $4 million was spent on cooperative programs financed by outside organizations.

During the year, TVA's board approved future projects expected to total nearly $40 million over 5 years for environmental research carried out by TVA and financed by EPA. Twenty-two of the projects are new areas of cooperative research between EPA and TVA, while three are continuations of existing agreements. Among the projects are studies to measure the effects of powerplant emissions of air and water quality and the continuation of studies to develop and evaluate technology for removing sulfur oxides from stack gases.

Examples of in-house research include pilot and bench-scale studies on stack gas cleaning, use of powerplant waste heat for raising fish and agricultural products, investigating improved methods of particulate collection, improving the appearance of transmission lines, feasibility studies of methods for producing synthetic powerplant fuels from coal, and analysis of new energy conservation schemes. About 50 projects were included in the in-house program.

Activities carried out cooperatively with other organizations included participation with ERDA in gasification of coal and studies of fluid-bed combustion. Conceptual design and cost studies of low-Btu gasification systems for producing fuel with low heat content were completed for EPRI during the year. Pilot-scale studies on sulfur dioxide removal from stack gases, conceptual design and cost studies for comparison of several alternate sulfur-dioxide removal systems, and combustion modifications for controlling nitrogen oxide emissions were conducted for EPA.

In the late 1950's and early 1960's when nuclear powerplants for the generation of electricity became feasible, TVA began its assessment of this new source of energy production. Some of the areas we examined in a 1966 study included cost alternatives of coal versus nuclear, nuclear safety and the ability to obtain licenses, operating assurance, and funding requirements, to name but a few. Compared to today's environmental review and the licensing process, the study was relatively elementary; but we did consider alternatives and impacts.

I would like to give you now, one localized example of how we assessed these impacts. TVA has begun preliminary construction work on a four-unit nuclear plant in a predominantly rural area of middle Tennessee. At peak construction, the project will require about 5,000 workers. In the final environmental impact statement for the project, TVA assessed the impacts of the influx of workers into the five-county area and, in cooperation with city, county, and State officials, has developed a mitigation program to provide necessary facilities and services in a timely and cost-effective manner. Some of the areas of concern include housing, education, recruitment? and training of local workers, water and sewer facilities, local governmental budgets, health and medical services, planning and coordination, and employee transportation.

TVA, as a resource development and conservation agency, has long been involved in the multidisciplinary review and assessment of its programs and projects. Mom recently, we have incorporated these existing assessment approaches into our procedures for complying with the National Environmental Policy Act in which social, economic, and environmental aspects of proposed actions are all carefully reviewed prior to decisionmaking.

We would be happy to respond to any questions which you might wish to ask.

Mr. BROWN. Thank you very much. Mr. Barren. We would like to pose a few questions to all of you gentlemen now. and we will try not to keep you too long. We would like to ask you, if it is desirable to do so, if we could submit additional questions in writing and have you respond to them and help us to complete the record in that fashion.

Dr. Galler. you put a great deal of stress in your statement on the relationship between the technology assessment (TA) process, and the preparation of environmental impact statements (EIS). I found your comments about EISs to be extremely useful and helpful. I wonder if you could just comment for a moment about how you perceive the differences between the two. Obviously there are areas of considerable overlap. In many cases they almost parallel each other. They are very similar. But do you see both similarities and differences and if so, what are they? How can we help to make a distinction between these two processes, if possible?

Dr. GALLER. There are of course, Mr. Chairman, both similarities and differences, as you point out. The EIS is a limited type of TA in the sense that it does not come into play until after a decision is arrived at that a proposed Federal action has a potential for significantly impacting on the environment. Only after that preassessment is carried out and a determination is made that it does fall within the meaning of section 102(2) (c) is the TA process that we call the EIS formally initiated.

Obviously there are many other categories of TAs—we heard of one in particular this morning from our colleagues (Messrs. Davison and Malick of Phillips Petroleum Co.) in the private sector-that would not ordinarily fall under the rubric of NEPA or an EIS. Such technologies however, embody much the same kind of criteria and principles that we try to follow in the EIS.

I would say that one way of making a distinction is that the EIS, to the extent that it does include or does really involve TA, is limited by the Federal Government today and applied only in those instances where there is a major Federal action that preassessment has determined could have an impact on the environment, a significant impact.

Mr. Brown. You suggested that one of the defects of the EIS is that it is made too late in the process to be as useful as it might be in the policy development phases. Do you perceive any possibility that this can be corrected? To the extent that it can be, then an even greater parallel with the technology assessment process is I think created.

Dr. Galler. I think it can be improved, vastly improved, Mr. Chairman. I think one of the most useful devices, institutionalized devices, that has evolved in the Federal Government over the years, a TA assist, if you please, can be seen at the institution of the county agent, the Agricultural Extension Service. Here you have an informational extension from the Federal Government going right out into the localities and working with that private enterprise, we call the farmer, and with local communities; providing both an informational assist that helps the local community come to some first determination and at the same time providing the kind of quality assurance that we desperately need in the EIS process, which it presently lacks. So that today, with the best of intentions, a locality or private organization can attempt to receive adequate information on, the social, the economic, the environmental costs and benefits of a proposed action, come to a first decision, a decision that becomes reinforced by discussions and interplay with the local community. And then 2 or 3 years later it is suddenly discovered that someone else's perceptions have supplanted the perceptions at the point of impact, vastly different—a different language, if you please, a different set of criteria, a different mode of TA. I think that it is very important that we in the Federal sector recognize that there is nothing in the law that I have been able to determine—and let me hasten to add I am not a lawyer, but I have asked our lawyers to examine this—there is nothing in the law that prevents the Federal establishment from considering providing the EIS process at the front end rather than at the hind end of decisionmaking.

Mr. BROWN. Do you see anything in the law that precludes the application of the environmental impact process to regulatory activities? Your Agency is possibly more engaged in regulatory activities than it is in the development of new technologies. I have in mind a specific problem not involving the Department of Commerce but involving the Environmental Protection Agency (EPA) when they proposed rules having to do with parking limitations and other activities of that sort in an effort to control atmospheric pollution. What they ran up against, of course, was a widespread perception that those regulations would have a very serious impact on economic and other activities, which had not been as thoroughly studied as they might have.

So my question is, is there anything that would preclude EISs being used for regulatory or policy-type decisions at an early stage in order to assist in the more coherent formulation of these regulations and policies?

Dr. GALLER. Mr. Chairman, let me be very careful and circumspect in my answer here. First of all, I want to make very clear that what I am about to say is not intended to be a criticism of a sibling agency—the EPA in this particular instance. I would like to point out—

Mr. BROWN. I should point out at this point, if I may interrupt you, that the agency claimed that they were only doing what Congress compelled them to do.

Dr. GALLER. Sir, I was about to say that. They are under some very specific statutory constraints both with regard to the Federal Water Pollution Control Act, especially the 1972 amendments to the act, as well as the Clean Air Act. And m the case of the Federal Water Pollution Control Act, the only two areas in that, Act that are exempted from a statutory ban on the preparation of EISs for regulations deal with construction ants and the National Pollutant Discharge Elimination System (NFDES) new source permits.

May I give you a generalized response, Mr. Chairman. I think regulations today-I am trying to be very neutral and very objective-regulations by the very nature of the goal of a regulation have a tremendous impact on technology development, technology innovation, technology transfer, and technology application For example, let us take a look at what has happened in the automobile industry as a result of a regulation, what has emerged as a technology, the end-of-pipe technology that we cll a catalytic convertor-I am not going to say whether it is good, bad, or indifferent-but it has in effect foreclosed on options to develop through some other means, perhaps a stratified char engine or another mode of pollution control. This derived from the regulation that was implementing something in the Clean Air Act. Unfortunately-well, let me put it in the positive; I honestly believe, that had we gone through t e kind of E S recess that we went through, let us say, with the Trans-Alaska pipeline, it might have revealed options and opportunities for technologies that were not revealed until ex poet facto.

Mr. BROWN. Mr. Pasternack, you commented in your statement on the applicability of TA to soft as well as to hard technologies, and its relationship to your role in identifying policy options. Do you feel that this is a proper and legitimate application of the TA? You have indicated that you do. I guess I would ask you to comment on whether or not there are any boundaries or limits that we need to think about in these terms. If we take it far enough, we could almost say anything Congress does or anything any agency does, whether it relates to technology or not, because it almost always results in some social or political impact on human beings, is a proper subject for TAs. Do you perceive it as being that broad?

Mr. PASTERNACK. No, I do not. And if I might, I would just like to add one thing to what Dr. Galler said about regulations in EISs. In contrast to anything in the National Environmental Policy Act (NEPA) precluding an EIS for a regulation, we in fact do prepare EISs ***on*** our regulations when they satisfy the section 102(2) (c) criteria of a major Federal action impacting human environment.

But to answer your question about the scope or the breadth of a TM; probably an advantage of not having been in the Government for a very long period of time is that I tend not to believe in overly structured bureaucratic or organizational theories in Government. I believe in allowing some flexibility. And I think that if we establish criteria that in effect require detailed TAs or EISs or whatever for every kind of action or every policy decision made in either the executive or legislative branch, I think it would make the system so rigid it would never be able to operate.

I think there is a need for looking at the broad decisions that have long-range impact, the ones for which you have the ability and the time to do a proper analysis, and for which you ought to be carrying out TAs or related kinds of studies; and then separating these from the short-term, crisis-kind of decisions that you have to make in running an agency or making laws.

Mr. BROWN. I would like to ask Mr. Daddario, also a member of the Board, as well as its Executive Director, if he cares to present any questions at this point.

Mr. DADDARIO. I would like to follow up the question to Mr. Pasternack, Mr. Chairman. You are involved, as you have said, Mr. Pasternack, with the Oklahoma University group. You have had experience with the outer Continental Shelf and with strip mining. That group has worked very closely with us in a whole series of our activities. In fact, it was one of the three university groups that assisted us in an examination of the Energy Research and Development Administration (ERDA) plan and program over the course of the last 2 years.

By their own admission as that group has worked over the years, they have become more comfortable and more competent in dealing with this. As Dr. Stever said yesterday, the mere fact that the Government, in one way or another *in* various places, is supporting this activity, it is developing capabilities that we did not have.

So I wonder from your point of view, what you have learned in that process, how you see it within your own agency? Do you find that there are policy constraints within the agency because you have to get things done that prevent you from using that experience and from being able to develop TA concepts that you would like to apply ?

Mr. PASTERNACK. I would be happy to answer that. It also leads me to think about an earlier question to Dr. Galler concerning how you would improve the EIS process. In my mind one of the ways you improve the whole EIS process as well as the TA process is by budding the capability and the experience for doing these kinds of studies. I can see, for example, in a specific case, namely the difference between the way the proposed gas pipeline and gas transportation systems from Alaska to the lower 48 states are now being considered versus the way they were considered with respect to the oil pipeline 5 or 6 years ago, that the experience that was gained by the Department of the Interior, EPA, the Council on Environmental Quality (CEQ), and other agencies has been invaluable in taking a much more contemporary approach. *In* fact, what we have seen over the last few years in our agency as well, is both growth and greater sophistication in the development and evaluation of policy. The kinds of activities like the work that was done in preparing the national energy outlook and the Project Independence reports are very much leading us toward the point where we have got the tools arid are able to use them much more quickly in making policy decisions. And so as a matter of course, even what might seem as a very quick assessment, in a 1- or 2-week study, in order to get some policy decision Or recommendation, often follows the same approach that you would have used but that might have taken you 2 years to do, a few years ago.

I do think there are limits. I also think that very often the decisions are such that the conclusions are very obvious, or your time limitation is such that you cannot make this kind of formal analysis, but you can do it informally. In my opinion, if you have people trained in thinking to consider secondary and other effects rather than just direct environmental impacts or direct economic impacts, you have advanced the state-of-the-art considerably.

Mr. DADDARIO. In what way are you able to determine how the public perceives this improvement ? Do you get that across or is that a problem? And would it be helpful if the public could realize that there has been an improvement in the capability both to understand the impacts and to deal with them more quickly?

Mr. PASTERNACK. I think the public-at-large does not perceive an improvement in the Federal decisionmaking process. I think in localized areas where there has been direct contact on major or even minor issues that the advancement is well-perceived. I will give you an example of that. We are working very closely right now with the town of Gillette, Wyo., which has experienced traumatic growth in the last few years, and is going to experience even greater growth as coal is further developed. We are working with them on planning for this development—financial planning systems, infrastructure development, et cetera. I think they are aware of the approach that is being followed. In fact, the mayor of Gillette is also a member of this advisory committee on Western energy development that I sit on.

But if you ask the average citizen in the State of Wyoming whether the Federal Government is any more sophisticated in its decisionmaking, I think the answer would probably be no. I think the credibility problem that is faced not only by our agency but by the Congress and by the private sector is one of the most difficult obstacles we have to overcome.

Mr. DADDARIO. Have you been able to use those regional meetings that you held as an opportunity to get the point across to those people who are emotionally concerned because of all the energy activities that are being proposed that you are dealing with very difficult problems but have developed a capability over the course of time? Have you been able to make that clear to them?

Mr. PASTERNACK. The regional meetings, whether hearings or advisory committee meetings, are invaluable both to communicate to the people in the region what we are doing and to get information from the affected areas. An example of the latter was in the recent hearings we held in Los Angeles on liquefied natural gas imports. We had held hearings in Washington where we had a whole range of witnesses come in and talk to us about the impacts and essential policies. But the first time that one particular subject came up was in Los Angeles where we had five or six State energy officials plus environmental officials and local government people talk to us about their concerns. They didn't discuss the safety problems of importing liquefied natural gas (LNG), but the problems of what they were going to do if they did not have the gas and had to burn more oil in the Los Angeles air basin; the impacts of that on air quality. At least two or three of the environmental officials expressed the judgment that this was a more significant adverse effect than the potential for an LNG tanker collision or any other kind of failure. This concern never came up either during our Washington hearings or in any of the analyses done by consultants or any of the inner agency group. Yet it was a very important fact and it is very important to us in doing the analysis.

Mr. BROWN. Dr. Galler, you started to interject a moment ago.

Dr. GALLER. I was just going to add one comment, Mr. Chairman. I do not disagree with what Mr. Pasternack has just discussed at all, but I think it is important to point out that the public perception of the decisionmaking process in Government has become more sophisticated. This is certainly true in the environmental arena as a result of the passage of NEPA and the institutionalized collaboration of the public in the EIS process. As you know, a key step in that process is to distribute the draft environmental impact statement for public review and comment. So the public, at least as I see it, has definitely become more sophisticated in examining environmental assessments.

One of the problems however, is that the flow of information to the public to help it participate in the decisionmaking process, is an attenuated and disjointed flow. The EIS today is, as I mentioned, a largely ecologically based presentation. The economic components are almost completely lacking in many cases. So that the public reading a document is really looking at two dimensions of a three-dimensional problem, while the decisions are made on three dimensions. The public, which gets only two of those dimensions, wonders what is the real basis for the decision. So, on the one hand, I think public perceptions have become more sophisticated. On the other hand, I think the information that the public needs to help it understand is still insufficient and has not caught up with the public's perception.

Mr. DADDARIO. Sid, would it be helpful if the whole question of EISs were reviewed by the Congress? Particularly in light of what you have said today that you have preliminary plans to look into certain standardization and review criteria? Is part of the problem that when the Congress originally passed legislation that included environmental impact statements, it was then wrestling with all types of early warning procedures to determine what the impacts of the application of technology would be? The Congress was sensitive to it, the public was demanding it, and the TA concept was floating around in the Congress, but it had not developed enough support. In fact, there were all kinds of difficulties with looking into the social, political, and economic impacts. Despite these difficulties the Congress was able to include EISs which were in a sense a part of the TA concept, in clean air and other legislation. Congress knew something had to be done but had not had the experience—no one had—to think this concept out so it would work perfectly. We now have had some experience and questions have been raised. Perhaps it would be helpful if the original organic legislation could be reviewed, taking into consideration the experience that we have all had.

Dr. GALLER. My personal opinion is that it would be timely, useful, and constructive. I think we need to internalize the experiences that we have gained in the last 6 years and fine-tune the process. So I would say, yes, I think it would be both germane and very useful for Congress to reexamine.

Mr. BROWN. If I may interject here. You mentioned the lack of an economic component to the EIS. Yet we have had in some parts of the Government—and I am thinking of the Corps of Engineers—a practice for many years of doing rather sophisticated cost-benefit analyses at a very early stage of development. It seems to me that what you are saying is that there should be a marriage between the EIS and the cost-benefit analysis——

Dr. GALLER. Precisely, Mr. Chairman.

Mr. BROWN [continuing]. as an improvement on our policy formulation procedures.

Dr. GALLER. Yes, sir, that is exactly what I am saying. I do want to emphasize that as one who has considered himself an environmental professional for more than 30 years, I look upon the EIS as a very important useful step in the direction of assessing the impact of technology on the total human ecosystem. We have got to have the ecological information that prior to NEPA was never really being marshaled,but which is only one of the three dimensions. I think we must find some way of incorporating either as an integral part of the EIS process or as a concomitant document the cost-benefit analysis, the economic dimension.

Mr. BARRON. **Mr. Chairman, could 1 interject? I feel as though I have to make some thoughts known here. I must disagree with my colleague from Commerce to some degree** I do agree that the EIS is an excellent tool that has contributed much toward TA. I agree also with his statement that the passage of NEPA has been responsible for requiring that various facets of TAs and environment assessments be made. But it seems to me, that from the point of view of TVA, an agency that has been involved since its inception with resource and development and considers itself environmentally oriented, the requirements of NEPA have always been with us. They are just more formalized by the enactment of legislation. They are now required by law. But there is nothing that prohibits our taking the requirements of NEPA and implementing them very early in the decisionmaking process which we do. Moreover, I should point out that the economic considerations are a vital art of our EIS preparation. What I am trying to say is it depends on your point of view, where you sit.

Mr. DADDARIO. How do you determine whether EPA's requirements are really the best ones ? Why should you accept them without a research analysis of your own? In several laces in your statement you talk of expenditure? of hundreds of millions of dollars apparently because EPA has Imposed these obligatlons on you. How do you know they are the right thing to do?

Mr. BARRON. If I left that impression with you, then our testimony has failed to -produce the communication that we desired. I think if you would go back and look at some of the key dates, you would see that man of the investments that were mentioned in our statement predated NEPA rather substantially. The requirements, for example, for reclamation provisions in our coal purchase awards were considerably earlier than NEPA. This decision was made after consideration of the cost versus the environmental effects. Similarly, our precipitator installation program and tall stack program predated NEPA very substantially. Actually at the time of the passage of NEPA, we were into the second generation of precipitator installation since pecipitator technology had improved in the interim. The TVA is probably unique among Federal agencies in that we have a very broad mandate that requires the generation of electric power sufficient to meet the needs of the power-service area while at the same time imposing a responsibility for the development and protection of the environment of the seven-State area that comprises the Tennessee Valley.

Mr. DADDARIO. I recognize that. I did not intend by any means to say that you were just reacting in a knee-jerk way to anything that EPA had put out. Obviously TVA has a good record in this particular area. But you are dealing with tremendously difficult problems. You use both coal and nuclear energy; and are working with the private sector in a consortium on breeder-reactor development. There are all kinds of management problems. Also certain of the safety and safeguard questions are far from being thoroughly researched.

The OTA is just completing an examination of the EPA R. & D. plan. We are finding some difficulty frankly between their regulatory capabilities and the basic research that goes into the development of the regulations. There is a need to understand what technology is available on which to base regulations and then to improve both the technology and the regulations by an R. & D. program. That is really what I am getting at.

Mr. BARRON. Sir, we could not agree with you more. I think perhaps a classic example is our position with respect to sulfur dioxide removal and the use of scrubbers. TVA has taken the position since the very beginning that scrubber technology has indeed advanced to the point where it has application in certain selected systems, generally those that are small, and in situations where the reliability is not a key factor. We have also pointed out that in effect the use of the scrubber simply exchanged an air problem for a solid problem, and that the sludge that results from the use of the limestone scrubber is going to constitute a very substantial problem in terms of disposal in future years.

It is ironic to us that at the same time that we are forced to retrofit scrubbers in some existing plants and to install them in any future coal-fired plants, we are being funded by the EPA to do applied research in scrubber technology and in the stabilization of the sludge resulting from the use of the scrubber. So we agree with you very definitely. But there comes a point in time, in this particular instance where we entered into litigation, in effect exhausted our remedies, and had no choice. There have been other instances when we have taken a strong contrary position. I think in many cases it has been successful.

I would like to point out that 1 think TVA has an unusual opportunity in that we are a member of the Federal family, hut a unique member. Basically we are a federally owned corporation with a diverse charge by the Congress. Also, we operate in a small region of the United States relative to the Nation generally. Throughout the discussion following the formal statements, it has come across more and more that one of the problems is how to apply TA in the microsphere as opposed to the microsphere. As a result of our being regional, we area testing ground.

For example, we talked about regulation. We in TVA feel as though our experience in the electric generating field, while at the same time we are a member of the Federal family. puts us in a special position to offer suggestions, comments, and criticism to proposed regulations affecting the electric generating industry. We feel that having the diversity of technical expertise that exists in an agency with such a broad charge, we are well-equipped to contend with problems that involve or mandate a multidisiplinary approach. In effect. we can give the private enterprise point of view but in our capacity as a member of the Federal family. I think that is a unique position we have to offer, for whatever it is worth.

Mr. Daddario. You are doing pretty well. Someone is always around every election trying to sell you off to the public.

Mr. BARRON. No one has come up with a buyer.

Mr. BROWN. **Gentlemen, I want to get back to the broader effort to understand** the role of TA and its relationship to other policy tools. I have lived long enough to have seen the development of a number of processes that purported to solve the problems of making policy decisions. During and after World War II, we had operations analysis for example. You referred to your background in systems analysis, a favorite catchword of the next generation. Today we have EISs and TAs.

How do we perceive all of these tools? Is there a magic solution to the needs of human institutions to make sound decisions? Are we groping for them, or are we achieving a more mature viewpoint, based on a "kit of tools" that can be applied in particular situations to assist both public and private institutions in improving the social quality of their decisions. React to this a little bit for me. I have not phrased it exactly as a question, but what does it generate in your minds!

Dr. Galler. May I make one comment on tha Mr. Chairman. I really cannot squarely address the question that you raised, But as a bureaucrat for some years now, it seems to me that the TA process, whether you call it TA, EIS, or systems analysis, is going on all the time. One of the problems is a lack of coordination, what I call the lack of hysteresis in the system. I wish we had a little bit more of a time lag between the first findings on an issue and the regulatory "hip-shooting" that takes place. I think it is terribly important that we institutionalize the process to the point where the private sector, the public sector, and the pubic-at-large, have confidence that when a regulatory decision is reached, it is arrived at only after a full, careful, and in-depth examination of the social, economic, and environmental dimensions of an issue. I fear this has not been the practice. I fault no one. There have been converging and contradictory pressures. The fact remains however, that once a regulation is in effect, it is awfully difficult, to undo it. So, I think we have to be much more careful to rely on TA, and also to have some kind of system to prevent regulations from being made until the TA has been completed.

Mr. BARRON. Mr. Chairman, as you were asking your question, I was thinking of the analogy of a medical doctor. I think it is still apropos in the light of my colleague's comments. The physician may utilize any number of tools in the diagnostic process, depending on two things, the extent of the malady and the patient's circumstance. In some instances he might have to rely strictly on "hip-shooting" if the patient is blue, is not breathing, and there are signs of cardiac arrest. On the other hand, if the malady is such that there is no apparent immediate need, then the full spectrum of diagnostic techniques can be brought into play. I think this analogy is perhaps the most appropriate answer to your question. Technology assessment is a vital member of a group of tools that are available to Federal agencies. I certainly do not believe that it is the final solution, nor do I believe that you would suggest so. But we consider it to be an essential major component of any decisionmaking process in our organization, whenever the circumstances permit.

Mr. BROWN. What bothers me is that as human beings we have an unfortunate tendency to grab onto a useful tool and think that it will solve all our problems. I was very interested in the testimony yesterday of the gentleman from the Department of the Interior. He referred to their use of TA as a part of what he called the Program Decision Option Document in which the basic concern is to examine program options and select the best one, by using TA and any other available tools. The tendency to look at a useful tool without seeing what it is to be used for is a failing we all share. I do not know how to correct it, but I am trying to create a record here from which to gain the insight that will help us to achieve this kind of perspective. Do you have any further questions, Mr. Daddario?

Mr. DADDARIO. I think, Mr. Chairman, that Dr. Galler's earlier remarks would be helpful on the point you just made. As I understand it, what he said was that it is not so much how you use a tool but how you fit it into the overall planning process in the first place. The tool is something you are trying to force into the planning process. If you could look at the constraints that are bound to arise earlier rather than later in the process, you would save yourself a lot of trouble.

Dr. GALLER. Yes, precisely.

Mr. BROWN. What bothers me, Mr. Barron, about your medical example is the difficulty that is being perceived in looking at the overall problem of human health today. Doctors may be causing as much disease as they cure. The fact seems to be that human health is being adversely affected by such environmental considerations as stress and pollutants of various kinds in the environment. But doctors are still trying to look at an individual human being without considering all of these environmental factors. In other words, they are looking with their rather limited tools for examining and diagnosing, and not seeing the broader aspects that need to be looked at.

Mr. BARRON. Yes, sir, I would agree. I think, as I pointed out earlier, it depends on where you sit. In the final analysis, whether by a physician or by a head of a Federal agency, the decisions must be made by human beings, and I for one hope that we never reach the stage where this is not the case. I think it is incumbent on that human being as a responsible person to use all the tools that are available to him in making the decision. But in the final analysis, the buck must stop somewhere, and he has to weigh the pros and the cons from the environmental and every other aspect to make a decision and be responsible for it. I really do not see a substitute for that.

Mr. BROWN. Your agency is unique in another way, in that it was created at a time when this country was temporarily concerned with broad problems of river basin planning, and the welfare of the human beings in the total environment within that river basin planning area. Thus your mandate as an agency is much broader than that of any other agency in its concern for the environment, for the development of the industries, for economics of the region, and for various other issues necessary to get a total perspective. Therefore, your experience and example can be useful in examining some of the problems of more narrowly defined agency roles.

I do not know how we can infuse that broader concern and mandate that you have into other agencies including the Congress, because the Congress needs an infusion of long-range planning and policy planning, a broad approach to problems that it does not take today. It looks narrowly and within a relatively short time frame at most of the problems that it faces.

Dr. Galler, in your testimony you made reference to a list of industries identified by your Department that were involved in TA. Would you be able to provide this information for the record?

Dr. **Galler. Yes, sir.**

[The information referred to above is as follows:]

COMPANIES CONDUCTING SOME FORM OF TECHNOLOGY ASSESSMENT STUDIES

Chemagro Co.	Gulf
U.S. Steel Corp.	EXXON
Kennecott Copper Corp.	Atlantic Richfield Co.
Lockheed Missiles and Space Co.	Alyeska
Deepsea Ventures, Inc.	Shell Chemical
DuPont	Hercules, Inc.
Reynolds Aluminum	Chevron Chemical
Alcoa	Ciba-Geigy
Ford Motor Co.	Dow Chemical

Mr. BROWN. As I said before, we have not exhausted all the questions that probably would be useful in making a complete record on this point. We would like to submit some of those questions in *writing* to you gentlemen. But in view of the time, I think it is best that we adjourn at this point So the heating will be adjourned.

[The following questions were submitted by Congressman Brown to Dr. Galler and his answers thereto:]

Question 1. You mentioned **lessons learned as a result of the Department's efforts to prepare the Trans-Alaskan Pipeline (TAP) Environmental Impact Statement (EIS). Would you expand on this comment, especially with regard to the organization and conduct of the TAP EIS. Do you recall anything in particular that would be helpful to the Office of Technology Assessment (OTA) in the conduct of technology assessment (TA) ? Also, how you you involve the public in the TAP EIS? Was the public informed ahead of time about TAP impacts on the environment?**

Answer 1. The Trans-Alaska Pipeline Systems Environmental Impact Statement (TAPS-EIS) is especially important as a historic benchmark in the implementation of the National Environmental Policy Act (NEPA). It was one of the first very large projects for which an EIS was required prior to its undertaking. The preparation of the TAPS-EIS was the responsibility of the Department of the Interior (DOI), although the Department of Commerce (DOC) provided substantial contributions during its preparation to DOI. This experience made us aware of several things: (1) the essential requirement for close cooperation and coordination among agencies to take full advantage of the specialization and expertise in each agency, *(2)* the great difficulty in projecting all potential impacts in the absence of a full understanding of the ecological social, and economic interrelationships of major projects with local, State, and national communities, and (3) the importance of a fully informed and involved public. The public was continuously kept informed by news articles, television news coverage, public hearings, and draft impact statements.

Question 2. In your opinion what Government action is necessary to insure that the EIS is not ex post facto in nature, but in fact is brought in and utilized early in the planning and decisionmaking process?

Answer 2. Under present arrangements, the preparation of an EIS is tied directly to a specific Federal decision. The information sought is that which is thought to be relevant to the making of that Federal decision. However, most projects involve a chain of decisions made by State and local bodies as well as private firms and individuals long before the project comes up for the "Federal decision." During this time the project may have gained considerable momentum and in effect lost alternative options without the benefit of the information and public participation involved in the Federal EIS process. The Federal EIS process often either reopens State, local, and private decisions creating confusion, frustration, and antagonism, or becomes a captive of the momentum that the project has already generated.

Furthermore, approximately half the States have adopted either comprehensive statutory or special EIS requirements. Unfortunately, most States lack the necessary technical expertise and resources to provide the type of impact assessment adequate for Federal purposes. With greater delegation of Federal revenues and decisionmaking to States and local communities, technical environmental assistance to industry, States, and communities should be investigated. Two specific forms of technical aid are categoric grants for personnel training and a federally sponsored State or regional environmental agent system.

Question 3. If an energy utility perceives it has a legal and societal responsibility to build a plant, would it be worthwhile for it to conduct a TA at that stage in order to determine if the perceived legal-societal need is real, and also to determine the best way to balance energy demand with environmental quality? Would public participation be important at this stage?

Answer 3. I believe most utilities now are under legal obligation to meet the market demand for electrical energy in their service areas. In recent years, most utilities with which I am familiar have conducted careful and conscientious environmental studies prior to committing their organizations to specific siting decisions. Because utilities are closely regulated, the public is involved in such decisions as, for example, the current discussions pertaining to the siting of a Pepco powerplant at Douglas Point, Md.

Question 4. How do you involve the public in the EIS and TA process at the Department of Commerce (DOC) ?

Answer 4. The DOC has no formal process, but it does have a formal EIS process. We attempt to encourage public participation through public information releases, draft EISs for public comment, and public hearings where appropriate. For example, during the preparation of the EIS on the Department's supertanker subsidy program, public hearings were held to obtain comments and information from the public. These were used in the preparation of the final EIS.

Question 5. You mentioned conducting some TAs at the Department that will examine the impacts of regulations on the private sector and the public. Has a formal structure for conducting TA been established at the Department? How is TA information integrated into reports of the Department? Do you use private sector advisory panels for your EIS and TA activities?

Answer 5. In my remarks, I referred to several industrial environmental energy studies the Office of Environmental Affairs is conducting in an attempt to evaluate the impacts environmental regulations have had upon technological pollution control options. Moreover specifically, the studies measure what the energy impacts are of existing pollution control requirements and evaluate available technological options in terms of their environmental, economic, and energy consequences. We do not have a formal structure for conducting these studies. Typically, they are conducted by outside contractors. Other Federal agencies are consulted in the development and consolidation of the information and analysis. The that reports are made available to interested Federal agencies and to the public. We have not used private sector panels for either EISs or these studies.

Question 6. Do you see any value in having better communications between the public and private sectors? What about closer relationships with State and local governments? Do you utilize NSF TA reports and are they given to concerned offices in the Department?

Answer 6. Yes, I believe the lack of good communication among government and private sectors can significantly decrease our ability to work together efficiently for assessing the impacts of technological development. A failure to communicate leads to the lack of understanding on both sides, and we are committed to improving the interchange of ideas and information among the components of our society and government in general. In fulfilling our NEPA responsibilities we do not rely on any given set of reports such as the NSF TA reports, but rather deal with the special needs of each project as it comes along.

Question 7. How does TA fit into the general policy formulation and decisionmaking processes in the Department?

Answer 7. EISs and other types of TA studies are part of the information package that accompanies a project or decision memorandum for use by policy level departmental personnel. They also influence the drafting of recommendations and desire of projects.

Question 8. Has environmental impact analysis or TA affected the way business is done at the DOC? Do you have training at the Department on the subject of TA?

Answer 8. The requirements for the the preparation of environmental assessments and EISs have led to the establishment of a definite, but not formalized, procedure for identifying and evaluating the potential effects of a project before making final decisions. This has led to an increased number of relevant areas for defining agency and departmental positions.

We do not provide training on the subject of technology assessment.

[The following questions were submitted by Co man Brown to Mr. Bruce A.. Pastirnack and his answers theret0:]

Question 1. Do you see any value in closer relationships between the public and private sectors? What value do you see in better communications on TA with local and State governments?

Answer 1. The liaison between the public and private sectors must be close enough to achieve the necessary interaction between these groups in formulating policy, especially on a national level. The formulation of national energy @icy is a complex task that requires the close cooperation of Peale@ State and local government bodies, and the public-at-large The FEA's Intergovernmental, Regional and Special Impact Office provides a continuous liaison with State and local government officials, national associations of elected officials, business, consumer, and other interest groups on a wide range of energy issues of particular concern to the states and the public. Better communication on all levels is, of course, a very desirable goal when considering energy policies that can impact virtually on every segment of society. Because many State and local governments do not yet have the capability to adequately analyze the effect of various energy policies on their own patricular locality, I see great value in better communications on TA with local and state governments.

Question 2. Has TA or environmental impact analysis affected the way business is done at the FEA?

Answer 2. Consideration of environmental concerns plays a major role in the development of an energy policy that properly balances resource development and environmental impacts. The FEA's Office of Environmental Programs acts to ensure the Agency's compliance with the National Environmental Policy Act by coordinating the preparation of Environmental impact Statements (EISs) for the FEA programs, and coordinating the review of other agencies' EISs. The major environmental issues associated with energy will focus on regional development questions. These include Outer Continental Shelf development, oil and gas production from Alaska, western coal development, commercialization of synthetic fuels, and nuclear power growth. The resolution of these issues will largely determine the future of energy production, and therefore, the future of resource development policy issues. In this way, environmental impact analysis does often affect, not necessarily the way business is done at the FEA, but certainly the outcome of policy issues.

Question 3. You mentioned that two ways to improve the TA and EIS processes at the agency level is both through experience and by building the capability of employees in these processes. Do you have such a program in effect at the FEA?

Answer 3. Although no formal TA or EIS training program is in effect at FEA, the experiences gained since the inception of the agency have resulted in a much improved, sophisticated system for policy evaluation. The FEA's forerunner, the Federal Energy Office, was instituted shortly after the start of the 1973-74 Arab embargo. initial efforts concentrated on necessary regulatory programs to oversee the equitable distribution and pricing of limited energy supplies throughout the Nation.

Question 4. How do human value systems affect technological development? What role should the analysis of value systems have in assessing the impacts of technology on society and the environment?

Answer 4. Socio-economic impact studies should Perform a major role in assessing the results of proposed policy actions on society and the environment. The FEA's Office of Economic Impact Analysis develops and applies advanced economic models of the economy in the performance of macro- and micro-economic analyses of the potential impacts of energy shortages, and of alternative energy policies and programs of the economy and society. These include analyses of impacts on specific sectors of the economy and population groups. Because this Agency believes that there is a need for the analysis of value systems in assessing the impacts of technology on society and the environment, we have a special office of Consumer Impact that interacts on a continuous basis with consumer groups and the general public so that outside value systems are considered as we make policy decisions.

[The following questions were submitted by Congressman Brown to Mr. John S. Barron and his answers thereto:

Question 1. At the end of your testimony, you mention that you are doing social, economic, and environmental impact analysis. How long have you been doing this kind of analysis in a formal process? How do the results enter into the decision and policy-making processes at the Tennessee Valley Authority? Are they taken into consideration at all in the planning process? For each of your major offices, what percentage of its time is spent on such analyses? Does a formal structure for conducting TA exist?

Answer 1. As the testimony suggests, the process of impact analyses became formalized with the enactment of the National Environmental Policy Act (NEPA). Prior to NEPA, the process was an informal, and often elementary approach to technology assessment (TA). Except in those situations where regulations require formalization, that informal process continues today.

Interdisciplinary coordination among the various programs is standard practice, both at the planning and the implementation level. Through this means, proposed actions are evaluated by interested disciplines to determine whether the action is acceptable, detrimental, or perhaps subject to a modification that enhances their particular interest with minimum adverse effect on the intended result.

Since the greater part of our TA is on an informal, day-today basis, it's difficult to estimate the time spent on this activity.

Question 2. How do you see the social, economic, and environmental impact analysis and TA differing or similar to the requirements for EIS ?

Answer 2. TVA's integrated assessment research has been designed to facilitate and improve the overall impact assessment process for power-generating facilities. The work has been designed not only to meet the current EIS requirements but also to provide the basis for improved analyses both now and in the future. The primary thrust of this research has been to: (1) improve lines of communication among planning, engineering design, and impact assessment workers; (2) develop a unified information system containing data for use by a variety of planning and impact assessment activities; and (3) utilize improved techniques for data display, analysis, and management decisionmaking.

Question 3. How does your social, economic, and environmental impact analysis compare to the integrated TA program of EPA in which you are participating? What lessons have been learned to date?

Answer 3. EPA's Integrated Technology Assessment is a broad research program designed to consider the development of numerous energy sources, various control technologies, and their resultant *impacts.* TVA's Integrated Assessment research activities are limited to developing methodologies for better assessing the social, economic, and environmental impacts of nuclear and coal-based power-generating facilities. Research is under way to: (1) develop improved economic forecasting of the demographic and manufacturing sectors within the TVA power service area: (2) incorporate in an existing power system's integrated planning model, a model that will be capable of predicting the environmental residuals generated at each facility under various system operating conditions: and (3) demonstrate the use of computer graphics as a means of facilitating the impact assessment of power-generation facilities. We have found that most of the techniques developed are readily accepted as a means of improving day-to-day assessment activities, and that our expectations for this research have exceeded initial estimates.

Question 4. How do you get the public involved in your decision, planning, and policy-making processes?

Answer 4. TVA's dialog with members of the public includes open meetings of the TVA Board of Directors (normally twice a month), public hearings, the environmental review process, Congressional hearings, hearings before State air and water quality boards, communication with TVA officials, participation in conferences, and symposia on issues facing the region.

For example, TVA held public hearings at three locations (Chattanooga, Tenn., and Florence, Ala., and Paducah, Ky.) in June 1976 to receive views and comments from the public about alternative electric rate structures. Members of the public testified at oversight hearings before the Senate Committee on Public Works in late April and early May 1975.

As a public agency charged by Congress with the responsibility for helping the people in the Tennessee Valley region carry out a unified resource development program, TVA has an obligation to respond fully and frankly to the public, and attempt to resolve conflicting viewpoints.

TVA hears from some segments of the public that electric rates are too high, and thereby detrimental to the economic and social progress of the region. Others maintain rates are too low, at least for some classes of customers, or in relation to other regions. Or they state by inference that rates are too low by advocating far stricter environmental controls on the production of power.

Others oppose the building of dams, while others support them to provide flood control, industrial, recreational, or other benefits.

TVA has responsibility in all of these areas as well as others, and the question the agency faces frequently is to whom shall it be responsive?

Question 5. How do you discuss impacts ahead of time and educate the public to the impacts?

Answer 5. TVA began consultations with State, local, and regional organizations in October 1972 about the possibility of building a generating plant at the Hartsville site in Tennessee, and its implications for the area. This consultation occurred almost four years before construction began on the site in April, 1976.

In mid-October 1973, TVA participated in a meeting with State and regional planning and assistance organizations to discuss assistance to the Hartsville area to offset construction impacts. In January, 1974, manpower needs were discussed with the Mid-Cumberland Development District Manpower Planning Board.

A TVA project coordinator was assigned to the area in February 1975 to work with local officials and organizations on resolving impacts resulting from the anticipated influx of construction workers. Since then the Hartsville Project Coordination Committee, composed of officials in a five-county area near the plant, has been formed to discuss and deal with project-related problems common to some or all of the committee participants.

Question 6. What value do you see in having closer relationships between the public and private sectors? What about the value of having closer State and local level relationships?

Answer 6. TVA believes that close relationships with both the private sector and State and local governments have the potential for producing products that are superior to the product that either could independently produce. Each has a point of view and an experience base that can and should be a factor in Federal decisionmaking and action. Particularly in our role as a utility, close relationships with the private sector are essential to the fulfillment of our mission. These relationships range from transmission line interconnections and the sale of electric energy to the exchange of information, techniques, and even personnel. Similarly, many actions are dependent upon local governments for adoption and implementation requiring close relationships with local governments, and the identification of mutual goods.

A key early decision by the TVA Board of Directors involved the question of how the agency would pursue its responsibilities under the TVA Act. The decision was reached to accomplish the Act's objectives through the strengthening of State and local governments rather than to establish some form of "system government." A close working relationship between local governments and TVA is essential to the fulfillment of our mission since change will largely be brought about through local actions.

Question 7. Have you done any research after the fact on the consequences of your project since TVA began operation? Are there any cases in your years of operation where your planning went awry? Please explain how it happened and what lessons were learned? Can you say that TA or EIS have affected your way of doing business?

Answer 7. In the mid-1930's TVA sent to Congress a general plan for the Tennessee Valley entitled *The Unified Development of the Tennessee River System.* This plan identified the needs and problems of the people of the Valley area and proposed programs to ameliorate these problems. Since the plan was formulated, TVA's numerous programs in multiple resource development have been aimed at solving those and other problems of the Valley.

These programs are constantly undergoing assessment, reevaluation, and modification. As the Tennessee River Valley changed from a rural to an urban character, natural modifications in the original plan and subsequent project plans have taken place. For example, the early general plan was concerned with flood control but did not specifically address flood plain management. As urbanization took place many structures that were built in flood plains were destroyed or damaged by regional floods. The implication for TVA program and project plans was to purchase in some cases, more flood plain land, and in other situations to assist local and State governments in establishing flood plain use controls. Similarly, with respect to recreation, earlier water resources projects did not place recreational use as a high-priority water use. However, since World War II, residents of the Valley have enjoyed more and more leisure time. The result has been a greater demand for recreational areas, and has necessitated provision of more recreational facilities and retention of greater amounts of reservoir shoreline for public use than was once thought appropriate.

specifically, the lesson learned is that as needs and problems change over time, original plans for programs and projects must be modified and adapted to provide solutions.

TA and the NEPA have definitely changed TVA'S way of doing business. With the benefit of retrospect and early environmental impact investigation of projects. better decisions regarding TVA programs are realized.

Question 8. What new considerations have entered into your Policy planning in the last 5 years?

Answer 8. TVA's basic policies are set by the TVA Act and have not changed during the past 5 years. However, as noted elsewhere, the greater weight our society has given to the environment is reflected in a heightened concern for identifying the indirect impact of our activities on the physical, social, and economic environment in which we live. A correlate of this impact analysis is the policy of adapting project plans to avoid, or at least mitigate, any otherwise undesirable effects. In addition to the above, TVA' policy planning has been affected by the apparent secular trend of high inflation, the regional need for skilled construction labor, and the importance of a greater concern for energy conservation.

Question 9. Has TVA examined the impact of new technology on job structure in its region?

Answer 9. TVA has not examined the impact of new technology in the region on job structure in a general sense, It has assessed the impact of technology on future skill requirements for the agency and is working with educational institutions to assure that training opportunities are attuned to job requirements.

Question 10. Does TVA offer training on TA and the environmental impact process?

Answer 10. Since the enactment of NEPA and the emergence of numerous environmental regulations, TVA personnel have been fully occupied in meeting existing demands in support of the power program. consequently we have not offered training in TA to others. Conceivably, once the backlog of demand is satisfied, we could offer such training.

Question 11. *In* your discussion *on* approaches to the mining and combustion of coal, you repeatedly emphasized the magnitude of the capital outlays. Could you comment on the opportunities lost to invest those moneys in other technologies or institutions or for other goals, as a result of commitments to the combustion of coal? Did you convene public meetings where the community was given an opportunity to discuss TVA's plans for the allocation of funds, prior to the actual obligation of the money? Does hydro-electric power have any role in the future provision of electricity to the area? If not, what assessment strategies were followed to justify setting this basic option aside?

Answer 11. In meeting its utility responsibilities for sufficient electric energy capacity to meet the needs of the TVA region, the alternatives are reduced to the question of what form of generation will be selected.

When TVA began building coal-fired steamplants in the 1950's, two methods of generating large amounts of electricity at the time were hydro, and fossil-fueled steam electric generating plants. Since the hydroelectric potential of the river had been developed and could no longer meet the electric needs of the region, TVA chose coal-fired plants over oil-fired plants because of the availability of coal in the region and its lower cost.

TVA did not convene public meetings to discuss the allocation of funds to coal-fired plants. The decision was made in light of TVA's responsibility under the TVA Act to supply power to the region it serves at the lowest feasible rate to the consumer.

Hydroelectric power will have a limited role in the future provision of electricity to the region, primarily for meeting peak-hour loads, but it cannot meet the total requirements due to the physical limitations of the river system. Thus the option has not been set aside, but is no longer available.

Question 12. With respect to your plans for nuclear power plants, did a disinterested third party conduct an appraisal or assessment to weigh the alternatives (fossil, hydro, and nuclear) and the diverse impacts on resources, economics, environmental elements, and rural institutions prior to a decision to proceed? If so, would you care to comment on the findings that persuaded TVA to select the nuclear option, and convinced the community to support the dislocatlon of many people?

Answer 12. Since its inception, TVA has relied chiefly on the advice of a diverse, well-qualified staff in making policy decisions. While consultants are sometimes utilized, their views together with other inputs such as the views of State or local governments or a part of the mix from which a staff recommendation is made.

This was the case when the decision was made to construct the first nuclear generating plant. Although the study could be considered primitive in comparison to today's environmental impact statements on generating facilities, it did consider such areas as comparison of costs, nuclear safety, and ability to obtain Atomic Energy Commission licenses and operating insurance, as well as the impact on the environment. Evaluations of a similar nature are made each time the decision must be made as to how Projected energy demands will be met.

There seeing to be some misunderstanding about dislocation of people as the result of construction of a power plant. The proposed four-unit Hartsville Nuclear Power Plant will require 1,940 acres for the plant site. Eleven households will be dislocated because of the plant Furthermore, TVA steam plants are not located in heavily-populated areas

[The hearing was adjourned at 12:3o p.m.]

TECHNOLOGY ASSESSMENT ACTIVITIES IN THE INDUSTRIAL, ACADEMIC, AND GOVERNMENTAL COMMUNITIES

THURSDAY, JUNE 10, 1976

Congress OF THE UNITED STATES,
TECHNOLOGY ASSESSMENT BOARD,
OFFICE OF TECHNOLOGY ASSESSMENT,
Washington, D.c.

The Board convened at 10:12 a.m., in room 2318 of the Rayburn House Office Building, Hon. George E. Brown, Jr. (member, Technology Assessment Board), presiding .

Present: Representative Marvin L. Esch; Emilo Q. Daddario, member ex officio and Director, OTA; J. M. Leathers, member, advisory council , OTA; and Dennis Miller of the staff.

Mr. BROWN. The Technology Assessment Board will come to order. This is the third day of hearings undertaken in an effort to clarify and improve the definition of the processes of technology assessment (TA) in order, we hope, to improve the utility of the Technology Assessment Board in its role of serving the Congress and helping to make better decisions on matters involving future technologies.

This morning we have a very distinguished grou_ __ _______ executives who are goin_ to help us with some insight into the TA process as it operates in their own industries. We are looking forward to hearing their testimony.

I might *say* that the House of Representatives is in session—went into session at 10 o'clock-and we are in the midst of a quorum call, but we trust that there will be *some* additional members who may be able to show up during the course of the morning.

We are going to start this morning with Mr. Harry E. Teasley, Jr., vice president, corporate business development, for The Coca-Cola Co. You may come forward, Mr. Teasley. We welcome you here this morning and are looking forward to your testimony.

Mr. Teasley. Thank you very much.

[The biographical sketch of Mr. Harry E. Teasley, Jr., is as follows :]

HARRY E. TEASLEY, Jr., VICE PRESIDENT, THE COCA-COLA CO.

Harry E. Teaslev, Jr. was elected vice president, corporate business development of The Coca-Cola Co. in May, 1975. In his present position, he is responsible for a group that focuses its activities on merger, acquisition, and divestiture analyses, new venture development and management, and internal product, package, equipment, and business system development.

Degree in industrial engineering from Georgia Institute of Technology.

Joined The Coca-Cola Co. in 1961 as a senior engineer with the technical research and development department ; has subsequently held positions of project engineer, senior project engineer, project manager in new packaging, and mananger of the snles equipment, packaging and distribution group of Coca-Cola USA, a division of The Coca-Cola Co.; was appointed vice president and head of marketing and business development department for the division in 1973; in March, 1975, was named manager of the newly formed corporate business development group of The Coca-Cola Co. ; and in May, was elected vice president, corporate business development.

STATEMENT OF HARRY E. TEASLEY, JR., VICE PRESIDENT, CORPORATE BUSINESS DEVELOPMENT, THE COCA-COLA COMPANY

Mr. TEASLEY. Mr. Chairman, my name is Harry Teasley. I am a vice president, corporate business development, The Coca-Cola Co., Atlanta, Ga. I am pleased to accept your invitation to participate in these hearings that seek to explore the methods used by both business and Government to lay plans for technological development, and evaluate the impact of such envelopment on our economy, the environment, our standard of living , and our institutions.

First, let me identify myself with respect to the activity on which I will report today. am an industrial engineering graduate from Georgia Tech and have been with The Coca-Cola Co.for 15 years in various marketing , technical, and developmental assignments. Between 1965 and 1974, I had functional and administrative management responsibility for the packaging activities of The Coca-Cola Co.

Today, I would like to report on a technology assessment (TA) activity for which I had project management responsibility during that period. I would like to describe briefly some of the decisions that we made as a result of that activity, and finally, I would like to discuss the use of TA with respect to a philosophy for managing resource usage and environmental impacts.

Let me begin by briefly describing the environment that led up to this activity. During the decade of the sixties, the SOft drink industry underwent substantial changes in its packaging and distribution practices. There was a shift from small or individual size containers to large multiuse containers, warehouse distribution replaced storedoor delivery in certain market segments, private labels were introduced and attained a market share, convenience packages became an important part of the packaging mix, and new packaging materials an containers were developed. These changes were brought about by a combination of events. There were changes in consumer lifestyles; there were changes in both wholesale and retail distribution patterns; there were new technologies; and economics played a major factor. For example. during the period 1960 to 1970, the cost of capit.al recovery increased by about 74 percent-that's a combination of change in cost of fixed assets and change in cost of money or interest rates-labor increased by about 65 percent in that period. while materials increased by only 21 percent. and energy by only about 10 percent.

It is obvious that the price of materials and energy. were stable relative to the cost of labor and capital during the sixtics. Since returnable systems are labor and capital intensive, there was an economic pressure on the returnable system. In addition, there were some internal economics that also affected the market structure during that period. Within the soft drink industry, trippage on returnable bottles decreased from about 20 to 22 down to about 9 or 10. Concurrently, productivity gains were being made in the container-making industry. The combination of all of these events-changing lifestyle, changing economics-gave rise to a market and economic environment that put pressure on the returnable soft drink system, and provided an impetus for the development of a packaging and distribution system that was more like the norma [illegible] system.

However, by 1970, it was clear that the decade of stability that existed with respect to the price and availability of materials and energy was coming to an end. Corporations needed to have an understanding of the various resource inputs on which they base their business, even if these inputs occur at the supplier level. In addition, the environmental debate made it clear that corporations, as well as governments, need to have an understanding of the impacts associated with their products, their services, their processes, and their policies.

So in 1970, The Coca-Cola Co. commissioned what we believe was the first systems study (we know of no prior study) to evaluate the material and energy requirements as well as the environmental impacts for a class of products. That class of products was soft drink packaging. The conceptual model was developed by The Coca-Cola Co. and articulated and executed by Midwest Research Institute of Kansas City.

Simply stated, the objective of that study was to define and quantify total material and energy requirements as well as environmental impacts from mining and extraction through all processing steps to disposal, for each technological option that was available to the industry. And I might parenthetically add here, each package that was underdeveloped, that was not commercially available at the time. In addition, analyses were made on the impact of container reuse and material recycling. I have submitted a more complete description of this study.

[The material referred to above is found in Appendix C, Exhibit 1.]

Since this study was the first of its type, there were many complications associated with assumptions, data limitations on operations measured, and a number of issues of that type. However, I believe it was a “first-cut” attempt to get us in the right ballpark. The study provided us with *a* data base at that time, and an analytical tool for making specific analyses on the impacts associated with changes in our packaging and distribution systems. As a result of that study and in context with our more conventional economic analyses, our market and consumer studies, and our internal TA regarding package performance, this technology assessment that we made did have an impact on our business decisions. I would like to review some of the things that we did as a result of that study.

We determined that a plastic one-use container was competitive in energy consumption to the containers that it would replace with additional safety benefits. We therefore made the judgment to continue the developmental activity that had been in process since 1968 in cooperation with the Monsanto Co. In that particular project, there were a number of other areas that required TA, especially in the chemistry area. It is my understanding that Mr. Monte Throdahl of

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Monsanto has testified on some of these earlier this week, and has provided the Board with written material on those tests.

We made some long-term procurement decisions regarding metal containers-that is, the percentage of our purchases that would be steel versus aluminum-and what types of containers we would use in different markets.

We recognized the long-term desirability of two-piece metal containers and have promoted their development.

We developed a clearer understanding regarding the environmental as well as the economic efficiency of large-size containers, and have promoted the development of large-size containers within the soft-drink industry.

We developed an understanding of the pros and cons of recycling various materials under various operating conditions, and were able to allocate our energies to recycling efforts that had the highest potential payoff.

We determined the "environmental break-even," a loose term that covers a comparison of energy, material, and impacts, between one-use containers and returnables. It is based on various trippage rates and various assumptions about such factors as transport distances. An outgrowth of this understanding has been an improvement in returnable trippage from about 9 to 10 in 1970 to about 14 to 15 in 1975 in our company-owned plants as a result of an improved segmenting of the mar Et between economy buyers and convenience buyers. In essence, what this means is that in the late sixties and the seventies, consumers were buying returnable bottles, and in many instances, throwing them away. We segmented the market to get the consumer that was throwing the container away not to throw away the high-cost container.

It is my belief that studies of the type that I have described-they are now commonly known as net energy studies or net environmental impact studies—are useful analytical tools in much the same way that economic analyses and market studies are analytical tools. A recent article in Science magazine questioned their usefulness in public policy deliberations. It is my view that the are useful in providing background and understanding of a specific situation but are not suficient for decisionmaking, because net energy studies deal with only a single variable, that being energy, while business and transfer decisions within the economy are made on the basis of dollars.

I would now like to shift gears and discuss philosophy for a moment. I believe that society is in the process of developing a philosophical framework for addressing the management issues associated with resource utilization and environmental impacts. I have attempted to state m observation of the fundamental concepts that are being proposed and debated in the wide-ranging discussion regarding environmental issues. This is not a personal opinion or acceptance of each concept but is more of an observation.

I think it is appropriate to review. these concepts at this session, because ultimately the use of data and informatlon from TA activities must be applied with respect to some philosophical or ideological construct. There appear to be four basic concepts.

The first deals with acute public heath or environmental issues, and it can be expressed by the following statement: activities, operations, or products that have the potential to cause acute public heaIth or environmental problems should be controlled, related, or prohibited. This could be from informal control to absolute prohibition. Examples include the disposal of radioactive waste; the disposal and use of very hazardous chemicals; the amount of residual insecticides or heavy metals permissible in food; and operations where single events are substantial, such as a pipeline break. The objective of this management philosophy, or this concept, is to prevent disasters.

The second concept deals with the short- to medium-term use of the "commons"—air, water, land, resources, and governmental services such as national parks, road systems, et cetera,. It can be expressed by the following statement:

When the aggregate use of the "(commons)" begins to approach their natural carrying capacity, adverse impacts begin to occur. These impacts are costs to society. Products and services should include all costs direct, environmental and social, in their cost structure. Therefore, the externalities should be internalized by setting limits via standards, or by charging direct fees.

Examples include air emission standards-one car does not generate an impact, a million cars in the Washington area, as we noticed today, may generate an impact: water effluent standards; sewage charges based on volume of biological oxygen demand or chemical oxygen demand; operations where single events are minimal to trivial, but substantial in the aggregate: land use regulation?; restriction of open dumping; strip mining regulations; and littering fines.

The objectives of this concept are to manage the "commons" in a fair and equitable manner; to manage impacts not activities, operations, or products; to allow the marketplace to manage activities or products; and to achieve a balance between the detrimental and beneficial effects *on* the "commons" of their use. Limits and standards have been the most effective methods for dealing with air, water, and in some cases, land; while fees and rationing are more appropriate for services. To date there has been no major Implementation of a depletion cost into the system except as defined by marketplace direct cost, that is comparing the cost of depletion or use of materials with labor and capital.

The third concept is a different management concept. It deals with the use and allocation of resources, and is expressed by the following statement: Over and above the management implied in the first an second concepts, society, acting through governmental institutions, should allocate private resources by managing the cost, availability> or terms of sale, for products and services within the economy.

Examples include-and these are general kinds of examples-the prohibition of any product if that prohibition is not a prohibition for the acute reasons discussed in the first concept; and legislating internalization on one product that generates an impact but not on all other products or services that. generate the same impact.

The objective of this concept is to replace the three fundamental functions of the market mechanism-resource allocation, rationing, and justifying investment. Implicit in this concept is the view that society can best handle the allocation process and make determinations on what products should exist and what products should not exist.

The fourth concept deals with the long-term use and availability of resources, and societal value systems relating to growth, consumption, and life-style. It can be stated in the following manner: Over and above the management implied by the first and second concepts, society, acting through governmental restitutions, should control the overall use of resources, and search for a no-growth equilibrium economic system. In other words, put a cap on economic envelopment or resource utilization.

The objectives of this concept are to reduce consumption and to take a longer term view of the world. Implicit in this concept is the belief that society should be culturally intensive rather than use intensive, capital intensiv'e at the consumer level rather than flow intensive, and labor intensive in many sectors rather than energy intensive.

These ***are*** my observations about the four concepts that I believe are being debated today with respect to how we manage resources. I don't say that they are mutually exclusive. I think they exist along a management continuum, but there are certainly nodes in that continuum. In making use of analyses arising from TA activities, I think it is essential that we debate not only specific controversial issues, but concurrently the broad philosophical concepts for managing resources and environmental impacts.

In summary, I believe that TA activity, both within industry and within Government, is a valuable means for providing decisionmakers with a good look at an issue. Furthermore I think the specific concept of net energy analysis is a good example of a new TA mechanism that will prove useful **in** many decisionmaking environments. Finally. I think that there is a need to develop a philosophical framework for dealing with these issues.

I would like to thank the Board for the invitation to participate. If you have any questions, I will be happy to attempt to answer them.

Mr. BROWN. Mr. Teasley, it is not often we have witnesses up here who refer to net energy analysis or net environmental impact analysis, particularly if they are not in the energy business. I **imagine** Coca-Cola is concerned about energy, although not exactly in it, and I am wondering how you developed a concern in this area. I know that Professor Odum, who has done a good deal of work in this area, is from Georgia.

Mr. TEASLEY. Professor Odum is at the University of Georgia, that's right.

Mr. **BROWN. Did you have some consultation with him?**

Mr. TEAsley. I have read two of his books. I guess the concept is one whose time has come. It has naturally evolved from the following activlties, input-output analysis in economlc terms, and general systems analysis. Net energy analysis is not new to the biological area—biologists have been doing net energy analyses for a number of ears-or to the process engineering area, where a single process may be studied to determine net energy impacts.

What we saw happening to us is that, our world was changing and we were getting criticized at times for the direction that it was taking. We had to understand not only the economics that were bringing about that change, but the environmental and market impacts that were associated with that change. Our studies were simply to provide

management with an additional tool that they didn't have before. With that tool we could make R. & D. judgments about whether we ought to pursue a certain kind of development or not, and we could make procurement decisions. From a business standpoint it has also been extremely useful to us because now that we know how much energy or how much diesel oil or how much gasoline is involved in a specific option, we can make long-term plans about what is going to happen to the cost structure of that option vis-a-vis another option. So we have improved our planning capability substantially by developing that data base and that analytical tool.

Mr. BROWN. I am going to ask my colleagues here if they have any questions. We have Mr. Daddario, who is a member of the Board and Executive Director of the Office of Technology Assessment, and Mr. Leathers, who is a member of our National Advisory Council. Mr. Daddario, do you have any questions?

Mr. DAddario. Just one quick question, Mr. Chairman. Your various concepts and the objectives you derive from them, Mr. Teasley, are very interesting. In the second concept you discusssed, the second of the three objectives was to manage impacts not activities, operations, or products. You allow the marketplace to then perform its function. In the fourth concept you say that society acting through governmental institutions should control the overall use of resources and search for a no-growth equilibrium economic system. It seems to me that these are mutually contradictory.

Mr. TEASley. I am not trying to say that these are all possible. They are four distinct concepts that I believe are being publicly debated today. It is my observation of the environmental debate. Let me give you my personal view. I think the first concept is generally accepted by most people. There are always questions about what is an acute problem and how you implement and manage this concept. I think the second concept is a natural extension that as you begin to have an aggregate set of impacts, and manage the impacts, then the marketplace, under that broad umbrella, is allowed to determine how resources are allocated.

Now, the third and fourth concepts are very different. They move away. from the market mechanism as a major allocator of resources and justifier of investment, and move to some other arena and some other philosophy decisionmaking. The second and third concepts are at odds and so probably is the fourth. I am just trying to state the concepts because I think that a number of legislative issues can be addressed if we can sit down and characterize them and say it's a second concept issue or a third concept issue. Then we can ask whether we philosophically agree with the concept.

Mr. DADDARio. Your fourth concept deals with controlling the overall use of resources and searching for a no-growth equilibrium economic system. When the limits-of-growth concept came through with the study from the Club of Rome some time ago, it developed considerable discussion in the public sector and so served a very valuable purposes.

But I attended a Club of Rome meeting in Philadelphia recently, and it seemed as though they were beginning to question their own data and approach to this concept. There might be more room to move around in insofar as growth in the overall society was concerned.

Herman Kahn has taken the opposite approach, saying that with the projected, technological advances in the utilization of world resources and the better balance of things throughout the world, we could probably sustain a considerable amount of growth. There is, therefore, some question about whether in fact we should be putting so much emphasis on control of overall uses by governmental institutions, when perhaps at this time, by improved resource use we might have greater opportunities. By setting arbitrary limits at this time, we ma prevent ourselves from taking advantage of these opportunities. No one knows which side of this argument is correct, but these are points that conflict with each other.

Mr. TEAsley. No question about that. I would certainly agree with you that it would probably be premature for society to be setting up absolute limits in any area. obviously, you also have to consider your position with respect to other world-trade countries at the same time. Again, it is an attempt to express the concept because it is being promoted by some people. I think I read the article by Mr. Kahn in the latest issue of Futurist magazine in which he takes the very optimistic view that we have a lot more room to move around in than the earlier Club of Rome study projected.

Mr. DADDARIO. Thank you.

Mr. BROWN. Mr. Leathers, do you have an questions?

Mr. LEATHERS. I just have one short one, Mr. Teasley. In the switch from returnables to the plastic bottle, did you make a net energy analysis to see where the break-even on energy would be?

Mr. TEASLEY. We have not switched. The plastic bottle that we have introduced in the marketplace did not substitute for returnable bottles; it substituted for already existing one-way glass containers. A net energy analysis on that move indicated, in the size range that we introduced, which was a 32-ounce size, that we were equal to glass in energy consumption. So it was a washout. Probably the assumptions and error one way or the other would tell us which one was really the lower energy consumer. We had determined that we had improved safety factors, and that we had very high market and consumer acceptance; and we introduced that in New England.

Mr. LEATHERS. Have you made one versus the returnables as to how many trips the returnable—

Mr. TEASLEY. OK, you are talking generally one-trip containers versus returnables.

Mr. LEATHERS. Let's say the plastic.

Mr. TEASLEY. Well, it will turn out to be roughly the same for plastic or glass one-trip containers, versus returnables. The break-even based on trippage for returnables depends on a number of factors including package size, shipping distances, specific production-distribution facilities, et cetera. On balance, break-evens occur somewhere between 3 and 5 trips or at return rates on returnables of 67 to 80 percent. These trippage rates exist in some markets. Trippage is the most important variable. In 1970 to 1971 industry trippage was at an all time low with very low trippages in major eastern urban markets. Since that time, the market has been segmented more efficiently between economy buyers who purchase returnables and return them, and convenience buyers who now buy one-trip containers and no longer discard the more costly returnables. In fact, since 1970, energy consumption per gallon of finished product has decreased due to this more efficient market segmentation, the shift to larger sizes, weight reductions in one-way containers, and recycling of used containers.

Mr. LEATHERS. Thank you.

Mr. BROWN. Mr. Teasley, getting back to your philosophical concepts, I am concerned about how the commitment to a philosophical concept might bias the results of a TA, and whether this is a possibility in the operations of the Technology Assessment Board in its own studies, as well as with TAs in general, as conducted by industry. For example, if we were to assume that those engaged in making a TA had adopted your fourth philosophical concept, it seems to me that might lead to a bias in terms of a particular attitude toward a new technology. I haven't thought the details of this through, but I can conceive of, let us say, a slight bias toward energy- and materials-intensive technologies, toward what you describe as cultural rather than use intensive--

Mr. TEASLEY. Skill intensive.

Mr. BROWN. Yes. Do you perceive this as having an impact on the TA ?

Mr. TEASLEY. I think you run the risk in any kind of study that somebody comes to the study with a biased point of view. They don't really pursue an objective, scientific approach to describing a situation and developing and analyzing the data. It just means that you have to be able to recognize the propagandist when he comes.

Mr. BROWN. Well, one man's propaganda is another man's wisdom, you know.

Mr. TEASLEY. Sure.

Mr. BROWN. I think the scientific process here would be to make the effort to at least fully disclose the underlying biases or concepts under which the operation is being conducted, whether it is by the manager of the TA or the various people who are providing the inputs. Would that be your estimation of a reasonable way to at least cancel out to some degree the effects of any of these biases ?

Mr. TEASLEY. I think that the man, the decisionmaker, who gets the results of a study or a TA has a responsibility to understand the assumptions that were made, their impact and implications. It means some hard work. You simply cannot just read a set of conclusions in a report.. You have to sit down, work hard at it, and participate, I think, in judging the quality of the work.

Mr. BROWN. It's a little premature to refer to it, but in our next presentation, from the Ford Motor Co., reference is made to their corn-missioning a TA by an outside institution. They had the Jet Propulsion Laboratory do an assessment for them. I presume that this was in part to separate out any potential biases that might exist or that might be attributed, even though nonexistent to the Ford Motor Co. It seems to me that this is a commendable way to approach the problem that exists here.

I have one last question. I am a little hooked on philosophical concepts myself, and I was very interested in your presentation along that line. The fourth concept you described is a matter of considerable ongoing political controversy, because it relates to the whole argument around growth. Reference was made to Herman Kahn's philosophy, as it is reflected, I guess, in his latest book—I don't think I saw the article to which you referred.

One of the noteworthy ideas that I perceived in Kahn's recent book, "The Next 200 years,') is that he postulates explicit limits--a global population limit of 15 billion, a global energy-use limit of five quints-and certain postulates with regard to energy efficiency and use, and some other things of that nature. I don't want to accuse Kahn of accepting the limits to growth concept, but it seems to me that he has established limits here. Under these circumstances, if we work to move toward a philosophy closer to your fourth concept, do you consider this to be incompatible with a competitive free-enterprise system?

Mr. TEASLEY. If a society faces a set of circumstances requiring some kind of capstones and some kind of limits, it does not necessarily have to affect the marketplace, as long as they are very broadly stated limits and people can stall make individual choices that are arrived at by allocating labor, capital, energy, and materials the way the marketplace wants to allocate them. If, however, these limits restrict the kinds of activities and products that are going to exist, then there is, I believe, a direct conflict.

Mr. BROWN. But you are suggesting in this concept that, in effect, we move backward toward a labor-intensive rather than a capital-intensive--

Mr. TEASLEY. I am not suggesting that, I am making the observation—

Mr. BROWN. Yes, I recognize that you have been very objective about it. But isn't it also true that our free-enterprise market system flourished in a much healthier fashion in the past, when there was not so much capital intensity, not so much Government regulation, and not so much of the other things that are the bane of corporate existence today?

Mr. Teasley. I don't really have a good enough historical perspective to comment on that.

Mr. BROWN. Well, you have done very well so far. I want to thank you for your testimony, Mr. Teasley. We would like to submit some additional questions to you in writing, answers to which will help us complete the record.

Mr. Teasley. Thank you very much.

Mr. BROWN. And I hope we will have a chance to see more of -you.

[The following questions were submitted by Congressman Brown to Mr. Teasley and his answers thereto:]

Question 1. What limits do you see to the utilization and application of the TA concept in the Government and private sectors?

Answer 1. Of necessity, TA activities are based on assumptions and subject to a number of limitations. The quality of the assessment will vary directly with the quality of the assumptions and the completeness of the model. The findings, therefore, from a TA activity should be viewed as an input but not as a total basis for making a decision. Managers making use of TA studies in the deeisionmaking process should have a background that will allow them to understand and judge a specific TA and not rely simply on the conclusions drawn by the preparer.

Question 2. Has a formal structure for conducting TAs been institutionalized since the early successes with this type of analysis?

Answer 2. No formal structure has been institutionalized within The Coca-Cola Company for conducting TA activities. Assessments are conducted on an as-needed project basis when there is an indication that the specific technology has the potential for bringing about major change in some area. The Corporate

Business Development Department of The Coca-Cola Company has been established to evaluate and manage major business projects. This department will conduct a TA if it is deemed advisable, and is able to call on other corporate resources such as engineering, corporate marketing, and corporate research, if specialized expertise is required.

Queution 3. Would you describe how it is currently decided what problems should be examined with TA? What kind of a decision-planning process is gone through in the conduct of a TA from its inception to publication and final utilization?

Answer 3. As a general rule, projects that involve new technologies and substantial long-term commitments are considered appropriate subjects for TAs.

Question 4. In a TA should the impact of a new technology on job structure be examined?

Answer 4. Yes, a new technology can impact job structure as well as environment, economic systems, social patterns, etc. Of special interest are the questions of whether the technology will generate the need for additional training and development of new skills, and whether existing workers can be effectively transferred to work with new technologies.

Question 5. How is TA information worked into reports?

Answer 5. As one of the analyses, in much the same fashion as an economic or market analysis.

Question 6. Based upon your TA experience, what lessons have been learned? Has TA affected the way business is done at Coca-Cola?

Answer 6. Technology assessment is an extremely difficult process. It requires people with systems skills. The assumptions upon which the assessment is structured are critical. Quite often data is difficult to develop. The second question is difficult to respond to with specificity. However, we can say that TA has widened the perspectives of decisionmakers. For instance, there now is a mechanism within the company for examination of new businesses and technology—the Corporate Business Development Department As the department gains experience, it should have valuable input.

Question 7. Is there any attempt in your TA process to involve the public?

Answer 7. No. We are, of course, concerned with the impact of TA on the public, and this aspect is carefully examined. Also, outside specialists are engaged as needed. However, no direct input from the general public is Solicited.

Question 8. Would you describe how your organization goes through the environmental impact analysis process that is involved in an MIS? Do you attempt to explain impacts and to educate the public and employees ahead of time?

Answer 8. An EIS can be requested by a city, county, State, or Federal Government. The need for such a statement is based on a project having environmental implications such as: increased traffic, noise, water and air pollution and high consumption of energy. As part of our capital project review process, projects are reviewed for engineering adequacy. This includes an analysis of the environmental impact of the project. Thus, a capital project review is not appoved unless it states how it will affect the environment, includes steps to come into compliance with all applicable standards, and provided capital funds to carry out the necessary work. Thus, the environmental impact analysis process can start at the plant level and progress through the division and corporate level It is typically a combination of all three levels working together to provide the best analysis and solution to a possible environmental impact.

This decision is made on an individual basis. For example, during the recent Bellevue plant expansion, notice was placed in the local Bellevue paper concerning the plant expansion's effect on storm and surface water. In the case of the Hightstown waste-water treatment system, agreement was reached with the local township concerning treatment to be provided. Employees involved with plant operation were informed of the treatment process and the necessity for proper operation of the treatment facility.

Question 9. What value do you see in having closer relationships between the public and private sectors? Do you see any value in working closer with State and local governments?

Answer 9. Too often in the past an adversary relationship has existed between the public and private sectors. The mutual exchange of information in a candid and cooperative atmosphere can be helpful in maximizing the constructive utilization of TA. I think that there are some issues in which a closer working relationship with State and local governments could be productive.

Question 10. How do human value systems affect technological development? What role should the analysis of value systems have in assessing the impacts of technology on society and on the environment?

Answer 10. Human value systems have a tremendous impact on technological development. The fact that a technology exists does not necessarily mean that it will be adapted successfully. The adaptation will be based *on* socio-economic factors, as well as the technology itself Value systems actually relate more to decisionmaking **than they do to TA.** TA **is a tool to provide information to decisionmakers who will then draw conclusions and make judgments within the context of some value system.**

Mr. BROWN. Our next witness is Dr. Dale Compton, vice resident for research for the Ford Motor Co. We are very pleased to have Dr. Compton here this morning.

Dr. W. DIALE COMPTON, VICE PRESIDENt-RESEARCH, FORD MOTOR Co.

Born January 7, 1929, Chrisman, Ill., B.A. **Wabash College; M.S. University of Oklahoma; Ph. D. physics University of Illinois.**

Employed at U.S. Naval Ordnance Test Station, China Lake, Calif., 1951-52; U.S. Naval Research Laboratory, Washington, D. C., 1$55-01; professor of physics, University of Illinois, 1901-05; director, Coordinated Science Laboratory, University of Illinois, 1965-70; director chemical and physical sciences, Ford Motor Co., 1970-71; executive director scientific research staff, Ford Motor Co., 1971-73; vice-president scientific research, 1973-75.

Over 40 publications in leading physics journals both American and foreign as well as in reference works.

A member of: Advisory committee for research and advisory committee on research applications policy, National Science Foundation: visiting committee, National Bureau of Standards; energy laboratory advisory board, Massachusetts Institute of Technology; energy advisory board, California Institute of Technology; Advisory Board to College of Engineering, University of California, Berkeley; board of visitors, School of Engineering, Oakland University; Arch T. Colwell merit award board, Society of Automotive Engineers; board of directors, Michigan Cancer Foundation; board member, Bloomfield Hills Junior High School, Parents Teachers Organization.

Honors include Phi Beta Kappa; a station fellowship from the U.S. Naval Ordnance *Test* Station for graduate study at the University of Illinois; and a certificate of commendation from the U.S. Naval Research Laboratory.

STATEMENT OF DALE COMPTON, VICE PRESIDENT, RESEARCH ENGINEERING AND RESEARCH STAFF?, FORD MOTOR CO.

Dr. Compton. Thank you, Mr. Congressman. Mr. Chairman and members of the Office of Technology Assessment (OTA). I am Dale Compton, vice president of research, Ford Motor Co. We are pleased to have this opportunity to review for you some of the ways that Ford uses technology assessment (TA), and to offer some comments on the limitations an strengths that we perceive for the TA process.

The National Academy of Sciences has suggested that TA is the process that “occurs when the likely consequences of a technological development are explored and evaluated.” Within this definition, we regularly carry out TAs and we believe that the results provide a valuable input to our decision processes. But before discussing specific examples, I would like to offer some general comments concerning the development and utilization of TAs. There are four issues that we believe are of particular importance.

First, a clear distinction between TA and technological forecasting must be maintained.

Second, a short time frame and a stable environment are critical if the assessment is to be useful.

Third, the ability to make an accurate assessment depends upon the adequacy of the data base being used.

Fourth, an objective assessment requires that no pre-assumed bias be allowed to penetrate the assumptions of the study.

It may be helpful to expand upon these points briefly. The assessment recess tends to assume an existing technology and to explore the ramifications of implementing it. This assumes that the technology is reasonably well-developed. one cannot establish the technical facts by consensus votes. Hard data on the particular technology must be available and must be agreed upon by the experts if an assessment is to be useful. This does not mean that implications drawn from the data will be universally accepted. In fact, the conclusions may be controversial. After all, one often is dealing with sociological forces and the ability to predict social events is at best imprecise. Far too often assessing the social implications comes down to a matter of judgment, rather than to a prescribed means of making a prediction. But the technical data must exist and must be valid before any assessment should be undertaken.

Further, it is basically impossible to anticipate the unusual event. The timing of an OPEC embargo is not predictable. Assessments are usually predicated upon an extrapolation of the current status. So if the time frame is long, the chance that an unusual event will occur is great. This suggests that an assessment should be viewed as a living issue, with frequent review and updates to reflect recent unpredicted events.

Forecasting technological events is subject to even more uncertainty than assessing the impact of technology. Technological feasibility can be established with a fair degree of certainty, but the probability of implementation is often not predictable. As a recent examle, the Wankel engine was in automotive production overseas and well on its way to implementation here when fuel economy became of increased importance. An engine that had been considered to be technically feasible suddenly became technically questionable, when the basis for assessment required that different values be assigned to the various criteria. The distinction between assessment and forecasting relates closely to the time frame being considered. An attempt to assess the long-term consequences of an event generally is more akin to forecasting than to assessment because of the greater uncertainty in the conclusions and assumptions.

Finally, it is terribly tempting to use TA as a tool for advocating a particular predetermined bias. We sense that the TA process at the congressional level has been based on the assumption that Federal intervention through legislation is required. Under such conditions the assessment process should be viewed as an investigation of the impact of intervention, and not as an unbiased TA of an area of interest. These concerns do not mean that it is improper to attempt TA. What they do suggest is that it is important to maintain an awareness of the limitations of the process and to recognize the dangers inherent in making major long-term decisions based upon such assessments.

The TA process has been used by Ford Motor Co. for many years in planning its product offerings. Recently, we have incorporated as integral parts of our assessments, the impact of a variety of new external factors along with market forces. In particular, we have seen the need to assess on a continuing basis the interdependence of energy, environment and resources as a key factor affecting the impact of the motor vehicle on our society. Consequently, our considerations of the impact of our product actions go well beyond the study of the sale of vehicles. Similarly, we carefully examine the implications of proposed actions relative to manufacturing as part of our assessment activity

I would like now to give you some examples of specific assessments we have performed. My intent is to concentrate on the reason for the assessments and their impact rather than to discuss the substantive details of the assessments themelves.

My first example concerns the development of a company position. As a large corporation, we want to speak out on public issues that may have a significant indirect bearing on our business, and we have found that the principles of TA are extremely helpful in the development of such company positions. An example concerns the 55 mph speed limit. Early in 1974, when the issue was the subject of general debate, we undertook an assessment of this issue. Various f actors were considered, including the impact on mobility and quality of life, the environment—specifically noise and air quality-safety, energy consumption, and car sales. While the assessment forecasted a near-term decrease in sales, the forecasts of reduced fuel consumption, reduced highway accidents, and improved environment were Instrumental in forming a company position solidly in support of the proposal. An interesting aspect of this assessment was that we revisited the issue a year later and published an updated report comparing the forecast with actual experience, and commenting on the probable impacts of more rigid enforcement. We found that our forecast was surprisingly close to the results for the first -year.

A second example, which concerns our manufacturing processes, is an assessment of the paint system that will be utilized by the company in the years ahead. This was precipitated by pending actions at both State and Federal levels regarding the allowable emission level of hydrocarbons from assembly plants. The proposed regulations appear to require the development of an alternative to the present paint system that uses organic solvents. A number of possibilities exist, including water-based paints, powder paints, and low-temperature curing paints of a very different chemical formulation than that presently used. The energy required to handle these low-temperature systems is substantially lower than for the others.

This assessment was required, not only to deal with the tradeoffs regarding energy costs and environmental considerations, but to consider allocations of natural gas, availability of propane, maintenance of outstanding product quality, the minimization of plant investment that would be required to introduce any of these technologies, and the timing that could be expected for requiring the achievement of particular levels of emission. This assessment was particularly instrumental in establishing the direction of future paint system development that will be needed to solve particular technical problems, and to maximize the probability that the optimal system will be available in time. Similar TAs have been performed on the opportunities and limitations of material recycling, and on the desirability of further developing specific manufacturing processes.

My third example will concern our product itself where most of our TA activities are focused. We must, as a part of our product planning strategy, assess impacts well beyond car sales in our attempts to develop contingency plans capable of dealing with changing consumer demands and a changing regulatory and legislative environment. A major constraint on these assessments is the recognition that our capital is limited, and our investments must be recovered through sale of our products. This constraint, which is an essential element to industrial TAs, requires that the theoretical net benefits of an innovation be weighed, not only against the identifiable internal and external costs but also against the risk of failure of the technology itself or of consumer acceptance of it.

Recent product-related assessments have included a wide variety of automobile power systems including turbine, Wankel, hybrid, electric, and many derivatives of our present engine. We believe that we are reasonably competent at this process, but we also recognize that we might overlook some key issues. For this reason, we recently did something unusual in the TA business. We asked a highly competent outside group to work completely independently of us to carry out an assessment essentlally parallel to our own in the evaluation of the potential of future automotive powerplants. On Ma 23, 1973, Mr. Lee Iacocca, president of Ford Motor Co., told the U.S. Senate Subcommittee on Air and Water Pollution, that our company intended to make a ant for an assessment of alternate power systems for motor vehicles cause "we feel we need to have an outside, independent check on our technical judgment as well as on our evaluation of such factors as the most approach utilization of national energy resources, the transportation needs of the future and the economic implications" After a lengthy selection process, a grant of $500,000 was awarded on October 3, 1973, to the Jet repulsion Laboratories (JPL) of the California Institute of Technology to conduct the assessment. I have submitted to the Board a copy of our description of the desired assessment. (See app. C, exhibit 2. It was understood at the outset that JPL would operate totally in independently of Ford. In fact we asked for no progress reports and agreed to read the final report only after it was released to the public. We did provide, ***on*** request, nonproprietary data for the study. Similar requests were made to many other elements of the automotive industry, and we are pleased that they responded so well to these requests.

We asked JPL to forecast the extent of the future development of the current internal-combustion Otto cycle engine, and to compare alternative future technologies with regard to economic, natural resource, environmental and societal impacts including production, and logistic and energy support requirements. We also introduced some new questions. We asked JPL to investigate various introduction dates for new technologies, and to evaluate introduction timing as a parameter. And finally, we asked them to try to sort out research and development requirements into those tasks which would logically call for either Government funding or industry funding based on considerations of risk, potential benefits, and cost, and the potential for meaningful industry-Government relationships.

We believe that the study met the objectives that were established and is proving valuable as a baseline source of information for Government and private sector policy guidance. This does not mean that all of the conclusions of this study are accepted by everyone, including us, but it has been very useful. It is also interesting that the Energy Research and Development Administration has recognized the need for a continuing evaluation of this area and has chosen to fund an update of this study on a regular basis.

Recalling my earlier remarks about an inadequate data base for assessment, we were particularly interested in the assessment that JPL gave of the potential of the turbine for vehicular propulsion. Several years ago we entered the turbine engine business, based in part on the results of an assessment. It was only after we were in business that we discovered that the stability of one of the key ceramic components severely limited the durability of the engine. The assessment led to the wrong business decision because of its failure to adequately explore technical details and its failure to account for risk. The JPL study recognized that this problem had now been solved. The availability of new materials now makes the turbine an attractive alternative.

What have we learned about TA as applied to our needs? First of all, we do not have a formal technology assessment office nor do we think one is desirable for us. We believe that it is important that the TA philosophy be understood and practiced by all of the groups in the company who are involved in decisions on technology. Our product planning staff, research staff, environmental research office, car operations office, and our various manufacturing divisions all participate in these assessments. We also frequently a preach the TA job on a task force basis with appropriate staff and line representation. A critical element is the identification and involvement of those who are best informed regarding the technologies at issue.

Second, we have tried to avoid the development of a highly structured methodology because we have not found a single methodology that is applicable to all of our needs. We have tried to be consistent in adhering to the principles of scientific methodology, that is, to make data and analyses available for critical review by others within our technical community, and to avoid the temptation to analyze complex, highly quantitative problems on the basis of opinions alone.

Third, we have found it essential to make every effort to maintain objectivity. Without proper review and extensive debate of all alternatives, it is easy for TA to degenerate into an advocacy tool. When this happens the conclusion of the assessment must be viewed as suspect.

We will continue to use TA as a means of evaluating various alternative products and manufacturing actions and their (societal) public implications. Accordingly I suggest that it could be of mutual benefit to the office of Technology Assessment (OTA) and to industrial organizations, such as Ford Motor Co., if procedures existed whereby we could more effectively provide an early input into governmental studies. It seems to me that the adequacy of the data base and the objectivity of the assumptions underlying assessment studies would be strengthened by opening the channels for greater industrial inputs into OTA studies. opportunities to contribute our own findings and analyses during OTA studies rather than the more limited system of commenting on finished reports, provides a healthier climate for Government-industry interaction. Recent experience along these lines in the OTA durability assessment now underway, demonstrated the value of early interaction.

Once again I wish to thank you for the opportunity of appearing and I would be happy to try to answer any questions that you may have.

Mr. BROWN. Thank you very much, Dr. Compton. I think your statement is an extremely valuable contribution to the subject matter of this hearing. I don't think we can stress too much the importance of some of the points that you have made about the necessity for adequate cooperation between the arms of the Congress that are trying to provide data for policy decisions, and the private business entities that are also involved in the results of these policy decisions.

In your opinion, does the study that you commissioned at JPL fit within the general structure of what we call technology assessment (TA) ?

Dr. Compton. We believe that it does.

Mr. Brown. Could I ask you to amplify a moment on what you felt the advantages were of having this done on an outside basis rather than internally within the company ? What were the factors which led you to feel that this was the best procedure to follow in getting the kind of results that you wanted?

Dr. Compton. Well, Mr. Brown, the principal reason that we wanted an organization outrode of our company to do this was because we wanted an assessment that was independent of our own biases. We often find that our studies are considered to be biased and self-serving and that our conclusions and suggestions, therefore, are often ignored out of hand. In this particular case, the subject matter was of such great importance to the country and to our own future business interests that we felt an objective independent study was needed that would have credibility, both with the public sector and with the private sector. Thus, we felt It was essential to go outside the company to have it done. I might say that it has served as a very valuable internal tool for our own planning and this has been very important to us.

Mr. BROWN. Well, I am stressing this because it bears directly on our own mode of operation in the Office of Technology Assessment (OTA); the question of whether we should do internal studies versus commissioning external studies. We follow both procedures at the present time, as you do in your company, and yet we need to be aware of when the circumstances might dictate going as you have done with JPL on this kind of study.

Mr. Daddario, do you have some questions?

Mr. DADDARIO. Thank you, Mr. Chairman. Dr. Compton, in your closing remarks you refer to the importance of the constant involvement of industry in various OTA TA activities, and yet that runs somewhat counter to what you have said about involvement in your own study. Why were you so sensitive to your own involvement, that this same philosophy would not have applied?

Dr. COMPTON. Well, I think it can be compatible in both cases, Mr. Daddario. In the JPL study, we provided a whole range of information and we attempted to respond to any question that JPL asked us during this study. We also were allowed to critique the assumptions that formed the basis of the study, but we were not involved in the assessment process itself. That was done by JPL independent of Ford.

What I was suggesting is that it would be very helpful for industry to be involved in the discussion of the study assumptions at a very early date, and also in the discussion of what data are available and the reliability of those data. But if it is to be an independent study, the carrying through of the assessment process would have to be done independently by the OTA.

Mr. DADDARIO. I recognize that, but I think that the argument works both ways. When a company has so much knowledge of the data, being so sensitive to the objectivity part of the TA might not allow you to take advantage. You might in fact have had a better report if you had participated more. I wonder if you have any comment on that?

Dr. COMPTON. I don't think we feel that the report was inferior because we did not have direct participation. We clearly have some questions with it and we have disagreements with some of the conclusions. But the processes which JPL followed led to some new methodologies that had not been used before. Those have proved to be very valuable to us. The important thing is for the discussions to take place at an early stage of the development of the study. Hopefully, this will lead to agreement on the general approach and will help prevent a confrontation on the results of the study. While there may be strong disagreements that can never be resolved, I think it will be valuable if these can be aired before the study is complete.

I might give one example outside of the OTA studies about which we have felt very strongly, Mr. Daddario. The National Academy of Sciences (NAS) study on air pollution was done for the Congress. When that study was published, it was reviewed and generally found to have some rather serious technical limitations. There was not an opportunity to critique that or to discuss the methodology prior to the final publications. And it became then a case in which we were confronting NAS in front of the Congress. I believe that the technical issues could have been resolved much earlier, much to the benefit of the country, if a serious review of the technical issues could have been held early in that study.

Mr. DADDARIO. Well, I would agree with you on that. You state with reference to the OTA durability assessment in which there was considerable involvement of all parts of the community, that this would be a good thing to do in all assessments. We have in fact, in every instance, followed that same approach where there is involvement, even though your statement indicates to the contrary. There is involvement in the first instance, and through the entire course of the assessments. So when the final drafts are sent out to industry, they have already been participating. I think we have done that in every instance.

Dr. COMPTON. There certainly is industrial representation on your advisory board, and some of their views, of course, are represented to you via that mechanism. But I don't believe that industrial groups have been asked to offer comments and to represent official company position. We did make a formal presentation in the wear and durability study, and it was very valuable, I think, to both of us.

Mr. DADDARIO. Well, you are making a distinction then, and I think it is an important one. It is very helpful that we have this dialog. It may not be enough to have the representation of expert people on an individual basis, but perhaps there ought to be some stronger involvement so that the connection is to the company as well as to an individual who has knowledge about that particular area of activity. Do you think that this might strengthen the process?

Dr. Compton. Yes, I believe that a stronger involvement of those companies competent to comment on specific issues is important. The involvement of experts is also important, but their views should not be considered equivalent to corporate evaluations.

Mr. DADDARIO. You touched earlier on four points The second one says that a short time frame and a stable environment are critical. What do you consider to be a short period of time?

Dr. Compton. It depends a bit on the technology that one is discussing. In the automotive industry, major near-term changes are restricted because of our leadtime problems and the type of investment that we have. Thus, a long-term technology assessment refers to 10 or more years. This was the general time frame that the JPL study was oriented to.

There are many studies that could be quite appropriate for 2 to 3 years in the future. It really depends? I think, on whether the investments and the commitment revolved in the implementing of a plan, a product, or a control process are so large that the inertia of the system and the time frame to change it is very long. Then you have to look well beyond where that time frame is. So you have to examine each case independently. In the automotive industry we think that technology assessment of new vehicle powerplants should be concerned with the events of the mid-1980's to the mid-1990'&

Mr. DADDARIO. One of the reasons I asked you the question about your own involvement in the JPL study, is that in our activities we sometimes find that in the course of our carrying out an assessment, a part of what is being done becomes useful. If we had to wait until the assessment was completed we might not have been able to use it during the course of other activities. For example, in our Outer Continental Shelf assessment, which has been going on over the course of almost 2 years, three or four sections have been taken out and utilized by congressional committees that have been placed in an adversary position. This material is put back in but not necesssarily ***in*** the orignal form. In a sense, this keeps it vital--one of the points that you raised-and makes the assessment a live type of activity. The material is not only useful but is also strengthened. I wonder if that is not an important involvement.

Dr. COMPTON. It is very useful. You recognize, of course, we were doing similar studies internally, and we had the benefit of those studies as we were carrying them on ourselves. But we felt the need for a high credibility for this study, which would not be a self-serving document.

Mr. DADDARIO. I am not talking about the JPL study now, but rather from a general point of view.

Dr. COMPTON. From a general point of view, I agree with you, sir.

Mr. DADDARIO. I would like you to go into a little greater depth, if you might, Dr. Compton. You touch on the concern you have about the TA process at the congressional level, the biases that might develop and the importance of having unbiased TAs with which, I am sure, the Technology Assessment Board would completely agree. It is a very important point and I wonder if you might elaborate ***on*** that a little bit.

Dr. Compton. May I just give you two examples of what we see as biases toward possible Federal legislative intervention. In the product and equipment durability study that is still under way, the stated objective, as we understand it, is the identification of the legislative options for the stimulation of the control of corrosion and wear. The important point here is the word control.

In the study that is underway on the changes of the use and characteristics of automobiles, the original request by Mr. Hart? we understand, was to assess the impact of Government regulations on the automobile industry employment and its financial health. It is our view that the major effort being devoted to that study is an assessment of the ways to cause changes in the characteristics and use of automobiles and to effect changes in the industry. We believe that there are significant differences between the original and the present objectives of these studies, and we are concerned that the results of these studies will reflect a preestablished bias for the need for Government intervention.

Mr. DADDARIO. Well, I would agree with you. As these activities continue to go through their design phase, within which I believe there is a good cross-representation, I would expect that these matters would be taken into consideration.

The significant point is that the question of bias is important. I think this question is important to the Technology Assessment Board, because the original request that came from Senator Hart was examined and returned. Adjustments were made over the course of time, all of which took into consideration certain of the concerns that were expressed by the industy that was most affected. The Board was certainly anxious to see to it that, as this assessment continued, it would be objective and unbiased. At the present time we certainly are making every effort to see to it that there is both objectivity and that type of participation. Thank you.

Mr. BROWN. I will now call on Mr. Leathers, one of whose functions is to provide that input from the industrial community to which you referred.

Mr. Leathers.

Mr. LEATHERS. Thank you. I have a question concerning the assessment examples that you have described. I really wanted clarification or some elaboration on whether or not TA as you presently carry it out, Dr. Compton, is not an extension of what was formerly known as economic evaluation, feasibility studies, and economic assessments ? You then extended it by adding the environmental impact of energy and similar considerations.

Dr. COMPTON. Yes, sir, they are indeed extensions of the types of studies you mentioned and they use many of the same tools that we have used for years in industry.

Mr. LEATHERS. Thank you. There is another aspect to this discussion you just had with Mr. Daddario on assessments. The Advisory Council is troubled that some requests as written to the OTA or the Technology Assessment Board, in our opinion frequently contain a basis. The Advisor Council has spent a great deal of time making sure that the final document is completely fair with all the biases clearly stated. We try to point out all the options available for Congress to act on without making recommendations or drawing conclusions. This sums up what I have to contribute to this discussion.

Mr. BROWN. Thank you, Mr. Leathers Just a question or two, Dr. Compton. In one of the earlier hearings in this series the view was expressed that there was a possibility that as TA procedures become more widespread, they might contribute to reducing the governmental role. The theory behind this was that frequently the governmental role becomes necessary as a result of a failure on the part of an enterprise to adequately account for all the second- and third-order effects of a particular course of action. But as those effects are taken into account in current planning, and where they are adverse to the public welfare, suitable preventive actions or alternative courses are. adopted, a certain amount of governmental intervention will be obviated. Do you see this as a possible benefit of the TA process or are we missing something?

Dr. COMPTON. I would hate to predict that as being a consequence of TA, because it seems to me that the critical issue here is what are the incentives to accommodate these second- and third-order benefits.

Mr. BROWN. Benefits or negative effects?

Dr. COMPTOn. The negative effect. Unless the incentives are clearly defined and can be applied universally across the entire industry or product, it is very hard for them to be accommodated, I think. I would hesitate to predict that this would change the level of Government involvement, but I would ho e that it would focus it, and make it such that we would realize the implications to both the public and to the private sector of a particular involvement on the part of the Government.

Mr. BROWN. There are many members of the Technology Assessment Board who would like to see TA used to analyze the effects of Government regulation on technologies, as well as on the physicial or economic-social impact of the technologies themselves. Do you see anything incompatible with the concept of TA that would preclude using it in this fashion, to delineate the problem for assessment as, what are the socioeconomic, environmental, and other impacts of a particular regulatory option that might be followed?

Dr. COMPTON. I think it is extremely important to include all of these factors. Had such an assessment been carried out very carefully at the time the clean air amendments were being discussed, I believe that it would have been recognized that there were insufficient data to make some of those prediction?, and insufficient technology to assume a certain time frame in which the specified levels of emission could be met. It would have been extremely important to have had a careful assessment of all of those factors at the time that those regulatory measures were being considered. The same is true, of course, of many of the water-pollution regulations that are now under consideration; from a physical point of view, to insist that there be zero discharge has certain implications in terms of the technology.

Mr. BROWN. I want to change the line of questioning briefly and get into another area. We are concerned about the role of public particpation in the assessment process. Frequently, when you are attempting to evaluate certain types of potential effects the views of the public are an important element in determining the nature of the final results of the assessment.

Have you faced this problem in connection with the kinds of TAs that you make in your company? Does the assessment that you had JPL do have any component of public participation in it? This doesn't necessarily mean the general public, but It could mean concerned special publics. You have referred for example, to the technical community and their reviews. Well, that is one kind of a public. How do you encompass this in your own thinking about TA?

Dr. Compton. We tend to look at various aspects of issues; how they affect the total labor market? how the-y affect the marketing and acceptance of our products, and so forth. When we do these internal assessments we do not generally invite public participation.

From the standpoint of assessments that are being carried out in the public domain, as are OTA studies, I think it is apropriate that the public be involved but only at an appropriate time. It seems to me that the technical consequences have to be considered and examined based on technical facts. The implications from a technical point of view have to be as carefully determined as possible. Technical issues should really not be debated or decided by public opinion. Where the public interest is important is the impact of an implementation strategy. I would view that as a second step, but make very sure that the initial step was as much a factual data-base evaluation as is absolutely possible. Always recognizing, of course that there are times where we have to extrapolate from a limited data base.

Mr. BROWN. Well, in the public domain, we have a particular problem in dealing with the public. For example, assuming that it was a desirable public policy say, to have offshore oil drilling or a large offshore supertanker port, some people might say that this was in the best interest of the public and of this country. Yet the people in the area might object to it. A political entity seeking to influence this public opinion is accused of manipulation. Whereas In the private domain, if you seek to influence the public on behalf of a particular technology, that is just sound marketing. There is a difference here.

This raises the question of what relationships the marketing role plays in your assessment activities! The history of the automobile industry is replete with examples. For example, when General Motors (GM) went to annual models, whereas Ford has been in the old days content with the model T. The question a TA would have raised would be; going to annual models by GM is going to take more capital, more energy, and a lot more other things, but it may sell a lot more cars; how do you reconcile the marketing role, which is best for profitability, and the TA role, which gives you a measurement of all of the energy, capital, environmental and other impacts ?

Dr. Compton. I think the important distinction is that TA establishes what the options are; that is, what the cost of those options will be. The marketing comes in determining what is a proper product.

Do you envision that it will be profitable to implement option A as opposed. to option B ? The answer to this then requires an investment of a major kind. But the options are based upon technical issues. For example, what does it take to go to 500,000 units a year of vehicle A with plant B, and so forth. Those are the technical issues that form the basis for the corporate action that then will lead to a product of one type or another.

Mr. BROWN. But stating this in an extreme form—suppose you took the worst possible technical option, because it turned out to be the best possible marketing option?

Dr. Compton. That could happen.

Mr. BROWN. What's the value of having TA then?

Dr. Compton. Because it resented the options to the corporate management that has to make the decisions on how to best use its capital and how to make the best profit on that capital.

Mr. BROWN. But is your final criterion or action always going to be best return on capital?

Dr. Compton. The final criteria involve many things, obviously. There are considerations such as corporate responsibility that are in that equation; there are issues such as customer loyalty that may be more important over a long period of time than a gain in the near term. There are many things that enter into that corporate decision. But the technical issues have to be presented as sound options. The other factors then get built in during the management assessment of these options.

Mr. BROWN. How do you evaluate the merchandising role, then? Suppose that it was conceivable that you could merchandise the best option from a technological standpoint if you put the resources into merchandising it-it would cost a little bit more than merchandising the worst option, but the social benefits might justify it. Are you or any industry, particularly one as important as the automobile industry, in a position to consider the effects of your merchandising activities; that is, the money that is put into promotion, media, and so forth?

Dr. Compton. Of course, that is part of our cost and has to be considered as part of the investment in a new product.

Mr. BROWN. How much interrelationship do you in the research end of the business have with the marketing and merchandising end of it?

Dr. COMPTON. We have very limited interaction within the Ford Motor Co. with either marketing or merchandising.

Mr. BROWN. This is a very serious part of the policy problem that Government faces, you know, because assuming that we exercise our trusteeship role properly, Government is not so much concerned with marketing and merchandising as it is with public welfare aspects. Here again, the point might be made that if an industry were to consider using its resources to implement the strategy most compatible with the public welfare, the need for the Government role would be reduced.

Dr. COMPTON. If one could be assured one's competitors would be doing the same and, if not, that there would be no net disadvantage to you, then of course—

Mr. BROWN. A pretty big "if."

Dr. COMPTON. The free market will operate properly.

Mr, BROWN. We thank you very much for your testimony, Dr. Compton. I think that this does illuminate very well some of the key policy problems as well as some of the important technical problems in the TA process. We would like to submit some additional questions to you in writing, answers to 'which will help us complete the record.

Dr. Compton. Thank you.

Mr. BROWN. We are very grateful to you.

[The following questions were submitted by Congressman Brown to Dr. Compton and his answers thereto:]

Question 1. In your TA activities, what limits do you place on the TA concept?

Answer 1. Essentially the only limits that are imposed on the TA concept result from the availability of reliable data that can be used in the evaluation of the issue under consideration.

Question 2. How do you decide what problem should be examined with TA? What kind of decision-planning process is gone 'through in the conduct of a TA from its inception to publication and final utilization?

Answer 2. As I stated in my testimony, we use TA in decisionmaking regarding products, processes, and public positions. The planning process varies depending on the application. In general, we examine a problem with TA when there are questions that involve technology options which cannot be answered by traditional economic or market analyses.

Question 3. Would you describe how Ford goes through the environmental impact process? Do you attempt to explain impacts and to educate the public and employees ahead of time?

Answer 3. In the case of facility construction or expansion programs for which regulations require the submission of an Environmental Impact Statement or Environmental Assessment, we would prepare such a report with our own staffs *(or* possibly with outside contractor help). Such reports, once submitted to the agency, are on public record. We consider environmental effects on a regular basis, but formal impact statements are only prepared at the instance of Government.

In the case of our products, we attempt, through public statements, to inform our customers and the public regarding the benefits and the costs of current and future environmental controls.

Question 4. In a WA should the impact of a new technology on job structure be examined?

Answer 4. The impact of new technology upon job structure is just one of many factors considered in a TA.

Question 5. How is TA information worked into reports?

Answer 5. It is often included as an integral part of the total report.

Question 6. Based upon your overall TA experience, what lessons have been learned? Has TA affected your way of doing business?

Answer 6. Good data are essential. Opinion is of little value. Yes, we have modified our thinking on various options as a result of a TA.

Question 7. Regarding the Jet Propulsion Laboratory-California Institute of Technology (JPL-Cal Tech) TA, would you desribe what the impact of that study was on decisionmaking and policymaking at Ford?

Answer 7. The JPI-Cal Tech TA provided an independent assessment of the advantages and disadvantages of various engines. The document provided an important input for our assessment of the desirability of continuing work on turbine and Stirling engines.

Question 8. Did it have an impact on the planning process?

Answer 8. Yes, as I just mentioned, it was used as an input into our planning process.

Question 9. What lessons were learned as a result of that TA?

Answer 9. Questions of manufacturability, tooling costs, process changes presented problems for the grantee. A better methodology is necessary for attacking these issues.

Question 10. Have any new TAs been commissioned to follow on that TA?

Answer 10. No.

Question 11. Do you expect that any will?

Answer 11. Yes.

Mr. 13 Brown. Our next witness is Dr. Henry L. Duncombe, vice president and chief economist of General Motors Corp. And you have an associate with you?

Dr. DUNCOMBE. Yes; I have, Mr. Chairman. Dr. Frederick Bowditch.

Mr. BROWN. Dr. Bowditch, we are very pleased to have you with us also.

Dr. DUNCOMBE Thank you very much. Before I proceed with my testimony, I would first like to call your attention to a report that I have submitted to the Board. This is the 1975 General Motors (GM) Report on Programs of Public Interest. I want to cite here some seven chapters in this report that deal with improvements in vehicle emissions control and fuel economy, alternative automotive powerplant research and development for improved fuel economy and reduced emissions, industrial energy management in General Motors, automotive safety engineering programs to establish field-relevant tests, public transportation as General Motors views it, noise-control regulation for medium and heavy trucks, and an update on continuing programs to control the industrial environment. All of these chapters, I believe, deal with this matter of TA and would be of immediate relevance to the concerns of the Board in its work.

Mr. BROWN, Without objection, that study will be made a part of the record of the hearing, Dr. Duncombe, you may proceed with your statement.

[For information about obtaining this report see appendix C, exhibit 3.]

[The biographical sketch of Dr. Henry L. Duncombe, Jr., is as follows :]

DR. HENRY L. DUNCOMBE, VICE PRESIDENT AND CHIEF ECONOMIST, GENERAL MOTORS CORP.

Born January 11,1914, Grand Forks, N. Dak.

B.A. University of Chicago, 1934; M.A. Northwestern University, 1938; Ph. D. economics, Northwestern University, 1948.

Instructor, Northwestern University; assistant dean and professor, Amos Tuck School of Business Administration, Dartmouth College; economist, Machinery and Allied Products Institute, Washington, D. C.; statistician, special studies, the treasurer's office, General Motors, 1957; director of economic studies, the GM Financial Staff, 1968; chief economist, 1972.

Consulting for industry and government relating to domestic and international economic problems in marketing research, labor arbitration, and economic and statistical analysis.

Advisory activities include: Chairman of the Economic Research Committee of the Motor Vehicle Manufacturers Association, the Technical Consultants to the Business Council, and the Economic Research Committee of the Business Roundtable; economic adviser to the International Chamber of Commerce; and member of the Council on Trends and Perspectives of the Chamber of Commerce of the United States.

Honorary and professional memberships include: honorary member of Beta Gamma Sigma, the national honorary business fraternity; and member of the American Economic Association, the American Statistical Association, and the National Association of Business Economists.

STATEMENT OF HENRY L. DUNCOMBE, JR,, VICE PRESIDENT AND CHIEF ECONOMIST, GENERAL MOTORS CORPORATION; ACCOMPANIED BY FREDERICK W, BOWDITCH, EXECUTIVE ASSISTANT TO THE VICE PRESIDENT, ENVIRONMENTAL ACTIVITIES STAFF

Dr. DUNCOMBE. Thank you very much, Mr. Chairman and members of the Technology Assessment Board. I am Henry Duncombe, vice president and chief economist of General Motors (GM). With me today is Dr. Frederick W. Bowditch, executive assistant to the vice president, environmental activities staff.

As we understand the congressional intent in establishing the Office of Technology Assessment (OTA), it was to give Congress an independent capability to understand the technological issues involved in legislation. OTA was created, according to the preamble of the Technology Assessment Act of 1972, to provide Congress with unbiased information concerning the physical, biological, economic, social, and political effects of the actions Congress may take on programs involving science or technology.

This is an awe-inspiring mandate as we would view it from the perspective of a single industry. It is truly breathtaking when we consider the diversity and dynamism of the American economy. I would like to discuss TA as we view it in General Motors (GM), with primary emphasis on the economic, marketing, and commercial considerations that of necessity are important to any private enterprise. We hope that with our statement and in answer to your questions we will be able to assist you in your search for a sharper definition of the potentials of TA.

General Motors has long been concerned with at least some of the elements included within this all-encompassing term. Engine and drive-train efficiency and performance, the structural integrity of our vehicles, feasibility for volume production, cost and marketability would all be relevant considerations in the normal course of the conduct of our business. And while all manufacturers have had to assess their products in terms of their appeal to the customer, the industry has long been concerned to improve highway safety, to understand the evolving role of the motor vehicle in the Nation's transportation system and its impact on land use and demographic change. We, even more than OTA, are concerned about the characteristics and the uses of the automobile.

During the past decade, the passage of legislation that superimposes nonmarket vehicle standards on those required by the customer has, of course, involved manufacturers in a much broader range of considerations. The recognition of photochemical smog and its relation to vehicle exhaust emissions, prompted research that produced the catalytic converter. Recognition of the Nation's dependence on overseas and insecure petroleum sources resulted in the voluntary economy commitments made by each company to President Ford, and we have of necessity, made assessments of the mandatory fuel economy standards included in the Energy Policy and Conservation Act. In the area of mandatory safety standards, we have on repeated occasions, expressed our views concerning feasibility. cost, and benefit.

In short, motor vehicle manufacturers have lived with the necessity for TA. broadly defined, for most of the past half century. What is new is the explosive growth of regulation affecting almost all facets of the design and performance of cars. In this process we have been forced to assign an increasingly higher priority to meeting Federal standards. relative to our traditional concern with the suitability of a vehicle to the customers to move people and goods

If we understand the term correctly, TA must involve a forecast, or more precisely, a complex of related forecasts. These would include the probability that a perceived technological alternative could be developed, as well as an evaluation of its costs and benefits relative to existing and other perceived technologies, an assessment of its acceptability to the customer in performing its function, and its related advantages and disadvantages. I can speak to the problems of forecasting with a substantial amount of personal conviction. During the past 20 years, the responsibilities of my staff have included the development of macroforecasts and, based on these, estimates of the probable levels of motor vehicle demand and the mix of car sales.

In the past, such forecasts have been made in a climate of reasonable stability in terms of the outlook for economic growth, our understanding of the regulatory recess, and, at least prior to this decade, without significant concerns about energy availability. In spite of this, our and other forecasting records have sometimes been wide of the mark, even when limited to a relatively short time horizon.

The stable climate of the past no longer exists. From the manufacturer's point of view, the regulatory outlook is pure chaos. Great uncertainties surround national energy policy and the courses of action that will be taken to reduce the Nation's vulnerability to insecure external energy sources. Finally, there is widespread debate about the content, nature, and magnitude of Government efforts to assure sustained economic growth in the future. To try to build, in this sea of confusion, an island of coherent policy applicable to motor vehicles alone for a period from 5 to 15 years in the future is, under the best of circumstances, a very difficult undertaking.

Business enterprises must do advance planning. This is paticularly ue in the automobile industry where long lead-time considerations make it imperative that we look ahead for several years, and try to anticipate changes in economic and social conditions, Government regulations, and life styles that affect demand for our products. The product decisions we make on the basis of that advance planning are not always correct. For example, current large inventories of unsold compact and subcompact cars reflect our inability to predict precisely market demand earl enough to tailor our production plans to conform ideally to that demand. And I would point out that these production plans were established less than 6 months before they were proved to be wrong.

When a business enterprise makes *a* decision based on a faulty assessment that business suffers the consequences of its failure to anticipate market demand. In that case, it loses out in relation to its competitors whose forecasts are more accurate. However, when the Government is in error in the assessments it makes as a basis for regulating the industry, the entire economy, not just one business, will be the loser. If for example, the fuel economy standards mandated by the Energy Policy and Conservation Act for the year 1985 were in effect today, it is highly probable manufacturers would be able to offer no more than a few of the intermediate and full-size models whose current brisk sales are contributing to the Nation's economic recovery.

The Government forecasters who believe they can define the "right automobile" for the eighties on the basis of studies today, and then impose their determinations through legislation and regulation on the automotive production and marketing system, are attempting to overhaul an extremely delicate and complex mechanism with a bludgeon. If they fail, no one will bear the responsibility in the vast anonymity of Government; but millions will pay the price of unemployment and the entire economy will be the victim.

Misdirections in regulations affecting vehicle technology are not always merely a consequence of failure to correctly assess the distant future. There are instances of failure to take the known facts into consideration in decisions affecting the short term. Insofar as our company is concerned, we think that there is indeed a high potential for OTA to play a constructive role in informing Congress and, in turn, other branches of Government, of the technological issues involved in automotive regulation, and thus improve the quality of overall decisionmaking in this area.

For example, Congress is now en din another round of amendments to the Clean Air Act that include consideration of amendments to the auto emission standards. We are hopeful that Congress will amend the stringent standards now schedule for the 1978 model year to a level that is more consistent with the existing state-of-the-art and a reasonable assessment of air quality needs. However, until such amendments become law, the industry must continue to try to develop technology to meet the statutory 0.4 grams per mile standard for nitrogen oxides. This is true in spite of the fact that it has long been recognized by the Environmental Protection Agency (EPA) and a large segment of the scientific community that the standard was not only established in error but is also substantially more stringent than necessary to meet air quality needs. Moreover, we still do not know the full cost. For examle, the existence of that standard has served to discourage the further development and introduction of alternative technology such as the passenger car diesel engine, which would make a contribution to national energy conservation objectives.

As an economist would view it, there was no evacuation of costs and benefits before the standard was set, and even after the direct cost-benefit relationship was shown to be negative, the. industry must continue to be concerned with its implementation.

In the area of vehicle safety regulation, many additional examples exist of standards already implemented with no clear demonstration of a positive cost-benefit relationship or demonstration of cost effectiveness. On past occasions we have reported that the cost to the customer in meeting current safety standards is estimated at $385 per car. If GM costs can be considered typical, this would be a total cost approaching $4 billion in a lo-million-car year. Has this expenditure resulted in a commensurate benefit? Equally important, if we are to impose this added total dollar cost on the consumer, is this the most effective way to spend it? Hopefully, these vehicle safety costs will be reduced in the future, but this does not reduce the need to subject both existing standards and proposed standards to the discipline of these questions. Surely we need better data, as GM and others have been urging for some time. This is in the interest of the Congress, the industry, and the national economy.

In our view, the time for Congress to pause and take a prudent dispassionate look is now, before new regulations are imposed on the industry. It is in this area that we also see a constructive potential for OTA. As great as our concern is that mandated vehicle standards clearly meet the related economic tests of benefit commensurate with cost and demonstrated cost effectiveness, we believe that OTA has an even more compelling mandate to assist the Congress in its understanding of those areas in which regulation maybe required, and those where market forces are superior. In our private competitive economy, it seems to us that the burden of proof must be on those who propose to limit the free expression of consumer choice by regulation.

The vehicle fuel-economy standards in the Energy Policy and Conservation Act passed last year are a clear case in point. The fuel economy of U.S.-produced cars is improving very rapidly in response to market demand for more fuel-efficient cars, and as a consequence of the fourfold increase in world petroleum prices. There is every reason to believe that the consumer's preference for small cars would have been accelerated had the price of domestic petroleum not been artificially held down. Even with this unwarranted intrusion in the domestic petroleum market, low group cars, compacts and subcompacts, are currently accounting for 45 percent of all new car sales, and vehicle manufacturers have responded to this market. The fuel economy of cars already has improved. The fuel economy of GM cars already has improved by 38 percent since 1974, according to EPA data, and we have estimated that the improvement would exceed 50 percent by 1980 in response to market demand, and without any action by Congress on fuel economy standards.

Mandatory fuel-economy standards, together with petroleum pricing, represent another entirely unsupported intrusion of the regula--tory process into the competitive market. Even up to the time the Energy Policy and Conservation Act was passed, there was no technological or other assessment demonstrating that it was desirable, let -alone necessary, to override the free choice of the consumer in this area; nor was there a convincing assessment of the implications of these standards.

As GM's president, E. M. Estes, testified before the Senate Finance Committee, the 1985 fuel-economy standard can be met-based on all we know about the automobile-only by limiting GM's production almost entirely to cars the weight of the current Vega or smaller. Hopefully, with time we would, as a normal consequence of market forces, make further progress in fuel economy. But who took the time to assess the consequences of this act before it was signed into law ? Our own preliminary assessment, which admittedly can be refined, is that the adverse consequences of the law for the industry and the economy will be very large and the contribution to the goal of energy conservation highly conjectural. But the point is, there was no real determination of what normal market forces in both the petroleum market and the vehicle market would have accomplished before we plunged ahead with new layers of Government regulation.

Another bill now waiting Senate action, the Automotive Research and Development Act, calls for the Department of Transportation to develop one or more "production prototypes" of "advanced automobiles" that are cleaner, safer, less expensive, more damage resistant, and more energy efficient. The approval of such legislation by a Senate committee also betrays, in our view, a disturbing lack of understanding of the compelling economic incentives that motivate the private sector to attempt to accomplish those objectives. Now, Dr. Bowditch can speak from a lifelong experience about these pressures.

As one who is concerned with the economics of these issues, I am appalled by the apparent lack of congressional understanding of the competitive pressures to which motor vehicle manufacturers must submit. If any manufacturer had been able to identify the ultimate technology and design the vehicle described in the bill I am discussing, it would have been done long ago.

It is frequently charged that auto companies are reluctant to adopt new and superior engines or other automotive components because of the magnitude of their investment in tools to make the current products This is a myth that is perpetuated only by misunderstanding of investment analysis. In GM's case, we have been and are planning to spend billions of dollars to improve fuel economy that will affect virtually every component of our products. GM expenditures to replace existing tools and equipment have been estimates to exceed $2.5 billion annually between now and 1980. Some of the changes that involve these large" expenditures of money are expected to result in fuel-economy improvements of small fractions of a mile per gallon. This effort however, is being made because we expect our customers to continue to demand improved fuel economy.

If there were an alternative engine or powerplant available that would deliver improved fuel economy and meet all other engine requirements at reasonable cost, let me assure you we would spare no effort to develop it and market. it. A minimal understanding of the return-on-investment criteria and analysis is all that is needed to see that "sunk costs" are not a limiting factor t. investments that offer advantages to consumers. A distinguished British economist over a century ago put this matter cogently when he said, 'bygones are forever bygones." There is nothing more useless than an obsolete investment.

Mr. Chairman, we are prepared to discuss this subject as fully as you wish. GM's interest in vehicle prototypes and power research is well known. And we know the costs and the risks; we have made the assessments. For example, it, is well known that GM mounted a major effort in research and development on the rotary engine and advanced to within a few months of actual production before deciding that fuel economy and emissions problems were substantial enough to justify assigning lower priority to the development of that engine.

GM- also had conducted a major research effort on the Stirling engine over a 12--year period. However, this project was curtailed in 1970, because in our judgment. the remaining technical problems are too great for us to consider the Stirling a viable candidate for the near or intermediate future. There are. some in the corporation who assert that GM continued its development program on the Stirling engine long after the limitations of this engine had been fully established.

Our experience with the automotive gas turbine also is relevant. We are continuing a major effort toward production of heavy-duty gas turbines, and we have made substantial progress. Our development work on the passenger car turbine also is continuing. A GM passenger car gas turbine has demonstrated the capability for low emissions, but fuel economy continues to be a problem. Although work on the gas turbine is by our assessment, somewhat encouraging, a reliable and durable system that meets all Federal emission standards has not been demonstrated.

GM research laboratories and engineering staff have done, and continue to do. a great deal of research on electric propulsion systems. But this research and engineering effort, would have little direction without an understanding of the role of the electric vehicle in the Nation's total energy policy. A research laboratory's assessment of the energy utilization of electric vehicles concluded that a small, lead-acid battery-powered 2-passenger shopper vehicle would use from 25 percent less to about the same amount of energy as a gasoline engine with similar performance, if coal were the prime energy source. With petroleum as the prime source of energy however, the same battery-powered vehicle would consume from 40- to 90-percent more energy than its gasoline-powered counterpart.

Let me summarize this part of my statement. We urgently need a better congressional understanding of where the free play of the market should end and regulation begin. Before we move farther down the road toward a regulated economy, we need full, clear, and concise assessments of whether the market is an inferior or superior institution for achieving our national goals in each particular instance. The OTA could make an enduring contribution to maintaining our free society if it would move forward with this task.

The second area where the OTA could make an invaluable contribution is by insisting that in those areas where additional regulation is required, an adequate data base be established as a precondition for new or more stringent requirements. One EPA scientist was quoted in the news media recently as saying the Government is making billion-dollar decisions on the basis of a 25-cent data base.

The validity of that statement was well illustrated last year by the turmoil that occurred over the issue of sulfates in automotive exhaust. An EPA report early in 1975, based on a mathematical model of atmospheric dispersion of sulfates, warned of the potential future danger to health of roadside accumulations of sulfates from automotive catalytic converters. In order to assess the extent to which sulfates could accumulate along the roadside, GM, with the cooperation of EPA and other auto companies, conducted a massive experiment at our proving ground in October 1975. This experiment, designed to create the environment of a busy "1985 freeway," required 6 months of planning, a fleet of 352 test vehicles equipped with catalytic converters and air pumps, the latest and most sophisticated air sampling and data gathering equipment for 20 different sampling stations? and participation of more than 450 GM employees. Nearly a million vehicle miles were driven in the course of this assessment.

While the results of this massive experiment have not yet been fully evaluated by GM and EPA, preliminary findings indicate that EPA's original estimates of the potential sulfate buildup at ground levels along busy freeways may be up to 20 times too high. Thus the calls by some for sulfate regulations now appear to have been unwarranted: and these calls were never supported by the carefully documented evidence of need that we support. This is only one indication of the need for improved data to provide an adequate foundation for reasoned analysis.

To proceed with costly regulations in the absence of a clear showing of need is, in my view, to invite disaster. If additional data are required, we should proceed with the development of the necessary information, not rush into the establishment of possibly unwarranted and expensive standards. When costly requirements that cannot be justified, either in terms of cost-benefit or of cost effectiveness, are imposed on the public, the result is higher consumer price-inflation by Government fiat. The inevitable consequence of unjustified regulation is lost sales, a lower level of production, reduced employment, and reduced standard of living. The whole economy suffers from excess regulation.

General Motors has responded and will continue to respond constructive to any standard for which a need can be clearly identified and justfied. However. we share with the President and many Members of the Congress the conviction that our national dedication to individual freedom and competitive enterprise has already been dangerously eroded by the proliferation of ill-conceived regulation. If events of the past 15 years teach us any lesson, it is that regulation begets more regulation and there seems to be no end. The current advocacy by some in Congress of national economic planning is, in our view, one more manifestation of this debilitating process.

I am hopeful that this process can be reversed. I would like to think that in the OTA there is a possibility for unwinding the regulatory maze in which the American economy now finds itself. 1 can assure you that GM stands ready to help in identifying areas where standards are in the national interest, or where our technology and expertise can contribute to the establishment of socially desirable standards, and in the elimination of regulations where the free play of the market can clearly do a superior job. But we would also submit that there is much more potential in this market economy for realizing our national goals than there is in the further proliferation of regulation.

Thank you very much, Mr. Chairman.

Mr. BROWN. Dr. Duncombe, first may I recognize the presence of our distinguished colleague, Marvin Esch from Michigan. Mr. Esch is a Member who has had a great concern with these problems of technology assessment for a considerable period of time, and I think he also has a legitimate concern with the health of the automobile industry. We are happy to see him here.

I hope you don't think I am trying to be offensive when I say that there is a considerable element of political ideology in your statement. I might say that to some degree at least, I have been converted, as many elected political officials have in today's climate, to the truth of what you say about the possibility that we have proceeded too far down the road toward regulation. What we are looking for are constructive alternatives to this. I say that in all sincerity.

Dr. DUNCOMBE. Yes, and I think in all sincerity—and the politics of this question aside—1 did not intend that. I think that some of the points I am making are bipartisan. But I think that the constructive alternative is a reassessment of the great virtues of the market economy. I think that in the past 10 or 15 years the tendency has been, possibly for some very good and sufficient reasons, to conclude that the market cannot accomplish our goals and that the only alternative we have is more Government regulation. And that, I think—I hope, I very much hope-that we are beginning to see that the market can perform many of the socially desirable functions that all of us seek.

Mr. BROWN. I have been converted-it was a very painful conversion, I might say—to the position that we would serve the public better by not seeking to set artificially low controls over the price of energy. You dwelled on that point as obviating the need for the regulation of automobile fuel efficiency-if we had merely let energy assume its expected price level in the economy today. The difficult problem facing anyone seeking public office, is that a large part of the public, independent of party, seems to think that there is some value *in* paying as small an amount as possible for energy . If you try to convince them that they would be better off paying a higher price, you lose an awful lot of votes.

Dr. DUNCOMBE. I realize that.

Mr. BROWN. I am willing to lose a few votes. But I have to carefully measure how many I will lose in pursuing this political course. I must say, in all honesty, that I don't think the automobile industry has helped to ease that problem by their insistence on continuing to market the less fuel-efficient automobiles, and conveying through the media the impression to the American people that this represents the epitome of the American lifestyle. I maybe doing you an injustice, but that nevertheless is the reaction that I have under these circumstances.

What I am trying to say is that none of us is without sin in this rather difficult situation. It is our hope and desire, in seeking to improve the processes of TA, that we can use this as a vehicle for helping to educate not onIy the Congress but also the public to the realities, the physical realities, as well as the institutional realities, the regulatory realities, that exist in our society today. It is the purpose of these hearings to explore ways in which we can improve on tEe job that we are doing. Well, with that pontification, I will call on Mr. Esch, and ask him if he has any questions or if he would like to wait for a few moments.

Mr. ESCH. Thank you very much, Mr. Chairman. I read your comments with interest. I guess I sensed some bias. It has been interesting that a major difficulty we have had in OTA is somehow to separate technology from ideology. I think our chairman, and our executive group, and the staff have tried to draw that line. I am not certain that we always can.

I sense that your comments obviously reflect the frustrations of a regulated industry, but I also sense that the suggestion is that perhaps out of the anti-Washington sentiment that emanates, both from a former Governor of California and a former Governor of Georgia, that we may be looking at new ways to interface between industry and Government.

You have suggested that General Motors stands ready to move away from the adversary relationship that regulation could cause, into perhaps a more constructive relationship in which your expertise could be more fully used. This Office and the Congress stand ready to welcome suggestions about what kind of structure could be employed to do that We don't see anything as yet to replace regulation. Would you comment on that broad area?

Dr. Duncombe. Yes, I would like to make two or three comments, if I may. First of all, on this matter to which the chairman referred, on the merchandising of cars. This year General Motors introduced a whole new line of cars that involved an investment of man-y millions of dollars. I was very closely involved in trying to estimate the probable sales level for this car just about a year ago now. Such estimates were necessary, because they would help us define the investment in tools, equipment, and plant that we should be making to produce this car. At that time our analysis and our investment were based on our sensing that we could sell 250,000 Chevettes in this model year. Our current sales of that car are going at about 103,000 units, less than half of what we had estimated. We had contemplated at the time that we introduced the car that we would bring on a second production facility in California to expand the production of that car, giving us the potential of 400,000 units a year.

That car is a highly fuel-efficient car; it is as fuel efficient as almost any car offered in the world today. From a manufacturer's point of view we can offer that car priced competitively, and I think it is priced highly competitively. But there is no way that we can take the customer by the hand and tell him this is what he has got to buy.

I think t is bears on the regulatory process, too. Unless we as a nation are willing to limit peeple's freedom, in the national interest, to severely limit their choices, there is no way that we can the. average American to go in and buy what we tell him he has to buy. I think, as we have said on many occasions in the past, we are convinced that were we to do this-and,, as you know, the 1985 fuel-efficiency standard would virtually limit us to that type of car—we think that this would be counterproductive. We believe it would be counterproductive because we think—and this is an assessment-that a great many of our customers will elect to drive their older cars longer rather than trade them in on new cars. So that rather than getting a contribution to fuel efficiency, we may be getting a negative contribution to fuel efficiency.

These are assessments. And I am not going to debate the question of assessment now, beyond making the point that there was really no systematic analysis. Having decided to regulate petroleum prices, we —the Nation-then decided to regulate fuel-efficiency standards. As I said, one regulation begets another. It does seem to me that in this process one of the many virtues of a competitive economy is that you can minimize the politics of economics that you have alluded to, which causes all of you equally all of us, so much soul searching.

I think that minimizing the politics of economics ought to be our objective. If you don't mind my continuing this, our country really grew and we have achieved more in this society of ours, in terms of relieving hardship and of achieving a thoroughly decent standard of living for our people, by relying on free expression and incentives for individuals. I think we can continue to do that.

One of the difficulties that we got into is that we seem to have been swept over into regulation. Carrying the politics of economics one step further, it is my view that a professional organization such as OTA can provide the Congress, and all of you who must be concerned with politics, with objective standards for judging where regulation is essential to the public interest. I am thinking here about areas such as emission controls, water controls, and so forth—at what level they ought to be? The OTA can give you the unbiased professional guidance that is required, and also help you to sort out those areas that are more properly left to the private economy. That is where looking down the road, I see the great strength of OTA helping us in this way.

Mr. ESCH. Thank you for your comments. I want to associate myself with many of them. Senator Muskie said recently, in a Detroit Economic Club speech, that he thought we should force technology in this country. I think that has been tried in other economic systems in other countries but we don't see it here. To put it in another way, perhaps that is why we are selling our trucks to the Soviet Union rather than vice versa. I think it is fine that you suggest a function that we in OTA can serve. But I am still concerned about the degree to which we can utilize the expertise in the private sector and maximize that use. We still really don't see a mechanism through which we can give you some broad parameters in which to function while still utilizing your expertise, especially related to emissions, to safety, and to similar problems. The situation that we find ourselves in, particularly with respect to the Department of Transportation and EPA, is that your personnel are spending a great portion of their time reacting to a regulation or a requirement rather than being productive, and innovative, and creative themselves.

How do we realize, how do we develop a system such that we could begin to maximize the expertise in the private sector, while still recognizing that we have a public responsibility concerning our environment and energy needs? How would you change it? We haven't heard anything constructive from the corporation as to how you would change what we have now restructuring it to have less emphasis on regulation. What would you do so that we might more fully utilize the expertise of the industry?

Dr. DUNCOMBE. Dr. Bowditch I think, can comment on that more fully than I can.

Dr. BOWDITCH. Well, as far as the corporation's expertise, we obviously work very, very diligently in any of the areas in which there is potential regulation or where regulation has already been initiated, if for no other reason than in self-defense, to maintain body and soul, if you like.

Mr. ESCH. That's the point, you are always reacting. What I want to know is, what you are going to do to contribute constructively before, rather than being in a reacting posture with respect to Government regulation?

Dr. BOWDITCH. Well, there are probably two different answers, or two different kinds of answers in this regard. First of all, we are working in the areas that we see in our future as being applicable to our product. We do that through many of the functions of our corporation. Second, I think that as a result in part of the rapidity with which we have seen some of these regulations come along, that the regulations have indeed caught up to technology. We are operating, as are you, on the policymaking end of the ruling business. We are both right up at the same level of technology. You are concerned with what we see, even with all of our capabilities, as being possible in the next few years, because the regulatory process has overtaken the technology end of the business. We spend a great deal of time.

men, and money looking at the future. But I think you are right up there dealing in the same future we are.

Mr. ESCH. Should we give you more time? Should we give you 3 or 4 years in some of these areas and say go to it? Do you think you could really reduce more that way? You know, that is the real question facing Congress in terms of safety, in terms of emissions, or of energy, when we go to the floor and discuss whether or not we should give you more lead time. What are you going to produce with more lead time? Should we tell you to determine the standards for the next 3 years and go at it? Do you think you could do more that way?

Dr. BOWDITCH. This gets back to what Dr. Duncombe has already indicated, how important is it that the solution be tomorrow, or a year from tomorrow, or 10 years from tomorrow? What are the appropriate times spans? We have a agreed that this is one of the functions that OTA should be doing, helping to make decisions about how rapidly these developments should come along. There were some instances, as I believe the scientific community has shown, that some of the present regulations kind of got off on the wrong kind of a calendar. I am sure there are others who say that we are right on the kind of a calendar we should be. But this is the kind of TA that I think is one of the a appropriate areas for OTA to be involved in.

Dr. DUNCOMBE. I do think that the virtue of OTA can be its potential for bringin ater objectivity to some of this decisionmaking. Possibly it could both provide a balance between the reluctance of the private sector to take the steps that are necessary on occasion, and the political pressures on the other hand that go faster than is desirable. If it can play this professional role, it seems to me that there is some real hope both for getting a better approach to the whole regulatory process, and also a better definition of where the regulatory process is appropriate and where it is not appropriate.

As I have tried to indicate and as we have said many times last year, we did not fed that in the case of the fuel efficiency of automobiles, that the regulation was appropriate. Given a functioning market, that was a task that could be performed by the market. On the other hand, we are fully in agreement that in areas involving externalities, such as emissions, particularly-safety is a more ambivalent area-but certainly in the area of emissions, these regulations are required, and the goal ought to be to make sure that the regulatory processes are established which will meet the needs at a minimum cost and with maximum effectiveness. Certainly in the whole area of defined externalities, of which the automobile is clearly a part, there is a proper role for regulation. What we are concerned about is that the proper role of regulation is moving over into an area where it is not required.

Mr. ESCH. Thank you very much for your comments. I think thw last statement was significant, because I see that as we enter a new generation in the next Congress that it will surely be an antiregulatory Congress. That will place added burdens. I think, on someone, such as OTA, who wants to function to supply the expertise. I see OTA as a major channel through which we might affirmatively utilize the private sector, the academic sector, and those in the departments and agencies responsible, in order to bring these together in a nonadversary relationship that can perhaps produce the evidence needed to make more adequate determinations in the regulatory agencies. Thank you very much.

Mr. BROWN. Thank you, Mr. Esch. Mr. Daddario?

Mr. DADDARIO. I have a comment rather than a question, Mr. Chairman. The discussion between Mr. Esch and you recalls to my mind the same type of discussions that took place at the time that Congress was trying to come to a decision as to whether or not it would support a concept such as OTA. During the early discussions, the question of regulations came up in somewhat the same way as it has here this morning, and the same amount of importance was attached to it. One of the concerns at that time was that we were then beginning to regulate--and some of us were questioning the regulations-automobile emissions during the time periods 1975, 1976, and 1980. There was some question then as to whether or not we actually had enough technological knowledge about those facts to so legislate.

At any rate, we passed legislation and the law came into existence. But as we examined this legislation, we were concerned about how this should be implemented. The discussion came to the tentative conclusion, that we should first come to an understanding of what our technological capabilities were, then regulate in keeping with the current level of technology. At the same time, we would encourage research and development in these technologies and increase the level of environmental regulation, whatever the impacts, as new tichnology was developed. Thus the one would keep ace with the other. The main idea was that we would not be overregulating, but we would be regulating with accurate facts and greater knowledge.

I think Mr. Compton's remarks this morning were aimed in this direction. How do you do it ? How do you get the data together! How do you do it in an unbiased and objective way so that there could be a better understanding. If there is a better understanding, it follows that there will be a better dialog between the Government and the private sectors. Such a discussion, I think, is very healthy and raises the level of our dialog. Indeed, since the issue that is being raised today, concerns the Congress when it first considered the TA concept, we may very well be close to arriving at an understanding on these matters.

Dr. DUNCOMBE. I think it is worth working for. It is essential that we work toward it.

Mr. BROWN. Mr. Leathers?

Mr. LEATHERS. I have a comment rather than a question. One of the aspects advocated in these regulatory matters pertaining to technical developments, is that where t e technology does not presently exist to correct an actual or perceived problem needing correction, that you start where the industries or companies are in the technology and work towards the regulations. So it is a rate of improvement, where the company sets its goals for improvement from year to year. If this is accepted by the regulatory body, then the industries are measured against their improvements. I am specifically speaking about areas where the technology is not readily available. My experience with this has been mostly in industrial plant air and water emissions.

Mr. BROWN. Gentlemen, there are a number of other questions or further aspects of this discussion that we could pursue, but in the interests of time I think it would be desirable if we proceed to our next witness.

I want to thank you very much for being here. I hope that we can continue a dialog with you. Possibly if we needed to complete the record, we might want to submit some written questions to you for your response to them.

Dr. Duncombe. Thank you very much.

[The following questions were submitted by Congressman Brown to Dr. Duncombe and his answers thereto:]

Question 1. What formal structure exists for doing technology assessment (TA) at General Motors (GM) ? Has TA been institutionalized throughout your organization?

Answer 1. General Motors does not have a staff or an office that is labeled TA. Nor do we label any specific reports as TAs, Rather, changes in technology affect our business decisions at almost every point. We believe that to be most useful a TA must be made by those individuals most familiar with the concerns of consumers and the possible technological solution. As a result, both technological possibilities and requirements are assessed at essentially every level and almost every part of the Corporation via cooperative efforts of various staff groups.

To be specific, as I indicated in my testimony technology at all levels involves basic engineering considerations such as engine and drive train efficiency and performance, the structural integrity of our vehicles, and the feasibility for volume production. At another level, considerations of cost and consumer acceptability must be evaluated. At still another level, we have long been concerned with the relation of our vehicles to highway safety, air pollution, and the evolving development of urban and national transportation systems. There are, as I am sure you are aware, interactions among these many levels of our concern that must be evaluated on a continuing basis The comprehensive nature of these processes is well-described in the "1975 General Motors Report on Programs of Public Interest" that was submitted for the record with my statement.

Question 2. How is TA defined at GM? What limits do you see for this concept in this definition and application? How it is bounded? Does it relate to your planning, decision- and policy-making processes?

Answer 2. Technology assessment is as broad as the corporation. It begins with individual research projects and extends through our engineering and design efforts into assessments of cost, marketability, and ultimately the place of vehicles-both cars and trucks—in the Nation's economy. To define TA any less broadly is, in my opinion, to increase the always-present risk that some vital link will be overlooked. These concerns enter into GM operations and decision- and policy-making processes. However, as indicated in my Answer to the first question, the TA process is not formalized or institutionalized so that the type of assessment made and the way it is utilized will vary from case to case.

Question 3. How is TA information worked into your reports?

Answer 3. Where apparently warranted, the equivalent of a TA is an integral part of a report or study. In some instances, these have a narrow focus such as a report on the development of a new engine or transmission and the implications for drivability. However, others are much wider in focus. For example, reports on the catalytic converter hare dealt with fundamental societal concerns such as the effectiveness of the converter in controlling emissions, the potential for the converter when widely applied to making a contribution to air quality, evaluations of the potential life of the converter, and its dollars and energy costs to the vehicle purchaser and to society.

Question 4. Based upon your use of T4 what lessons have been learned? Has TA affected the way you do business? How do you decide what problems should be examined with TA?

Answer 4. We have long recognized that TA is, at best, a very uncertain art. I recall, for example, reading in Alfred Sloan's, "My Years with General Motors" the discussion of the so-called "copper cooled" engine and the inherent difficulties involved in making assessments of complex automotive systems. Prior to the passage of federally mandated safety, emission, and fuel—economy standards, all manufacturers were concerned about producing cars to meet a variety of State vehicle regulations. Inherent in this was the need to assess such factors as the structural characteristics of the vehicle, the adequacy of lighting, and the performance of brakes—all of which reflect both customer and societal concerns. This process has been extended in order to conform our vehicles to Federal regulations and, of necessity, this regulatory process requires evaluation. For example, we have strongly urged a stretch-out of 1976 auto emission standards and encouraged a reasoned evaluation of whether the tighter standards still mandated for the future would be desirable even if accomplishable.

Unfortunately. the particular problems analyzed are to an undesirable degree a result of governmental regulations or proposals. I say “to an undesirable degree” because time and effort spent in such areas necessarily utilize scarce analytical resources that could otherwise contribute to cars meeting consumer demands and the transportution needs of society better.

Question 5. Would you describe how your organization goes through the environmental impact statement (EIS) process ? Do you attempt to explain impacts and to educate the public and employees ahead of time? What relationships do you see between the environmental impact and TA processes?

Answer 5. The requirement to file EISs is imposed on Federal Government agencies in connection with major actions or regulations that are likely to impact the environment. Insofar as the Federal Government is concerned, GM does not have the responsibility for tiling EISs. However, GM does evaluate environmental considerations in connection with major facilities projects, and State governments have varying requirements concerning environmental studies and assessments.

The procedure GM follows in considering environmental impacts often varies to fit the needs of the particular problem involved. In this connection we have expressed our views on the cost-benefit relationship of specific automotive standards in the hope of contributing to the establishment of standards that show promise of yielding a margin of benefit in relation to cost. In addition. as a consequence of the explosive growlh of Federal regulations, their often contradictory objectives and negative impacts on the product viewed through the eyes of the consumer, we have felt an obligfition to try to inform the public as to what is involved. I call attention, for example, to the cooperative GM-EPA program to check allegations concerning dispersion of sulfate emissions from catalyst-equipped cars as a case in point. A brief summary of this sulfate dispersion experiment is attached for your information (see appendix C, exhibit 4).

Question 6. In a TA should the impact of a new technology on job structure be examined?

Answer 6. The term “job structure"' is vague. New technologies very often involve new skills or the expansion of old skills and thus job requirements. However, changes due to such causes are apt to be relatively slow and nondisruptive if they are accomplished through the marketplace.

Unwise regulations that require forcing unwanted car types on consumers could result in unemployment of major proportions. General Motors has strongly advocated that such costs should be carefully factored into evaluations of new regulations. Unfortunately, this was not done in the case of the fuel-economy standards now scheduled for implementation.

Question 7. In your TA process, how do you involve the public?

Answer 7. In contrast to most TAs done outside the auto industry. we have every incentive to consider the views of the public. Technological developments that have market attributes-such as fuel economy of new engines—must be evaluated via product clinics, market surveys, and ultimately consumer purchase decisions.

Externalities, such as emission controls, are not market attributes and must he treated in a different manner. Emission and safety regulations all involve costs that in one way or another the public must bear. Insofar as our research contributes to a better public understanding of costs and benefits, we try to make this available for public information and debate.

The most difficult aspect of any public policy decision involving externalities is the ultimate reaction of consumers. Consequently, we have tried from time to time to test public reactions on a voluntary basis. For example, some years ago we offered a low-cost vehicle emission control retrofit in Phoenix as a test market. It reduced emissions on older cars by about 50 percent. Even though there was a major advertising campaign, we found that the car owning public was not interested. Similarly, we have *offered a* passive restraint system (the air bag) at a cost to the customer substantially below GM’s cost and we have found what can only be described as a negligible response to this program.

Question 8. You mentioned that GM mounted a major research and development program on the rotary engine that advanced to within a few months of production, Did you conduct a TA on the engine prior to stopping all work on it?

Answer 8. A continuing assessment was conducted at all stages of the research and development program on the rotary engine. The final decision to postpone introduction of the rotary engine was announced on Tuesday, September 24, 1974. While the level of R, & D. effort on the rotary engine was reduced when the decision on the postponement was reached, GM has not stopped all work on the rotary engine, R & D on the engine is continuing.

Question 9. Regarding the California Institute of Technology-Jet Propulsion Laboratory (CalTech) TA that dealt with the question "Should we have a new engine ?" How did that study impact the decision- and policy-making processes at GM? Did it have any impact on the planning process?

Answer 9. GM cooperated closely with JPLCalTech during the two-year period of their study of the question "Should we have a new engine?" Much of the information contained in the report was supplied by GM and most of the information was familiar to us prior to publication. Soon after the report was issued however, we did analyze it very carefully. For the reasons stated in the following summary of the GM critique of the report, it has had minimal impact on the decisionmaking. planning, and policymaking process of GM.

GENERAL MOTORS' ANALYSIS OF JET PROPULSION LABORATORY REPORT "SHOULD WE HAVE A NEW ENGINE? AN AUTOMOTIVE POWER SYSTEMS EVALUATION"

SUMMARY

The Jet Propulsion Laboratory (JPL) report entitled, "Should We Have a New Engine? An Automotive Power Systems Evaluation", dated August, 1975, has been reviewed by several interested research and engineering groups within General Motors. Generally, they concluded that the Report is a good technological review of the stat-of-the-art in alternative power plan development, identifying the pertinent characteristics of the various engines studied as well as many of the obstacles which must be overcome. Certainly, this type of report is useful at any time.

One of the major GM concerns with the Report centers on its assessment of all of the various technical interactions and, from these, the probable resulting characteristics of the various alternate power plants. This process depends heavily on the reliability of the predictions made for overcoming the technical obstacles, and the associated impact on the total design development and production capabilities of the industry. To illustrate this concern, a review of the conclusions reached in a number of similar alternate power plant studies made Iv "contemporaries" of JPL shows that they reached widely different conclusions even though they used essentially the same set of facts. There is certainly no consensus in the conclusions reached by these studies.

The JPL Report, as with most other studies of the alternative power plant situation, contains an array of assumptions concerning how and when various obstacles will be overcome. Included is the tacit assumption that all of these problems will be solved "on schedule" with adequate funding. Thus, the assumption is made that it is possible to "schedule" technological breakthroughs. Past **experience does not support this, and GM engineers and scientists are not able to find support for this *critical* assumption in any of the past history of alternative power plant development.**

A second major GM concern is that the Report fails to recognize that the ultimate success of any alternative power plant must be determined in the marketplace. The economic and market risks cannot be "assumed away," as is the case in almost all technological-fix studies. Before any precisely stated conclusions such as those included in the JPL Report can be formulated, the total area of technological and economic risks, manufacturability and materials must be effectively evaluated. This should occur both *in* terms of the organizations which are required to take the risk, and acceptance of the results in the marketplace. Without this type of sensitivity study, no realistic actions may be taken regarding the conclusions.

In summary, while the study is interesting, there does not appear to be any significant new information contained in it, and the conclusions appear to be highly speculative.

Mr. BROWN. Our next witness is Dr. Dean Gillette, executive director of systems research of the Bell Laboratories. Dr. Gillette, would you object if I called Mr. Day from Bell Canada to come up?

Dr Gillette. I would be pleased to join with Mr. Day.

Mr. BROWN. All right. Mr. Day, would you come forward also. We will ask each of you to present your testimony. Then we will question both of you together in the hope that we may be able to complete this by a reasonable time.

We are very happy to have you here, Dr. Gillette, representing the Bell Telephone Labs, which I visited about 10 years ago. I know what an outstanding restitution it is. Possibly you can help shed some light on how we can distinguish between systems research and technology assessment (TA).

Dr. GILLEtte. Thank you for your kind words, Mr. Chairman. I am pleased to have this opportunity to describe some of the methods we in the Bell System use to assess the technology we develop, manufacture, and operate to provide telecommunications for the Nation.

I have prepared a written statement for the record of these hearings, and with your forbearance I will submit it, and here only select some portions and give illustrative examples.

Mr. BROWN. Without objection, the full text of the written statement will be included in the record.

[The biographical sketch of Dr. Dean Gillette is as follows:]

DR. DEAN GILLETTE, EXECUTIVE DIRECTOR, SYSTEMS RESEARCH DIVISION, BELL TELEPHONE LABORATORIES, HOLMDEL, N.J.

Born Chicago, Illinois.

B.S. chemistry, Oregon State College, 1948; M.A. mathematics, 1950, Ph. D. mathematics, 1953, University of California at Berkeley.

Joined Bell Laboratories, 1953, worked on a variety of government systems. Appointed executive director, the Transmission Systems Engineering Division, 1966. Assumed present position, 1971.

Member of American Mathematical Society; the Society for Industrial and Applied Mathematics; the Institute of Electrical and Electronics Engineers; the Research Society of America; the American Association for the Advancement of Science.

Numerous articles published in: IEEE publications, Annals of Mathematics, Trnasactions of the Communications Society, Research and Management, Bell Magazine, and Bell Laboratories Record. Also articles published in the proceedings of communications conferences both in the United States and abroad.

[Tile prepared statement of Dr. Gillette is as follows:]

STATEMENT OF DEAN GILLETTE, EXECUTIVE DIRECTOR, SYSTEMS RESEARCH DIVISION, BELL TELEPHONE LABORATORIES, INC., HOLMDEL, N.J.

Mr. Chairman and distinguished members of the Technology Assessment Board, I am pleased to have this opportunity to describe some of the methods we in the Bell System use to assess the technology we develop, manufacture and operate to provide telecommunications for the Nation.

As a regulated common carrier, the Bell System is responsible for providing services that are in the public interest. We also feel it is our responsibility to take care that the apparatus and equipment needed to provide service is made and used beneficially. Further, because the Bell System's structure embraces all aspects of technology from research through recycling, we have some unique opportunities to shape the direction of technical progress and to control some of its less beneficial side effects.

We at Bell Laboratories have a special role in telecommunications. Our broad mission is to provide the knowledge and technology needed by the Bell System in meeting its service obligations in both the near term and in the more distant future. This mission includes assessment of the impact of new technology on the Bell System's services, on its work force and on the environment within which it operates. While our terminology may differ somewhat from that currently used in formal TAs, I feel that much of what we do in evaluating systems options is consonant with its basic concepts. Some of our methods have been in use for decades as a part of our systems engineering and human factors work. Other efforts, particularly in environmental protection, are newer, but all reflect our continuing interest in developing and applying technology for the Nation's benefit.

SYSTEMS ENGINEERING

"Systems Engineering"—a term created at Bell Laboratories-involves analytical and experimental investigations of the potential value of new systems to be integrated into the Bell System plant. One purpose of systems engineering is to provide information to help in deciding whether to allocate funds and manpower for design and development of a new product or service. A second purpose is to establish broad requirements for the product or service, given that it is to be developed. A third purpose is to evaluate the impact of introducing a new product or service into Bell System operations. This includes interaction with other parts of the plant and demands on the new system for new skills to be acquired by craft and operational personnel. If we think of impacts on type, quality, or cost of service as the "first order consequences" of a new product, we may take as "second order consequences" the impact of a new development on the other work at Bell Laboratories, on the capital and expense needs of the Telephone Companies, on the physical environment of the plant, and on the nature and quality of work of the plant forces. Systems engineering does take these factors, as well as many others, into account and so includes many aspects of TA within an even broader context.

Perhaps I can illustrate some of our methodology of systems engineering by describing some of its facets. To begin with, we take it as a necessary condition that any new system will be introduced into the plant without disrupting service. We do not attempt to assess the consequences of a service interruption ; we know they are serious, so we try to minimize their occurrence. To meet this sort of objective means that we must know the characteristics of all of the plant. A single example suggests the need. On its first day of operation, the newly developed No. 4 ESS toll-switching machine was connected to 219 other switching machines of many different types and vintage. It was designed to-and did—interact with each of these flawlessly, immediately on being put into service. Intimate knowledge of plant details was, of course, critical to the rapid restoration of service after the New York Telephone Company fire in 1975.

The methods used in plant characterization range from simple counting of facilities to intricate measurements of the electrical behavior of built-up connections. Bell Laboratories engineers plan the plant characterization programs and work closely with AT&T and the telephone companies in carrying them out. In many instances, the telephone companies conduct the surveys and report their findings for BTL analysis. In cases where experimental or novel performance measurements are needed, Bell Labs people will carry out the characterization. Modern data-processing methods and field use of minicomputers make the process more effective and the results more relevant. The most recently completed such project characterized the performance of the network in controlling echo on long distance circuits. l-he result of this study, like past ones, are published in open literature to be of benefit to all manufacturers of telecommunications products.

An existing design is obviously the most viable alternative to a new system development. Initial questions in a systems engineering study are directed at just this issu--will a new system offer an advantage over the one it is intended to replace? The continued emphasis on cost reduction can make an existing design a formidable competitor. Systems based on the new technology will be used only when they are less expensive than the newest models based on the older technology. Nor example, we are now exploring guided Iightwave technology as an alternative for interoffice trunks. The existing system concept, pulse code modulation (PCM) on wire pairs, was introduced commercially in 1962 by the Bell System. In 14 years, first costs of PCM have decreased in spite of inflation. Western Electric's original PCM system repeaters were sold at $143 each; their current version costs the Telephone Companies $73 each. We think that lightwave communication systems will be even more economical.

Analyses of relative costs were originally of the simplest sort: will the price of the new product be lower than that of the old? More recently, with better understanding of in-service costs and with use of modern computing technology, we have been asking more sophisticated questions and gaining deeper insight. First, price remains important, and for many years we have recognized the time value of money in such terms as present worth of future costs. Many of our analyses now follow discounted cash flows in annual operation—including development and start-up costs, as well as maintenance and administration. These analyses investigate alternative strategies of meeting anticipated growth in demand-including options for use of any of several products. And we study these parametrically in discount rates, relative costs and inflation factors. Application of such mathematical models to system analysis is *not* unique to the Bell System or even to telecommunications. However, because of the technical integration of the Bell System, analyses of economic impacts must consider all aspects of technological innovation from design through introduction and administration. And, since all aspects are coordinated within the enterprise, the Bell System can maximize the economic benefits to the subscriber by balancing development, manufacture, installation, and operation.

In our studies of needs for communications, we try to anticipate long-term demands as well as to establish requirements for current designs. We expect the Bell System to be providing service well into the future. In our assessment of economic values of a given technology, we look to long-range impact, and as we compare technical alternatives, we do so in the context of our perception of the most promising directions of technological evolution. For example, it seems that in the long run it may be technically and economically advantageous to use digital techniques for transmitting and switching almost all kinds of telecommunications. Thus, in the future nearly every part of a connection may be over a pulse-code modulated, multichannel facility. This long-term view influences our research and advanced development programs, but does not divert us from short-term realities. Right now for example, it is less expensive to connect most subscribers to the central office with single-channel wire pairs carrying analog signals.

Of course, performance of the telecommunications network can always be improved at the cost of more expensive equipment; the interesting questions center around trade-offs. Another task of systems engineering is to establish quantitative relationships between increased cost and improved performance process that must take into account differences in the nature of the service. The operational quality of data transmission service can be measured by such objective criteria as mean error rate or error free minutes, and can be readily monitored and recorded, When the service is voice or image transmission-either video or facsimile-important criteria are in terms of human responses. To discover whether modified electrical behavior will lead to a perceived service improvement, we must carry out subjective preference-testing under carefully controlled conditions. For example, our studies of satisfaction with echo control methods were fundamental to the measurements in the previously-mentioned assay of the echo characteristics of the plant We have been doing that sort of work in the Bell System for well over half a century. And such efforts must continue as social needs for communications change and as individual preferences are influenced by experience with the increasingly complex technical environment.

Major advances in telecommunications depend on discoveries in the physical sciences and developments in technology, and Bell Laboratories has a worldwide reputation for contributions in these areas. The examples of systems engineering studies suggest the importance of other sciences-including mathematics, economics, acoustics, and behavior. Research in these too, is carried out at Bell Laboratories, again with results appreciated outside the Bell System and applied within, both to enhance the value of communications to our subscribers and to improve the effectiveness of our work force.

HUMAN FACTORS

The Bell System as a whole employs almost one million people, of whom 800,000 are in AT&T and the Telephone Companies. These are the people responsible for assuring that the Bell System network functions to meet our subscribers' daily demands for telephone service. We are convinced that the best service is delivered by a well-motivated, highly trained work force. New telecommunications technology introduced with the purpose of improving service or increasing productivity will be effective only if its impacts on the plant work force are beneficial.

The humanistic approach to work motivation resulted in great part from a 1925 study of work conditions in an apparatus assembly line in Western Electric's Hawthorne plant. The purpose of the study was to find the shop environment—light-level and wall-color, for instance-that would give greatest productivity. In one sense, the experiment was a failure because it was found that many of the changes tried increased productivity, and none could be isolated as critical. But in the greatest sense, the experiment was a turning point in scientific management because it showed that productivity went up when the work force recognized that it was their interests that were being considered and that they were being valued as individuals.

The insight into motivation gained at Hawthorne has been followed up. One example is AT&T's broad effort to reduce tedium and routine and to make jobs more personally satisfying. The improvement program was fittingly called "The Work Itself." And too, the physical work environment is protected, certainly by adherence to the standards set by the Occupational Safety and Health Administration (OSHA), as well as by results of older interests. One such is noise level& By heritage and by the nature of our business, we know a great deal about human perception of sound-of light and images too, for that matter. We are concerned about sound levels in the work environment as well as on telephone circuits. This interest led us, for example, to assist a motor generator manufacturer in controlling the noise level in a 2.5 megawatt reserve power system before it was installed in a Bell System building. We also consider low-level sounds. Studies have been made in telephone equipment rooms and in other work locations to determine if certain noises, such as the clicks in an operator's headset, could be annoying or disrupting.

Application of research to practice is important in other areas of behavioral science. Improvements in training methods are particularly valuable since nearly 500 million dollars are spent annually in the Bell System to teach new employees the skills they will need on their jobs, and to train experienced people in new technology being introduced into the plant. AT&T also supports Bell Laboratories research in learning processes and in applying skills in plant operations. One learning study showed that fact retention is enhanced by testing immediately after a lecture. Analyses of maintenance documents and their use in the field have led to new ways to prepare materials for use by the craft forces in maintaining the network.

Assessment of work environment and its impact on the work force are not nearly as susceptible to mathematical modeling as is, say, comparison of products on an annual expense basis. Despite the lack of formalism though, we feel that attention to the working environment has helped the work force help the business. For example, Telephone Company output per man hour increased at the rate of 6.5 percent per year from 1960 through 1976--compared to 2.4 percent for the private domestic economy for the same period. Perhaps clues to success are in the depth of knowledge of specialists at AT&T and Bell Labs, in AT&T's continuing support of research in the field, in competent management in the telephone companies or a combination of these. Combining research and application in long-term programs enhances the opportunities for early implementation of new practices and for research based on observations of effectiveness.

ENVIRONMENTAL FACTORS

The telephone industry is relatively nonpolluting and has not had to make major changes in products or processes to conform with new environmental protection standards. Localized trouble spots have gotten needed attention. For instance, stack gasses from the reserve engines I mentioned earlier can exceed standards if not controlled. Bell Labs has developed new instrumentation to accurately measure pollutants from these so that effective mitigative measures can be taken.

Certainly Western Electric's (WECo) manufacturing plants are more likely to contribute pollution than are telephone central offices. Control of manufacturing by-products is an area in which WECo has long been active, well before it became the prominent public issue it is now. The company's concern for the environment is the logical extension of its traditional concern for safety among employees. All of WECo's plants had the most modern waste-treatment facilities designed into them at the outset, and older locations are modernized to meet new standards. At the new Phoenix plant, "used" water from cable-making operations is released cleaner than when it came into the @ant. Heating and power plants have converted to low-sulfur fuels to reduce sulfur dioxide.

Bell Laboratories and Western Electric have worked together on new manufacturing processes that will reduce or eliminate pollution hazards. One example is a new closed loop printed circuit etching cycle that allows the recovery of the etched copper and restoration of the etching strength of the bath, thus avoiding the disposal problems for the spent baths.

Another way to limit waste products is to salvage--recycle--junked equipment. The Bell System has been in the recycling business in a big way since 1931 when Western purchased Nassau Smelting and Refining-now Nassau Recycle Corporation. All kinds of scrap materials are sent through Nassau, which reprocesses and reclaims a large variety of critical material and redirects it back into the Bell System. For example, the following percentages of Bell System usage were obtained from Nassau:

IAmount in percent]

	1974	1975
Copper	31	51
Lead	100	100
Gold	52	47
Palladium	23	28
Platinum	48	100
Rhodium	58	64

Recycling of junked telephones is a project that well illustrates the importance of close association of materials research, manufacturing, and scrap recovery logistics.

The process of recycling the plastic in the telephone must cope with the nonplastic items that are part of the working telephone-the cotton balls in the handset and the brass and steel inserts and screws in the housings. Materials scientists and telephone design engineers at Bell Labs know exactly what these are and developed a separation process tailored to the composition of the scrap. Further, the recycled plastic has properties different from original raw materials, but design groups are now busily engaged in setting specifications for different compounds in which the reclaimed materials can be substituted for raw resins in many molded parts.

The Bell System program of recycling plastics is still at the beginning stage. The pioneering work continues at Western Electric, and the rate of production is expected to reach half a million pounds per year. Nassau Recycle is setting up a similar reclamation plant. The amount that potentially can be reclaimed may total as much as 6 million pounds a year from scrap phones alone, and reclamation of other components is anticipated.

SOCIAL IMPACTS OF THE TELEPHONE

So far I have spoken mostly to our assessment of technology and control of second order consequences as they might affect the Bell System itself: cost savings, work force impacts, and environmental controls and recycling. These actions are also beneficial to our subscribers. As a regulated industry, we pass on cost savings to telecommunications users, whether the savings are achieved by introducing more efficient technology or by increasing the productivity of the work force. Certainly any environmental protection benefits all.

We are aware that we have created in our network *a* national resource. We are also constantly working to improve the network, to find new ways to use it, and to add to its capabilities, To help us choose directions of augmentation that have the greatest potential benefit, we carry out research into the various factors that influence the ways that people communicate with each other, and into individuals' judgments about their communications. These factors include communications modality-for example, telephone, face-to-face, closed-circuit television—the situational context or task, and the relationship between communicators. One purpose of such research is to help understand customer needs and how to tailor new services to meet them. We find for example, that there is little difference in gross visual behavior between face-to-face-in person—and closed-circuit TV discussion. However, there does appear to be a difference in speech activity between the modalities; there is more simultaneous talking in person than over TV. Even so, we install a "mute" button in video conference systems, just as we do *on* a speakerphone installation. We do find video conferencing to be effective-for example, as a means of conducting the business of a regularly scheduled committee. Audio conferencing, by itself, is not nearly so powerful. However, when supplemented by a real-time graphical capability, a facsimile adjunct, or even premeeting distribution of documents, audio conferencing can be extremely useful.

The Bell System also supports studies of broader social impacts of the telephone, mostly carried out by scholars outside of the Bell System. One example is a program of seminars and invited papers at MIT that culminated in the March 10, 1976, symposium celebrating the centennial of the telephone.

Another type of societal-technological interaction has received recent atten-(ion-the exchangeability of telecommunications and travel. We are familiar with the studies of the Office of Telecommunications, Bell Canada, the British Post Office, and others. We have also carried out internal studies of the values of telecommunications in managing affairs in our physically separated operations. Our methods are conventional; we use surveys, questionnaries, and experiments with various systems and we make additions and changes to our telecommunications facilities as they seem economically beneficial. (Let me hasten to point out that I am talking now about how we at Bell Laboratories use telecommunitions-- and we pay fulI rates for all services.)

Our studies of our own enterprise have shown that the costs of added communications are hard to recover by savings from reduced travel. It may be. though, that this result differs from that of others because of the amount of communications we now use. We have facsimile equipment at all locations, speakerphone and conference telephone sets available to those who need them, and experimental video services between major locations. Others have a different base and different findings Recent studies by the British Post Office, for example, suggest that the "loud speaking telephone" will be of great rise, and they are planning an experimental installation. We agree they are valuable; the Be11 System has offered the service for forty years, and we use them extensively at Bell Labs. We expect that video services will help us manage our decentralized business more efficiently, and will add to the facilities we now have as costs come clown.

I have now come full circle in my discussion of TA. As users of communications. we find that the limits of applicability to, and impact on, our business are in the costs of service. It is exactly these costs that are under the most intensive attack in our programs of research development, and systems engineering. As we at Bell Labs find opportunities for technical advances, we expect that our commonality of objectives with Western Electric, AT&T, and the telephone companies will enable us to improve telecommunications services and lower costs. I have tried to illustrate how these various elements of the Bell System work together to achieve these objectives without producing side effects that are harmful to our work force, our environment, our natural resources and the society we serve. The most important single method in our efforts to control side effects of technological innovation is integration of research, development, manufacturing, and operation in a single enterprise.

STATEMENT OF DEAN GILLETTE, EXECUTIVE DIRECTOR, SYSTEMS RESEARCH DIVISION, BELL TELEPHONE LABORATORIES, INC.

Dr. Gillette. Thank you. As a bit of background, we realize that as a regulated common carrier the Bell System is responsible for providing services in the pubic interest. We also feel it is our responsibility to take care that the apparatus and equipment needed to provide service is made and used beneficially. Further, because the Bell System's structure embraces all aspects of technology from research through recycling , we have some unique opportunities to shape the direction of technological progress, and to control some of the less beneficial side effects.

We at Bell Laboratories have a special role. Our broad mission is to provide the knowledge and the technology needed by the Bell System in meeting its service obligations in both the near term and in the more distant future. This mission includes assessment of the impact of new technology on the Bell System’s services, on its work force, and on the environment within which it operates.

Many facets of the assessment of the director first order impact of technology are also part of a through engineering study we carry out before the development of a new product or service. Different words may be used to describe, these engineering studies and TAs, but the intent is much the same. They overlap in great part, but not completely. For example, the Technology Assessment Act requires the Office of Technology Assessment (OTA) to identify existing or probable impacts of technology or technological pograms. In our case, for a new transmission system, we would evaluate the savings to the Bell System if the new system rather than the old one were used to meet growth demands. We would also evaluate the costs of development at Bell Laboratories.

Similarly, the act calls for identification of alternate technologies and alternate programs to reach the same ends. An engineering study would compare the benefits of one new system with another, and with developing nothing new at all, but rather continuing to use what we have. Such studies area part of what we call systems engineering, something we have been doing for decades at Bell Labs. TA also includes identification and analysis of indirect effects of technology, second-order consequences. Among these are human and social impacts, environmental effects, and natural-resource demands. We too, take such factors into account. I will discuss those. But first, I would like to expand a bit on systems engineering because of the desire on your part to have indications of the kinds of methods that we use that are in areas similar to TA.

One purpose of s stems engineering is to provide information to help in a decision of whether to allocate funds and manpower for the development and design of a new product or service. A second purpose is to establish broad requirements for the product or service, given that it is to be developed. Here is an example where systems engineering really has no parallel in TA. A third purpose of systems engineering is to evaluate the impact of the new development on other work at Bell Laboratories, on the capital and expense needs of the telephone companies, on the physical environment of the plant, and the nature and quality of the work on the plant forces. All of these must be done before development of a new product is started. It is part of the decision process.

Perhaps I can illustrate our methodology by describing some of its facets. To begin with, we take it as a necessary condition that any new system will be introduced into the plant without disrupting service. We do not attempt to assess the consequences of a service interruption—we know they are serious. So we try to minimize their occurrence.

To meet this sort of objective means that we have to have a thorough understanding of the characteristics of the existing 'plant. Let me give you a single example. The No. 4-ESS is a name that we have given to an electronic machine for switching long-distance telephone calls. This new machine has a capacity of handling half a million calls an hour; it can be hooked up to 100,000 trunks. It was just put into service, after 6 years of development, in January of this year. And when it was cut into service, it was connected to 219 other switching machines of many different types and vintages. It was designed to, and it did, interact with each of these flawlessly immediately upon being put into service.

The methods used in plant characterization range from simple counting of facilities to intricate measurements of electrical behavior of dialed-up connections. Simply keeping track of 10,000 switching machines, 6 million trunks, and nearly 70 million subscriber lines is a big job in itself.

We also make new measurements of the existing plant. For example, much of the existing plant was installed first for voice service. When the need to transmit data-digital signals—arose, we found ways to use the old plant for the new purposes. To get the most benefit, we wanted to send high-speed data. signals, so we measured the capability of the switched network. Here is an example of an assessment that led to a need for more data collection. It is also an example of a use of existing technology for a new service rather than -developing a new technology to meet the need. Bell Laboratories engineers planned the plant characterization program and worked closely with A.T. & T. and the telephone companies in carrying them out. In many instances, the telephone companies conduct the surveys and report their findings for Bell Laboratories analysis. The results of this study, like many others, are published in the open literature so as to be of benefit to all manufacturers of telecommunications equipment.

Analyses of relative costs are another aspect of systems engineering. Originally these were the simplest sort-will the price of the new product be lower than that of the old? More recently, with better understanding of in-service costs and with the use of modern computing technology, we have been asking more sophisticated questions.

We are certainly concerned with first costs, but man of our analyses now follow lifetime costs in annual operations, including development and startup costs as well as maintenance and administration.

We also investigate alternate strategies in meeting anticipated growth in demand, including options for the use of many products. We study these parametrically, in discount rates for the time value of money, relative costs among the various products, and inflation factors. Certainly, the use of mathematical models in systems analysis is not unique to the Bell System. However, because of the technical integration and because of our scope of interest, we have to worry not only about Bell Laboratories but also about the manufacturers including Western Electric, the associated companies and, as I will get to in a bit, recycling.

I have cited these examples of systems engineering to suggest methods that we use to assess the direct impact of technology, measurements of the existing plant, mathematical modeling, economic studies and so on. We are also concerned with other effects, particularly the impact of new technology on the plant forces.

The Bell System as a whole employs almost a million people, of whom 800,000 are in A.T. & T. and the telephone companies, and these are the ones that are responsible for assuring that the Bell S stem network system functions to meet our subscribers' daily demands for telephone" service.

We are also concerned about the physical work environment, certainly ***as*** a result of adherence to the standards set by the Occupational Safety and Health Administration (OSHA) as well as other interests. We have been working on these things for a long time, too. One example is our enduring studies of noise levels. Of course, by heritage and by the nature of our business, we know a great deal about human perception of sound—we know a lot about light and images too, for that matter.

We are concerned about sound levels in the work environment as well as on telephone circuits. This interest led us, for example, to assist a motor generator manufacturer in controlling the noise level in a 2.5-megawatt reserve-power standby power system before it was installed in a Bell System building. We are also concerned about sound levels that seem relatively small. Studies have been made in telephone equipment rooms and in other work locations to determine if certain sounds, such as the clicks in an operator's headset, can be annoying or disrupting.

Improvements in training methods are particularly valuable, since nearly $500" million are spent annually in the Bell System to teach new employees the skills they will need in their job, and to train experienced people in new technology being introduced to the plant.

Another impact or facet of TA that we carry out is environmental impact evaluation. The telephone industry, fortunately, is a relatively nonpolluting one, and has not had to make major changes in products or processes to conform to the new environment protection standards. When localized trouble spots occur, they get needed attention. For example, the stack gases from the reserve engine I mentioned can exceed standards if not controlled. We at Bell Laboratories applied some of our knowledge of X-ray spectroscopy, laser techniques, and mathematical modeling, to **develop new instrumentation** and analytic methods to measure and understand the effect of pollutants and how to control them so that we might take effective mitigative measures.

Bell Laboratories and Western Electric have also worked together on new manufacturing processes that will reduce or eliminate pollution hazards. one example is a closed-loop, printed-circuit etching cycle that allows the recovery of the etched copper and restoration of the etching strength of the bath, thus avoiding disposal problems of the spent bath.

Recycling of junk telephones is a project that well illustrates the importance of the close association of materials research, manufacturing, and scrap recovery logistics. The process of recycling the plastic in the telephone must also cope with the nonplastic items that are part of the working telephone--cotton balls in the handset and the brass and steel inserts and screws in the housing. We know exactly what these nonplastic parts are because we designed the telephone, and we know what the scrap is because we in the Bell System collect it. Materials scientists at Bell Laboratories have developed a separation process tailored to the composition of the scrap. Further, the recycled plastic has properties different from the original raw material. The design groups are now busily engaged in setting specifications for different compounds in which the reclaimed material can be substituted for the raw resin in the molded parts.

So far I have spoken mostly about our assessment of technology and control of second-order consequences as they might affect the Bell System itself. We are also constantly working to improve the network, to find new ways to use it and to add to its capabilities, to help us choose directions of augmentation that have the greatest potential benefit. We carry out research in the various factors that can influence the ways in which people communicate with each other, and into the individual judgment about communication. We do that at Bell Laboratories.

We also get help from the public. The public helps us by commenting on our service, sometimes critically. We ask their advice; for example, we send out surveys for service attitude measurements. We also get advice and assistance in the kinds of service and the grade of service from the regulatory agencies. All of these provide inputs to our studies of communications.

Another type of societal-technological interaction has received a great deal of recent attention—the exchangeability of telecommunications and travel. We are quite familiar with the studies of the Office of Telecommunications, the work of Bell Canada, the British Post Office, and others.

We have also carried out internal studies of the values of telecommunications ourselves, part of our processes within Bell Laboratories in managing the business. I will give you an example of this, but let me hasten to point out that I am talking about running our own business at Bell Laboratories. I should also remind you that we pay full rates for all services—we do not get telephones free within Bell Laboratories.

Our own studies of our enterprise have shown that the costs of added communications are hard to recover by savings from reduced travel. We are a widely dispersed, distributed, laboratory collection, and we find we have to use a lot of telephones, and we also have to travel a great deal. This may be because of the kind of communications we have and the kind of business we are in. We have facsimile equipment at all locations. We have speakerphones, and conference telephone sets available to those who need them. We have experimental video services between major locations. We would use more video services to help us manage our decentralized business if they were less expensive, and we will add to the facilities as the costs come down.

Of course, I have now come back full circle. I am talking about the economics and the costs of communications that we at Bell Laboratories not only pay for but study. As users ourselves, we find that the limits of applicability to and impact on our business are in the cost of service. It is exactly these costs that are under the most intensive attack in our programs of research, development, and systems engineering. As we at Bell Laboratories find opportunities for technical advances, we expect that our commonalty of objectives with Western, A.T. & T. and the telephone companies will enable us to improve telecommunication services of lower cost.

I have tried to illustrate how some of these various elements of the Bell System work together to achieve the objectives without producing side effects that are harmful to our work force, our environment, our natural resources, and the society we serve. This increased interest in the side effects is a direct result of changes in the national interest, and in emergence of TA as a recognized activity. Actually, as far as implementation goes, I think our single most important method in controlling the side effects of technological innovation is our integration of research, development, manufacturing, and operation into a single enterprise.

I would like to thank the Board for the opportunity to present these views, and I will be happy to attempt to answer any questions.

Mr. BROWN. Well, Dr. Gillette, you certainly covered a broad range of activities of the phone company here, and one which does raise a number of questions with regard to the role of the company in some of the startling new technological developments that I am sure are going to be before us in the near future.

I would like to proceed however, to Mr. Day and receive his testimony at this time.

Mr. DAY. Thank you for the invitation, Mr. Chairman. I would like to formally submit my written testimony and just make a few brief remarks summarizing some of the material in it.

Mr. BROWN. Without objection, the full text will be included in the record.

[The prepared statement of Mr. Lawrence H. Day is found in appendix C, exhibit 4.]

[The biographical sketch of Mr. Lawrence H. Day is as follows:]

MR. LAWRENCE H. DAY, ASSISTANT DIRECTOR—BUSINESS PLANNING, BELL CANADA HEADQUARTERS BUSINESS DEVELOPMENT DEPARTMENT, MONTREAL, CANADA

Born July 20, 1942, Halifax, Nova Scotia; married, two children.

B. Comm. Dalhousie University, Halifax, N. S., 1964; M. B.A., McMaster University, Hamilton, Ont., 1967.

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Positions in sales and marketing, Bell Canada, Toronto, Ont., 1964; market research consultant and research assistantship, McMaster University, 1966; supervisor—Business Development (Computer-Communications Services), Bell Canada, 1967; supervisor—residence services, Bell Canada, 1969; supervisor—business planning, Bell Canada, 1969; staff supervisor-business planning/assistant director-business planning, 1970-75; Dec. 1975 promoted to present. position in which responsible for building and managing team of planners whose mission is to conduct long-term technological forecasting and assessment studies for corporate executives.

Educational activities include guest lecturer on futures research, planning, and telecommunications at a number of universities in both Canada and the United States. Also, co-chairman and organizer of "Technology and Growth," a major conference on technology assessment and the "Limits to Growth" held in Ottawa during February 1975. This conference was sponsored by the International Society for Technology Assessment and the Ministry of State for Science and Technology; one of four co-chairmen of a group of advisory committees developed for a technology assessment study sponsored by the U.S. Department of Transportation and NASA during 1974-75; member of the Steering Committee for a technology assessment conference directed towards government officials in the Northeast U.S. states funded by the U.S. National Science Foundation; and organizer of the Telecommunications Policy set of conference sessions to be held at Intelcom 77 in Atlanta during Oct. 1977.

Publications include over 40 papers published in a wide variety of international journals, conferences, and symposia. Mr. Day is general editor of a forthcoming new journal, Telecommunications Policy, that will be published by IPC Science and Technology Press of the United Kingdom. This international journal will deal with all issues associated with the development of telecommunications policy and the impacts that arise through the uses of computer and communications technologies. He is also a contributing editor to the newsletter on communication published by the World Futures Society.

Memberships in professional societies include: The International Society for Technology Assessment, the Institute for Management Science, the Association for Computing Machinery, the American Marketing Association, the Canadian Association for Futures Studies, the World Futures Society, and the World Future Studies Federation.

STATEMENT OF LAWRENCE H. DAY, ASSISTANT DIRECTOR—BUSINESS PLANNING, BELL CANADA

Mr. **DAY. Thank** you. I would like to note in an introductory remark that Bell Canada is the A.T. & T. of Canada? and that we are not a subsidiary of A.T. & T. We always like to point that out. We have a very similar structure to the U.S. Bell System; research labs, manufacturing, operations, operating companies, and so forth.

And just one final comment on the Canadian telecommunications industry, it is a mixed system. We are somewhere between the United States and Britain. Some telecommunications companies in Canada are owned by governments, others are joint ventures between government and private industry, and some are private like Bell Canada, which is a shareholder owned organization.

My group, the Business Planning Group, is in shorthand terms, the technological forecasting and assessment organization for Bell Canada. Our mission statement is to identify future business opportunities and-or threats-and that can cover considerable territory. I don't think for the sake of time that I will describe the range of our research interests. These are outlined in my submitted written statement (see appendix C, exhibit 4). I will move right into the TA area.

Our definition of TA is, I think, one that would be acceptable to anybody on your Board. We use the standard definitions from the textbooks. These identify secondary impacts resulting from the uses of technology. I have quoted one from Vary Coates in the written testimony. This is normally the philosophy that directs our work.

We have been involved with four major TAs; three that we have conducted internally with our own resources and our own staff (we have people on staff who can conduct TAs, and one that is being funded at an outside organization, a Canadian university. And getting back to some of the discussion earlier this morning about whether TAs should be conducted in-house or out, we arc also on the third art of the triangle. My group has also a subcontract from the Stanford Research Institute in one of their communications-related TAs funded by NSF. We are buying and selling and somewhere in the middle in this whole field. For tills reason I would be happy to answer any questions based on our experience as it relates to the issue of credibility (where corporate assessments should be conducted).

We conducted one study of computer-aided instruction, an internal study using the Mitre methodology—an a preach to TA that might, if anything could, be considered classic. We have sponsored an outside funded study, the impact of new satillite-based communications services on native populations in the Canadian north. We have spent a considerable period of time researching the area of substitutibility or transferability, the int~rrelatlonshlp—pick your label--of travel and communications. This is a very complex subject, so forgive me if I use the term Substitutability, which really disguises a lot of interactions. Lastly, we have just completed a 3-year study that is a TA of the impact of so-called wire-city services. This is an interactive cable televisionlike service—the real futurist part of the telecommunications business.

We don't try to draw regulatory lines between the computer and telecommunications. That takes up a lot of effort, and many more knowledgeable people I know are busy at that. We do not try even for our TA purposes to draw that line, although it is obviously an important issue.

We make the assumption that the technologies that provide the basis for services are going to be available. Basically, we have a competitive choice of technologies in the telecommunications and information fields. It is not so much a matter of any specific technology being the basis for a service, it is more a matter of which blend of technology you are going to use. Dr. Dean Gillette of Bell Labs has pointed out the important integration issue in the communications business. It is an evolutionary use of technologies. This is not to downgrade the importance 'of telecommunications technologies. This is probably the most explosive area in technology right now, the whole field of information, computers, and communications technologies. We also assume that the market will evolve for something—we are not conducting market studies. In other words, we don't have to worry about the negative impacts of something that is not bought and used. If people don't use the services we don't have to worry about the negative impacts.

So assuming away all of the technology problems-that statement always bothers all of our engineers and people at our labs-and assuming away all of the cost-benefit marketing problems, we look at this from the point of view of services. We look at the types of services that may be available and try to assess what the impacts may be. So we are service-oriented; the technology is not the key.

To move briefly into the substitution field, I think that it is la good example of this approach. If you think about the topic for a second, the substitution field is an impact area that is the study of impact. We are not particularly concerned about which technology will be used to create the substitution potential, and when I say substitution I am talking about two almost totally different things. The first is the substitution of intercity travel by the use of a whole array of teleconferencing, telecommunications, and information systems. We have conducted considerable research in that area in the last few years.

The second is a totally different type of substitution which, if it occurs, is going to have a very fundamental impact on society. That is the whole question of the redistribution? over a very long timeframe, of people from central cities through the use of remote working centers, remote electronic education systems, the so-called ultimate " wired-city. The key question is whether we need to come to major cities every day to work A very, very complex area. The Stanford research study is looking at this. Right now they are looking at 50 different impact areas. Each of these has varied subdivisions. It is a very complex field.

One of our major activities in the substitution field, intercity substitution, was a very large survey of business travellers in Canada before the energy crisis, to find out what their attitudes toward substitution were. Summarizing again 3 years of research in one sentence, 20 percent of the travelers said they would like to substitute the existing type of trip they were on--these are business travellers— for some form of telecommunications alternative. There seems to be interest here. That is an issue, of course, that is important. You may have a cost-benefit tradeoff, but people still may not want to substitute.

Another area of research that we have been involved with is the energy implications of substitution. The transportation sector is one of the most energy-intensive sectors in society-approximately 25 percent of the energy consumption in both Canada and the United States. We have conducted considerable research, along with the British, looking at the energy implications of this substitution field. Again, I will not attempt to summarize the results here—some of them are in the submitted testimony.

There are a host of other types of implications that we have to consider here-privacy, what happens when people start to interact this way, will it affect their approach to life, is it going to cause unemployment problems in certain industries, who is going to have the right to assess this, who should be regulating what, who should be subsidizing what. It is a rather interesting field.

Moving on toward the conclusion, our views on TA itself, we have been actively involved for about four years in this field. The impact has been dual. First, at the executive level, I think we have definitely gone through an educational process. I mean that we have a set of senior managers who know what you are talking about when you refer to TA. So I think the educational process has been a very useful function; we have a commitment right from the top of the corporation to be involved in social impact analysis. I don't think that it is accidental that since we are a regulated utility we are interested in tile social impacts of what we do. I think it is a part of the regulatory process.

Second, at the professional level—with the people we hire to conduct TAs-we have had our fingers burned, and learned the fine details of how to and how not to conduct TAs. We could sit and debate the methodological issues for days on end. If there is a viable TA technique around, we have used it. One thing I can say is that there is no tecnique today that has received any sort of universal acceptance; they all have wide holes in them, and the professionals have a lot of fun finding out why various studies have gaps in them.

What does this mean in a decisionmaking environment ? In our type of decisionmaking environment—I would call it an incremental decisionmaking environment—relatively rarely do you approach what I call the big-bang decision. In other words you do something and you are stuck with the results for the next 20 years. It is very much of a step-by-step procees, and I think it is because of the integration issue that Dean Gillette mentioned earlier. This also means that you can have an ongoing incremental type of TA. I am very skeptical of the value of very expensive single-shot TA studies that fill many bookshelves but do not appear to be used in many cases for any decision support. Also by the time they are published they are out of date. They are published or prepared by people who then go on to study a totally different subject area. Just about the time they get up on the learning curve they have to stop. They are controlled by the availability of money. When they run out of funding from the sponsor, the study stops.

I think as far as the credibility issue goes, there is very much to be said for having the in-house capability with people who can conduct ongoing TAs and monitor what is happening as technologies are tried out. There is a very significant role for trials of new systems. We can conduct '(paper studies" until we are blue in the face. Let's try out some of these services in a measured environment and see if we can determine some of the real impacts. I think this is very important.

If I can be permitted to generalize, a lot of studies have not really got at gut issues, in funding agencies, in government, or in business *even* though today we heard some exceptions to the rule. We study matters that really aren't near-in; some of our own studies are in that category. I will close with one of our studies that is current and that I think is going to be very important. It is a service called incasting. Briefly put, it is the opposite of broadcasting. It's an inadequate name. but we are using it right now has an internal label. It is a form of electronic polling. We have all heard about electronic polling services, but this one is different. With this method you can use the regular telephone network. You can even be polled while the telephone is being used for a normal call. Technologically, we have now developed a way to take local or nationwide polls and deliver the responses in 10 seconds or less after asking the question, to a TV network or other user. Let me underline that I am talking only about polling and not about voting.

I know that this field-the electronic polling field has been talked about for a long time, but it has always been comfortable because we have talked about putting it on interactive cable TV systems that we knew were going to grow slowly. Now we can do it on the existing telephone system. We have been working on the technological aspects for a number of years, and patents are now available.. We will be hap y to lease them to the Bell System, Dean. This is a very interesting business opportunity, the broadcasters think that it is fantastic, you can think of an unbelievable range of applications through interactive broadcasting, nationwide polling, interactive advertising, and so forth.

But the implications are rather interesting, too. This has mainly been discussed internally to date. It has also been discussed in a highly technological environment. What is curious is that when you get a bunch of engineers together and they start talking about "incasting," the discussion rapidly goes to the social issues. Once you explain how you can do it-and it is very simple—it comes down to the social, political, or TA issues. There have been some very strong debates at the highest levels in our corporation on whether we should or should not even introduce this service based around these social issues. I don't know which way the final decision is going to go.

Right now we are bringing selected groups of outsiders in to the evaluation process and we are assessing the possibility of a trial that we can monitor and evaluate. We have had a consulting political scientist tell us what he thinks the impacts are going to be and we are going to have a private meeting with a group of rather distinguished people associated with universities throughout the United States who have looked at the basic field for a long time.[1] We are using the TA philosophy and approach on something that I believe is going to be basic to our busines. Thank you.

Mr. BROWN. Thank you very much, Mr. Day. I think it is safe to say that your testimony is probably the most comprehensive, detailed, and stimulating of any that has been presented to us. You seem to be deeply involved in a wide range of fascinating potential technologies that could drastically shape the nature of our society. Mr. Leathers, do -you have any questions?

Mr. LEATHERS. Just one, to Mr. Day. I agree that a TA as carried out by the OTA is not provided with a mechanism for updating a TA after it has been completed. My concern is that if there were to be a mechanism for following up all the TAs, this arm of Congress would wind up with more people doing these things than the administrative branch. So I wonder if you have a suggestion for how to carry on the updating of a TA without involving a large number of people.

Mr. DAY. T was not referring to the OTA when I talked about studies going on shelves or about an ongoing monitoring operation. However, I think that both in corporations and in Government mission agencies, there are people who have the skills along with access to the necessary information, where TA should be a part of their regular decision-making process.

The OTA, I think, is a totallay different type of environment because Congress makes decisions that tend to stick for a long time and are what I would call big-bang decisions. I am talking more about the business environment and to a certain extent, the mission agency environment in the Government, where these people are involved in

1 Mr. **Day subsequently informed the** OTA **that a successful meeting was held in early July.**

more day-to-day incremental decisiomnaking. I would not try to impose that structure on the OTA.

Mr. LEATHRRS. Thank you.

Mr. BROWN. I think we will have to face up to the problem in the OTA of the proliferation of bureaucracy, as it seems necessary to keep up with the continually increasing mass of work. The office is now relatively small; it is structured into subject matter areas, with the intent of developing an in-house expertise in certain broad technological areas—energy, for example. But as they develop more and more assessments and attempt to keep these up to date, there will be some real problems involved in how to do this.

I hardly know how to get into the questions that have been raised here. Both of you have dealt with certain developments that will have major impacts on our society. This business of video and audio conferencing—the substitutability of communications for transportation. The question that comes to my mind is that in view of the potentially massive impacts that developments of this sort could have, how much effort are we justified making in the way of TA, and at what stage in the decisionmaking process as well as in the analysis itself, do we involve a broader audience?

For example, in both countries the telephone companies are regulated utilities. You have to make decisions, I suspect, that have the approval of the regulatory bodies. How do you interface with these regulatory bodies as you proceed in exploring these potential new developments ? How fully o you have to justify your assessments? Is there a need to sound out the public in connection with these kinds of things? How do you handle that?

Dr. Gillette. If I ma-y respond first, Mr. Chairman. The interactions with the regulatory bodies in the United States, both at the Federal and the State level are as you can very well imagine, continuous. As far as the technology itself is concerned, there has been relatively little effort to regulate the means with which we provide services. Certainly the regulatory bodies are interested in our efforts to keep costs down. But the Federal Communications Commission for example, although it must approve each of the transition proposals, has not said that one technology is ours for the Bell System for common-carrier use, and another is for broadcaster use. Consider coaxial cable. for example. We use it in the telephone business to carry 100,000 telephone calls across the country in one system. Exactly the same kind of coaxial tube may be used by the local cable TV operator to carry up to 40 channels of TV in a local distribution system. Fortunately, the regulatory agencies have not attempted to describe one technology as being for one corporation, entity. or service, or another. There are counter examples, but they are few in number, and I deplore even those.

The question of getting public interest and involvement is, in part, a normal marketing activity, but the question of the social impact is not part of a normal marketing exercise. Here, we in the Bell System have had to get *some* help. We do not have a cadre of knowledgeable sociologists, so we have supported studies of the social impact of the telephone m academic institutions. A most recent example is a series of seminars that we sponsored, carried out at MIT (Massachusetts Institute of Technology) under Professor Ithiel de Sola Poole, on the social impact of the telephone. There was a final symposium on that particular phase on March 10, the centenary of the telephone.

Much was learned, much more needs to be learned about the social impact of telecommunications. We do have advice and requests for services from the public, from the regulatory agencies, suggestions from academic institutions, even from our sister nation to the north, of new services. We certainly pay a great deal of attention to all of these.

Mr. BROWN. Mr. Day, you brought up what you call "incasting" or internal polling. This could have potentially massive effects on the political structure.

Mr. DAY. It could. I am aware of one study in the United states, a survey of congressional attitudes toward the emerging telecommunications services that came down rather negatively on these types of capabilities. They were not exactly favored. and I can understand why. Obviously these things will start small. That is why I was talking about trials. These would be done in a local area. You would pick a city where the capabilitiy would be provided. Again, problems of time. We have two different types of "incasting" on the books. One is statistical—that can take the standard polling-type of subject matter-Gallup or Nielsen or a similar type of poll. You can say this gives a snapshot of opinion. Already that has the implications of locking out people.

So we have a second type of availability that is not statistically sound. YOU say you have to give anybody one of these things who wants one. You cannot take a selected group of 1,200 or 500 or whatever number of people and say you are the guys that are going to give the polling, or you are going to provide the information. Immediately you have the problems of access, then you have the problems of how It is used. I think that since both in Canada and the United States the same regulatory body looks after both telecommunications and broadcasting communications, it will be used intelligently. These are, of course, the issues that have to be assessed. The ultimate negative scenario is electronic mob rule. obviously this would not happen. There are too many factors in the political system to stop that from happening.

I think it will start with some localized types of activities, such as municipal politics and interactive advertising. Eventually you would have nationwide capability, but it will go a step at a time. I feel Confident in saying that if in a trial some very negative things start to happen, my corporation is not going to introduce the service. We are a regulated utility. It would only represent a fraction of our existing business, so it would just be a dumb business move in the larger sense. That doesn’t mean, however, that somebody else using an alternative technology such as interactive cable TV could not also do this. It’s just going to take them longer? but they may want to do it as well.

What is essential to realize is that the emerging frontiers in the communications field are all going to be competitive because various institutions are going to use various technologies to provide services. You have the cable people, the computer people, and the telephone companies. No one in the communications field can make a single decision alone and make it stick If we decide not to introduce this, somebody else might anyhow, which brings the people in the political and regulatory process into the picture at some point.

As far as your question goes, how do you get the people involved? We follow a very aggressive program of making our work public to anybody who wants it. That's the reason why I attached the list of publications, just to give you a feeling for the scope of our work. The least we can do is make the work available, put it up for critical analysis and debate, for two reasons: First, people in the public policy arena have to have access to this type of material and, second, the credibility issue again. If your people are professionals who have a professional involvement with external researchers, then if they put work out that is regarded as a piece of intellectual nonsense, they are going to get negative feedback from other professionals. The members of my staff are very conscious of their professional image.

On the other hand, if we produce just internal working papers that nobody ever sees, how do you involve the-general public? We have tried out some new methodologies that revolved members of the general public in our study process. In one study we had housewives help us try to assess the impact of some of these services. We were " told it couldn't be done; however, these ladies had some fantastic insights about what the implications for the home might be of some of these future services. We expanded this approach and involved welfare workers; students, educators, and Government officials. There are ways you can involve the public. It's very time consuming.

Mr. BROWN. Well, I imagine your business planning group, Mr. Day, must be a fascinating place in which to work.

Mr. Day. Yes. sir, it is interesting.

Mr. BROWN. I would very much like to pursue this further, but I am afraid the time is running along, and I am going to be called over for some votes on the floor shortly. I would like to ask if we could submit some questions in writing after the staff has reviewed your testimony in a little more detail than we have had a chance to do here. If you would cooperate with us on that, we would appreciate it very much.

Dr. Gillette. We would be very pleased to, Mr. Chairman.

Mr. BROWN. I do want to express my very deep gratitude to yell for your cooperation in this exercise; it has been extremely helpful to us, and I am certain that this record will be persued in great detail by the members of the Board. Thank you very much. The hearing will be adjourned.

[The following questions were submitted by Congressman Brown to Dr. Dean Gillette and his answers thereto:]

Question 1. You mentioned that part of the mission of Bell Laboratories is to make assessments of the impact of new technology. How do you define this process in terms of the impact on society and the environment? Are the results worked into reports?

Answer 1. Probably the greatest social impact of telephone technology has been to nearly achieve the goal of universal service.

The purpose of new technology developed at Bell Laboratories is to reduce the cost and improve the quality of conventional, widely-available communication services, and to foster economic introduction of new services. The evaluation processes include systems engineering studies, as discussed in some detail in my written and oral statements. Another part of the evaluation includes consideration of the environmental consequences of proposed technology, procedures, and environment-related research efforts. Flammability of products, and X-ray and microwave radiation effects are examples of items reviewed in such environmental studies. An Environmental Quality Committee at Bell Laboratories is responsible for advice on environmental control.

Results of various Bell Laboratories assessments of the impact of new technology are documented in internal reports supporting decisions for product and service development, and outlining broad requirements of new developments. The Bell System has an open publication policy. Results of scientific and technical work are published widely in professional journals including the Bell System Technical Journal (BSTJ) and in AT&T technical references, for the benefit of users of telecommunications services, and suppliers of telecommunications products. For example, the results of plant characterization work mentioned in my written statement in connection with echo control and in my oral statement in connection with data transmission were published in the *BSTJ.* Reports of study approaches and product developments may also appear in the Bell Laboratories Record, as noted in connection with the response to Question 2.

Question 2?. Can you give us a specific case study of a TA that was done at Bell Labs and point out how it impacted the decisionmaking processes? Has TA affected the way you do business?

Answer 2. Bell Laboratories does not conduct studies that are labelled "Technology assessment." Rather, we carry out systems engineering and other studies, including those of environmental effects, of the kind appropriate for the particular technology and service. Some of these analyses—and of the follow-on product and operational developments-are illustrated in the June, 1976 issue of the *Bell Laboratories Record!.* The issue is devoted to what we refer to as "special services' '-communications applications ranging from intercity toll-free lines to data links from central computers to remote locations.

That social values of these special services are recognized in our studies is indicated on page 142: "Clearly, special services are meeting a variety of special needs, particularly in the business community. Often, these services are not merely a convenience in a business but actually are essential. We all know what happens to a business operation when its central computer quits. The outcome is essentially the same when the branch offices suddenly find that telephone lines to the main computer aren't working. So when special services circuits fail, they must be fixed-quickly."

Such studies as those of special services, have led to decisions for development of supporting systems illustrated in other articles of the June 1976 Record issue. Development of systems to support operations such as these is an interest new to Bell Laboratories in the last several years, and is an example in which systems analyses affect the type and the way we at Bell Laboratories do our business.

That environmental factors have long been important to the Bell System is noted in another item in the same June 1976 issue of the *Record.* Under "50 and 25 Years Ago in the Record," we find an article on Conservation and Substitution Materials. Other examples of Bell System consideration of environmental effects and conservation of resources are given in my statement.

Question 3. When using Systems Engineering as a way to analyze a particular problem, how is it decided what shall be studied when attempting to determine the social impacts of a technology? With regard to future considerations, how do you evaluate the impact of your telephone service on the handicapped, on housebound, and so on? To what extent do these considerations enter into your planning? Is this Systems Engineering analysis institutionalized In the Bell System as a part of the planning and decisionmaking processes? Do you have a team that does this kind of analysis? Is Systems Engineering a kind of policy analysls? HOW do you involve the public?

Answer 3. Individuals and groups involved in systems engineering make the choices as to what shall be studied in connection with a given problem or application of technology. Those responsible for providing the background information for decisionmaking are expected to anticipate questions that might arise and to make appropriate analyses. Bell Laboratories systems engineers work closely with their counterparts at AT&T in carrying out these studies.

When considering the impact of telecommunications services to the handicapped and the housebound, we attempt to understand both the opportunities and limltations of conventional telecommunications. Within the Bell System we have specific programs for providing such specialized equipment as transmission amplification for the weak-voiced. visual signals, loud ringers and receiving amplification for the hard-of-hearing, and dialing aids for the physically handicapped. We have developed systems to connect housebound students with their classrooms via telephone. Operating Telephone Companies make special arrangements to meet particular *needs.*

Systems engineering, as I discussed it in both my written and oral statements, is primarily an activity at Bell Laboratories. However, engineering analysis and quantitative investigation is a fundamental part of the Bell System's operations simply because the industry is technology based. Within Bell Laboratories systems engineering is carried out by groups (teams) involved in planning for evolution of the network as a whole and in product development areas.

In the sense of providing information for decisions regarding product develop ment, systems engineering is a kind of policy analysis. Since systems engineering studies must anticipate the demand for products as a portion of cost-of-manufacture analysis, it must take into account public acceptance and public demand. In addition to attitude survey and market studies, we frequently conduct trials of new products and services, and take public reaction into account in arriving at standard designs.

Question 4. Regarding the introduction of new technology, how do you discuss ahead of time with the public possible impacts and try to educate the public ahead of time? How do you get the public involved?

Answer 4. AT&T's General Departments take a leadership role in involving the public in telecommunications. In addition to guiding the service and product trials mentioned in the response to Question 3, AT&T surveys subscriber responses to service, and studies of public preference for new products and services. Subscriber views as reported by the Operating Telephone Companies are reflected in AT&T's determination of the needs for new services and products.

The public frequently does not recognize the introduction oil much of the new technology used by the Bell System except as it results in improvement of service or reduction of costs. For example, unless a subscriber chooses to use the special features available via electronic switching, he will find very little difference between the central office service provided by electromechanical switching technology and electronic stitching technology.

New services provided by new technology will, of course, be of value only if subscribers know of their availability. The marketing organizations in the Bell System are responsible for anticipating the Nation's needs for new services, and tile operating elements of the Bell System, particularly the Associated Companies, are responsible for informing the subscribers on the availability of new services and how they can be obtained and used.

Question 5. What value do you see with regard to TA in having a closer working relationship between the Public and private sectors? DO YOU think closer ties with state and local government would be beneficial?

" Answer 5. A close working relationship between industrial, governmental, and public sectors is important. As a regulated public utility we in the Belt System have very close working relationships with the Federal, State, and local governments, and we find these greatly beneficial.

Question 6. What new considerations over the last five years have entered into your engineering system planning?

Answer 6. As telecommunications technology grows more complex, it has become even more important to plan effective exploitation of the opportunities available. In the last several years, Bell Laboratories has taken advantage of the growth it has stimulated in one area to develop means of managing applications of new technology in others. A major consequence of the invention of the transistor and development of subsequent integrated solid-state circuitry is evolution of minicomputers and microprocessors that allow efficient and economic centralization of operations of a variety of systems and functions. The Bell System has developed new approaches to operations that will lead to productivity increases, service improvements, and cost reductions, as illustrated in several of the articles in connection with "special services" in the June, 1976 issue of the Bell Laboratories Record, cited in the response to Question 2.

The national emphasis increasingly placed, in the last several years, on environmental protection and natural resource conservation has influenced the *types* of analyses and direction of engineering studies in Bell Laboratories, as exemplified in my statement.

Quesion 7. You mention that fiberglass technology and laser technology may become a more important factor in the future. To what extent do your systems analyses take into account effects of such new technologies on materials, effects on imports, freeing of materials for other uses, etc. ?

Answer 7. In our systems analyses of materials, effects on imports, and freeing materials for other uses, our principal focus is on costs. We must concern ourselves not only with the initial cost and availability of materials, but also their future availability and opportunities for recovery through the recycling operations that I mentioned in my statement. This interest is not new, as noted in the response to Question 2.

Question 8. Do you examine the secondary impacts of your own developments in communication on the internal operations of Bell? That is, do you measure telecommunications improvements in terms of increases-decreases in demand,* for certain skills and similar changes in capital outlay s,* or transportations costs?* Can or should Bell attempt to measure the social sideeffects of advances in communication—for example, does the health of the elderly (and other infirm) respond to access to improved telecommunications?

Answer 8. We do examine the impacts of our own developments in communications on the internal operations of the Bell System. In my statement I gave several examples of the way we view interactions between new technology and the work force. The June, 1976 issue of the Bell Laborataories Record, cited in Question 2, illustrates the increased attention we are giving to the development of technology to improve operations within the Bell System itself.

We do analyze the interaction between introduction of new technology and costs of labor. For example, productivity increases can be and are, measured by labor efficiency. Another factor in evaluation of new technology is the change in requirements for operational personnel skills and consequent change in training programs. Because the Bell System incorporates both technological development and service application, it is possible to plan introduction of new technology and force requirements together—a process that leads to efficient and effective human resource management. Capital outlays are, Of course, central to an economic evaluation of the introduction of new technology and are essential to any systems engineering evaluation.

In addition to the considerations of the handicapped and housebound mentioned in response to Question 3, we are concerned with general social uses of telecommunications. We in the Bell System depend more upon academic studies than on internal resources for study of such social side effects as advances in communications on the health of the elderly. From all of the studies we have at hand, it seems clear that the telephone is extremely important for social intercourse among the elderly, particularly the infirm. This is one reason we attempt to keep the cost of basic telephone service as low as possible and look to other services to make major contributions to common costs.

Question 9. Does Bell limit its concerns to anticipated needs for electronic engineers as it continues to rely upon more sophisticated systems, or do you accept that such systems also call for more expertise within Bell in the social and behavioral sciences?

Answer 9. Bell Laboratories has not limited its technical staff to individuals trained in electronics engineering (and the physical sciences). Nor do we expect that such imitations would be appropriate in the future. Bell Laboratories' responsibilities require research into the social and behavioral sciences, and we have individuals and groups making fundamental contributions in these areas. Long-term interest in human elements in the operational forces and in the foundations of human communications are illustrated in my statement. More recently the Bell System has expanded its interest in broad-based economic studies, and Bell Laboratories has buiit a solid research effort in the field. We expect all of these to be long-term interests.

[The following questions were submitted by Congressman Brown to Mr. Lawrence H. Day and his answers thereto:]

Question 1. Would you describe how your use of TA has affected the way Bell Canada does business?

Answer 1. To date, TA has not altered our fundamental way of doing business. This is mainly as a result of topics studied to date, and the findings of those studies, which have not resulted in any serious negative impacts being identified. More specific comments on the impact on Bell Canada of its TA activities are documented in the written and spoken testimony and in replies to the questions below.

* within Bell.

Question 2. In a TA should the impact of a new technology cm job structure be examined ?

Answer 2. Definitely yes. In our evaluation of the impacts of the so called "(Office of the Future", we are directing a great deal of effort towards the questions of computers, communications, and job structures.

Question 3. What value do you see in having a closer relationship between the public and private sectors?

Answer 3. I assume here that we are talking about the narrower issue of public-private cooperation in the TA field rather than the broader field of business-government relations, I have no particular expertise to address the latter issue.

Closer relationships for TA purposes have the following benefits:

The sharing of information that is vital to a well conducted TA; hence, a reduction of TA costs that appear to be heavily impacted by information gathering activities.

Reduction of the credibility gaps between the sectors on the uses and quality of TA activities on both sides.

Creation of the possibility for structures that will foster continuing or incremental TAs.

Reduction of the learning curve required to address new types of impacts resulting from the use of evolutionary developments in technology.

Question 4. When you identify negative or positive societal or environmental impacts, do you try to inform and educate the public ahead of time?

Answer 4. To date, this is somewhat hypothetical for us, since our TAs have not identified serious negative impacts resulting from the use of new telecommunications services. Specified impacts on special interest groups of the public (e.g. teachers, students, government officials, etc.) have been transmitted to members of these groups with the distribution of our reports and papers. Of course, the positive impacts of any new or existing service are always communicated from a public relations and marketing perspective.

My view is that we would attempt to communicate potential problem areas to the public if they were identified in a TA of new or existing services. This is a tricky area for a telecommunications common carrier since most of the impacts are associated with the specific applications that subscribers develop as they use the telecommunications capabilities provided by the carrier. Carriers normally avoid involvement with the subscribers' uses of their services unless the application is clearly illegal or unsafe. Thus our TA activities are oriented towards new types of services Bell Canada may provide rather than the myriad of uses that customers develop.

Queation 5. What is the basis for deciding to do a TA as opposed to some other kind of analysis? In the past how have your TAs impacted the decisionmaking and policy processes at Bell Canada? Has management requested further study, more TAs, etc. ? What lessons have been learned as a result of doing TA at Bell Canada?

Answer 5. TAs are usually decided upon using normal managerial judgment. The decision is not so much that of conducting a TA versus some other form of analysis but more that of conducting a TA in addition to other analysis. The results of our TA studies have been used as an input to the regular decision-making process in the company. As noted in the testimony, some of the impact has been of an educational level. *Hence,* it is difficult to identify specific decisions being made or modified as a result of a specific TA study. The current interest in identifying the social impacts of "incasting" is a direct result of senior management concern with the social-potential impacts of that potential service and specific decisions will be impacted as a result of the TA activities.

The lessons learned with Bell Canada TA experience:

TAs should be directed towards specific services or products rather than towards broad service or technology trends;

.4 wide mix of methodologies should be used;

Methodologies that gather impacts from a variety of factors and interest groups should be chosen;

TA should be viewed as part of the decisionmaking process rather than a stand-alone activity;

TA activities directed towards future services rather than here-and-now ones are always more academic and educational in nature than ones directed towards services currently in existence or to be introduced shortly;

An extension of the above point is that observers seem to discover a much wider range of negative impacts that should be examined when they are told that a service is possible today rather than at some more distance point in the future; and

TA activities should be incremental and on-going if they are going to match the decisionmaking process.

Question 6. Based upon your experience, what are the factors that limit the application and utilization of TA in the public and Private sectors? How may we define the bounds of the concept?

Answer 6. Limiting factors for TA:

The subject definition must be precise; studies that attempt to examine broad issues tend to end up consisting of a series of generalizations;

impacts should be ranked in some order of importance using an acceptable methodology; too many studies end up as "catalogues-of-impacts," which reduces their usefulness;

TA results tend to be distributed only to those interested in TA itself; summary reports written for a wider public should be made more available.

We are not overly concerned with defining the bounds of the concept. It should be flexible enough to evolve, based on direct expedence with TA studies and their impacts. Hence, my concern with "incremental" TA versus "classical" TA.

Question ?'. How do human value systems affect technological development? What role should the analysis of value systems have in the assessment of the impacts of technology on the environment and society?

Answer 7. Human values impact upon everything that we do. There is no such thing as truly value-free or objective research. All individuals and organizations have their stated and unstated value profiles. The best we can do is try and make them as explicit as possible in a TA environment. Value analysis should play an important role in TA, but most studies tend to bog down in an attempt to classify the types of values and methodologies to study values (some of the best summary work here has been that of Arnold Mitchell at SRI). Thus, value analysis should be part of the TA process as long as it does not become an end in itself for the TA.

Value systems affect technological development at the most fundamental point—financing. Clearly, the value systems of decisionmakers in business, government, foundation universities, and non-profit research organizations help determine what technological research is funded. Some organizations state their value profiles quite clearly in the form of check sheets, scoring systems, relevance exercises, etc. Others rely more upon managerial judgment, or "gut feel", which is of course, wrapped up in the value systems of the individual or group decisionmaking entities. Value systems also impact upon what issues are emphasized in a TA, who conducts the study (in-house or a specific choice of an outside organization), which methodologies are chosen (note here the hair-splitting debates on TA methodologies that are often meaningless, considering the lack of precision in information inputs to those methodologies), how the results are presented or packaged, and of course, whether TAs are even conducted by an organization.

[The Board adjourned at 1 :10 p.m.]

TECHNOLOGY ASSESSMENT ACTIVITIES IN THE INDUSTRIAL, ACADEMIC, AND GOVERNMENTAL COMMUNITIES

MONDAY, JUNE 14, 1976

CONGRESS OF THE UNITED STATES,
TECHNOLOGY ASSESSMENT BOARD,
OFFICE OF TECHNOLOGY ASSESSMENT,
Washington, D.C.

The Board convened at 10 a.m., in the Regional Planning Hearing room, room 150, Hail of Records, 320 Temple Street, Los Angeles, Calif., Hon. George E. Brown, Jr. (member, Technology Assessment Board), presiding.

Present: Dennis Miller, OTA staff. *

Mr. BROWN. This hearing will be in order.

This is the fourth day in a series of hearings conducted by the Technology Assessment Board for the purpose of seeking to more adequately define the parameters of the art and science of technology assessment (TA), and how it can most usefully serve the Congress of the United States. For most of you, I do not need to outline the background of the Technology Assessment Act, which was passed about 3 years ago after several years of struggle.

The Technology Assessment Board perceives a lack of clarity in defining the specific boundaries of the technology assessment field, and the specific methodologies that are most appropriate to the conduct of TAs. In general, the Board can use this new tool to most effectively fill in the gaps in any information system setup to serve the Congress. The purpose of these hearings is to create a record that the Board can use to help achieve an improved definition of its role, and assist it to be more effective in general in its work.

These hearings are part of an ongoing process. Our interest in opening and developing communication between the public and private sectors will not conclude with this particular series of hearings. This record will be the first part of a continuing dialog that will take place on a regular cycle. Thus the Board will hopefully get the most out of those TA activities in which it is engaged.

This morning a distinguished group of TA practitioners are testifying. The hearing will be conducted in a relatively informal fashion. There is enough time so there is no need to be rushed, except for those of you who need to catch planes. Each witness will be asked in turn to present his statement, and then to engage in a brief discussion of its contents. I hope I can do justice to our discussion. Normally there is no objection to all of the witnesses participating in the discussion after each of the statements. But if we do that, we may not be able to keep the discussion within a reasonable time frame. However, if the spirit moves any of you to interject at any point on a particularly important matter. I will welcome your comments.

Our first scheduled witness, Dr. Mueller is not yet here. The second witness is Mr. Jack B. Moore, who is vice preside.nt, advanced engineering, Southern California Edison, a major utility in the southern California area. Mr. Moore, would you like to come up to the table. Since I haven't had a chance to read your statement, if you would proceed at a sedate pace so that I can keep up with you, I will be able to digest it a little more fully.

[The biographical stretch of Jack B. Moore is as follows:]

MR. JACK B. MOORE, VICE PRESIDENT, ADVANCED ENGINEERING, SOUTHERN CALIFORNIA EDISON

B.S. mechanical engineering, Texas A&M College; additional technical and management courses at the University of California and Stanford University; registered mechanical engineer in California.

Joined engineering department of Edison, 1949, where served successively as senior mechanical engineer, chief steam station design engineer, and manager of engineering; elected vice-president, 1967.

Present professinal activities include memberships in: The American Society of Mechanical Engineers (Chairman of Los Angeles Section, 1963) ; the Advisory Committee On Solar Energy Research Institute: the American National Standards Institute Policy Committee; the Atomic Industrial Forum Committee on Reactor Licensing; Edison Electric Institute Codes and Standards Committee; Electric Power Research Institute; Nuclear Power Divisional Committee; Electric Power Research Institute Nuclear Safety and Analysis Task Force (Chairman) ; and the Los Angeles Chamber of Commerce Water and Energy Committee.

Past professional activities include memberships in: Edison Electric Institute's Prime Movers and Research Project Committees; the Executive Committee of the Nuclear Standards Board, American National Standards Institute; the Association of Edison Illuminating Companies' Committee on Power Generation: the Nuclear Mutual Ltd. Engineering Advisory Committee; and the California Legislative Council of Professional Engineers.

STATEMENT OF JACK B. MOORE, VICE PRESIDENT, ADVANCED ENGINEERING, SOUTHERN CALIFORNIA EDISON CO.

Mr. Moore. Thank you, Congressman Brown.

As the Congressman stated, my name is Jack B. Moore, vice-president. Southern California Edison Co. In his letter of invitation, the Honorable Olin E. Teague, chairman of the Technology Assessment Board, stated that the purpose of these hearings is to identify technology assessment-related activities and develop information on the experience gained im the practice of such assessment that will be of benefit to the public, industry, and Government.

The first point that must be addressed is the definition of 'a technolo-g assessment (TA). Although several definitions have been stated, I believe that the definition written by Vary T. Coates in July 1972, best expresses the concept.. She stated that the process is "the systematic identification, analysis., and evaluation of the real and potential impacts of technology on social, economic, environmental, and political systems and processes". It must include second- and third-order imparts, and planned and unplanned consequences whether good or bad.

Mr. BROWN. If I may interrupt, Mr. Moore, and I will try not to interrupt too frequently, there is just one minor flaw in that definition, and that is that it doesn't define what technology is. Of course, there are many definitions of technology, but one of the problems that confronts us is trying to clarify whether technologies include not only hardware technologies and software technologies, but also what you might call institutional innovations. These are a third type of activity that sometimes gets woven into definitions of technology.

Go ahead. We need to clarify all of these points if we can, as we go along.

Mr. Moore. Well, buried in this statement, and one of the reasons that I selected it as being the closest of any that I had seen in print, is a very broad definition of technology. Thinking back to the time that I was in college as an engineer, technology then was strictly the analytical process applying to systems and equipment, and the use of these systems and equipment. Certainly, we in the utility business have learned that probably the smaller portion today of the meaning of the word, technology, applies to the system and equipment that you are applying to some need. So certainly part of the technology is the analytical approach to understanding fully the impact on almost any manageable situation that could occur once the system or equipment is applied to do some function. I think this is a moving target that we have to look at today. So as you suggested, a definition of technology is difficult. But I think in the broadest concept, technology includes not only anything that is economic and functional but also the impact on any area of society.

To continue, it is clear that Congress and Federal Government agencies require TAs on a grand scale due to the scope of Federal activities that require policy and legislative actions. It is possible that certain industries may conduct assessments in this same broad context because of the very nature of their business.

For electric utilities such activities would properly be done by the Electric Power Research Institute, the Edison Electric Institute, the Atomic Industrial Forum, or other national associates. I will not address any efforts by these ups; rather, I will concentrate on efforts conducted by Southern California Edison. However, I should point out that Southern California Edison does use as inputs to our efforts assessment results produced by these associations and the Federal Government.

There are several types of assessments that a large electric utility such as Southern California Edison, may conduct. First, there are generic evaluations to assess the applicability of an advanced technology to meet the projected needs of our system which in turn will be responsive to the needs of our customers. Second, there are the specific evaluations related to new and existing facilities.

The generic evaluations most closely resemble the t e of TA being conducted by the Office of Technology Assessment (OTA). This type of study, although conducted for management guidance, may be given external distribution. Once completed it serves to provide management with the information needed for decisionmaking. Generic evaluations of new alternatives are quite straightforward in approach. An alternative can be studied for its technical feasibility. From such a study, judgments can be made of a technology's current level of development, means of implementation, environmental impacts, and need for research and development.

Such an assessment can be conducted in a controlled environment with reasonable assumptions being made of the factors affecting the technology. The outputs can provide a reasonable picture of where the technology stands and serve as excellent input to the decisionmaking process of what next steps should be taken. The decision may be to consider the technology as a viable resource at a date in the future and conduct R. & D. directed at developing it in that time frame. The viability date and research required would depend on the current level of the technology.

An excellent example of such an assessment is the study performed for Southern California Edison by the Jet Propulsion Laboratory (JPL) entitled '(Assessment of Solar Heating and Cooling for an Electric Utility," completed in August 1975. A copy of the summary report is appended to this statement. The full report, which I might say is about 8 or 9 inches thick, is available if the Board wishes a copy.

Mr. BROWN. Without objection the summary will be included in the record. If we need to have the full study, we will ask for it.

[The material referred to above is found in appendix D, exhibit 1 of this report.] .

Mr. MooRE. As stated in the introduction, "The basic objective of the study was to understand the interaction between elements of the heating and cooling energy supply system well enough so that utility objectives and directions for R. & I). activities in solar heating and cooling could be defined.)' The study included assessments of impacts on both Southern California Edison and on society . Potential overall societal benefits were evaluated by integrating solar devices into the energy system and estimating the reduction in the total cost of heating and cooling as well as the benefit of conserving energy in this area. Benefits to the utility and the customer were accounted for without any prejudice, based on existing institutional arrangements.

Four categories of factors that influence the market penetration of solar energy were included in the study. These were: (1) buyer decision criteria and market resistance to adoption, (2) energy scenarios, (3) solar-system costs, and (4) financial incentives. The relationship of these factors on the level of market penetration is not well understood. However, the historical resistance to market penetration of new concepts may be overcome by public enthusiasm based upon concerns for the environment and finite energy sources (conservation). It was assumed that the legal, economic, organizational, and cultural characteristics of the building industry would not change greatly.

We consider the study to be successful since it has defined appropriate project areas for company sponsored research in the field of solar heating and cooling systems. I might add that we are currently looking at or studying systems that were pointed out b-y this stud-y. The systems currently being researched are those identified as fitting the requirements of conserving energy and reducing the total cost of heating and cooling.

If there is a deficiency in studies. of this type it may be in the areas of analysis of social and political impacts. By this I am referring to possible actions by the Federal. State and/or local governments, and reactions of the general public to such actions. The effects on the technology by implementing any governmental policy can be anticipated; however, the impact of any such action can only be crudely estimated in *many cases. We* must realize and always be aware that TA studies do not promise to accurately predict the future. Their purpose is to make us aware of future possibilities. This type of assessment generally can fulfill the need by identifying the technological status and the requirements for implementation. By doing so, it serves to bring about change by the orderly development of the new technology.

The second type of utility TA comes about in the extremely dynamic political, environmental, and financial arena of developing and maintaining projects within the regulator-y process. In many instances the term, "technology assessment," is not used but, as we will see, this type of study does qualify as a true asssesment.

A key ingredient in this process is time. Anywhere from 5 to 20 years can be required to obtain energy from a modern, cpmplex project. During this time, the critical variables affecting the viability of technologies change:

Regulations change and become more restrictive.

Public and political attitudes evolve.

Costs continually increase and financing becomes more difficult.

Technology itself advances rendering the original proposal obsolete before it can be implemented.

It might be helpful to understand the interactive nature of these factors if I use as an example the steps through which a major generation facility must pass during its development. Each step requires an ongoing assessment of the proposed and alternative technologies. In addition, each of these steps must be integrated into the overlapping and complex regulatory process.

1. The need for generating capacity is identified based on yearly load increases projected to be required over a 20-year period.

2. The types of technologies available for each year must be based on the amount of time available between the present and the particular year in question. For example, as turbine units can be built with shorter leadtimes than large coal or nuclear plants. Refinements are included based on the environmental and regulatory constraints of a particular site.

3. The formalization of step 2 is presented in the form of an environmental assessment prepared by the utility, which includes an assessment of alternative technologies.

4. The project then enters the process of obtaining the particular approvals required prior to its construction. Next to construction, this is typically the longest phase of project development. During this phase, the environmental report is written, challenged, and usually rewritten. Challenges to the project and changes in the variables mentioned earlier, often. require reassessment of the various technologies making up the project. Many agencies and groups are involved in this process.

5. As finally approved for construction, the degree to which a project resembles the original proposal depends on the results of reassessments during step 4.

6. often during construction! the TA process continues; sometimes clue to the need for additional permits to operate, court challenges to the approved technology, or regulatory changes requiring new technology.

7. Even during operation, assessment studies continue as new air, noise and water quality regulations necessitate modification.

These variables when considered in the framework of the continual review and approval process required by a variety of regulatory agencies, have resulted in some changes in most of our generation facility projects. A good example of this is the Lucerne Valley Combined Cycle facility currently being developed.

The project has evolved since the late 1960's, a highly dynamic period insofar as the variables mentioned earlier. As initially conceived, it was intended to be a coal-fired plant in a particular location of the high desert. We found quite dramatically that coal technology, as developed at that time, was unacceptable to the high desert residents. They blocked the project by declining a ballot measure to sup- [illegible]

Assessment of alternative technologies available and many sites resulted in a proposal to build a conventional oil and gas facility at another location in the desert. However, emerging air quality regulations, and adverse meteorological conditions rendered this alternative infeasible as well. During this time, we were also learning new methodologies for site selection and evaluation.

A meteorologically acceptable site was located in the upper desert in 1972. At that time, new technologies were emerging in generating equipment. The combined-cycle concept was being shown to be excellent in regard to air emissions at the expense of substantially higher fuel costs. In the 1973/74 time frame, it appeared that the combined-cycle system offered a better alternative for the Lucerne facility, and we have been developing the project in this mode since then. Thus we can see that this project has been evolving since the late 1960's although construction has not yet begun.

The continual TA as projects proceed through the approval process is unwieldy, expensive, painful, and cumbersome. However, it is not possible at the outset to account for all technological advances that will occur during project development, or to forecast those that will be acceptable several years in the future.

This second type of TA is an integral, ongoing part of long lead-time projects. In one sense this type of assessment meets the test of the definition of an assessment to a greater extent than the more classical generic study described earlier. This statement can be made when one considers the continual interactive environment in which this type of study is conducted. Secondary and tertiary impacts are scrutinized and qualified as perceived at that juncture.

We encounter one fundamental problem in studies of this type. An assessment without an upper bound in time complicates the decisionmaking process. As with any major project there comes a point in time when a final decision is necessary; to fix the system design, finalize financial resource requirements, plan for personnel needs, and permit the timely construction of a major generation project. Of course an alternate final decision not to proceed is possible, and I might add has happened, more often than not recently. But this too is necessary within a fixed time frame so as to allow sufficient time to adequately prepare alternative plans and to minimize such costs.

I am sure that the members of the Technology Assessment Board can appreciate this delimma in decisionmaking. Time will allow more complete input to the assessment process. On the other hand, unlimited time is a luxury few, if any, can afford, whether it be an electric utility considering a new facility or Congress considering legislative action. Consequently, to aid the TA process there is need to develop and improve methods of gathering and evaluating relevant data such that a meaningful, well-defied assessment results within reasonable time.

We have several concepts along these lines in various stages-of development. One such project is an ongoing land use study program to assist in forecasting future electrical load growth and general facility planning. In addition to the technical program, which includes data from high altitude imagery, automating of the data, overlay and mapping studies, Southern California Edison has worked closely with various local and county planning agencies.

Another project, which we have initiated, should prove to be of assistance in helping to meet the varied requirements for biological and health impact data for any new—or existing—facility. This biological assessment program has as its goal the ability to accurately model on a predictive basis the interaction of any of our facilities with the local ecosystems. In addition to the models themselves, there is a strong requirement for baseline data of a generalized nature to support the predictions. One hope is that this approach, once refined, will permit Southern California Edison to provide definitive data on the criteria on which to base a meaningful monitoring program. Currently monitoring studies are done on a piecemeal basis, thereby reducing the overall effectiveness of the TA process.

We hope that the statements above and the examples I gave will assist the Board in its deliberations. In today's world, any organization, be it governmental or industrial, having large impacts on society cannot continue without the ability to perform sophisticated TAs. I am sure that through discussions such as this, more meaningful methodologies as well as a better understanding of the process itself will result. Thank you for the opportunity to discuss this concept with the Board.

Mr. BROWN. Thank you very much.

I think, Mr. Moore, you have given us a very clear statement of the significance of technology assessment (TA) in your own operation. There are some questions that, arise about how you distinguish the TA process from those activities that take place before and after a TA. To clarify what I mean—an assessment is not a policy choice. It is defined as a tool to facilitate improved policy choices.

Mr. MOORE. I can certainly agree with that.

Mr. BROWN. You have indicated some situations in which you have made assessments and on those bases made policy choices; for example, powerplant siting or type of powerplant. Then you found these decisions disrupted by factors that developed subsequently. This raises a question about clearly defining the role of the TA assessment and its relationship to the policy-planning and policy decisionmaking activity. Then of course, after that decision is made there is the whole process of implementation, which is another more or less normal aspect of most management activities. You are accustomed to making decisions and implementing them, and I suppose there is always a small amount of confusion involved. How can we enter into this process a situation such as you described, where a constituency in the high desert began to oppose you and erected roadblocks, which made it difficult to go ahead with your original decision ? Would you consider that such a factor made your original policy decision a bad or a wrong policy decision, or are you prepared to include in the process of assessment the attitudes that develop within a constituency that is concerned about a particular development on which you are trying to make an assessment ?

Mr. MooRE. Well sir, I certainly would say that the decision made to install a coal-fired plant in the high desert was a poor decision. That decision was made on an inadequate assessment of the situation. It was made on a, type of planning that we had done for many years in which the in-house understanding was that any type of industrial process or project because of tax base, is acceptable to the general public. We had not taken adequate steps or made an adequate assessment of the overall picture from a corporate standpoint.

We now have people on our staff who are qualified in many areas that 10 years ago were not included in a utility staffing. For instance, we have a doctor of terrestrial biology to understand the impact or look separately at the impact of a project on inland areas. We have people who are similarly qualified to look at impacts in the marine world. Today we have far larger staffing in the science fields than in the engineering fields, so that we can make what we believe is a full assessment of the impact of any program that we would start that would include facilities or would include changes in facilities. As I mentioned earlier, we are now staffed to do a broader TA. We view it as such before senior management will make a decision to sink large sums of money into a project that is fated for disaster before we can ever get started. As I mentioned, often the assessment doesn't necessarily give you the final answer, but it certainly opens your eyes to many areas that could cause problems as a program moves ahead.

Mr. BROWN. Well, I raise these questions because as a part of our own assessment activities on the Board, we are confronted with finding out the degree and type of public participation that should be an ingredient in this TA process. Presumably the Congress is a little different from the Edison Co. in that we have a mandate to represent the public interest in the assessment process, and the assessments undertaken are for the purpose of providing us with other kinds of data. On the other hand, it is essential to the whole political process that elected public officials who make decisions in them representative capacities, are highly moved by their perception of public attitudes to particular decisions.

In a larger perspective than your experience with the powerplant in the high desert. is the situation involving the whole of California on proposition 15. Here the question of public attitudes toward a technology or toward the full deployment of a technology becomes a matter of almost overriding concern if we are going to be able to plan for the future energy needs of the State. We therefore need to have some way of rationally evaluating the role of public opinion and public attitudes. As we evaluate any of these technologies, we need to have a mechanism whereby the public can assist and participate in the decision-making process.

The mechanism may simply be sophisticated polling. This is one way to a form of public participation. It may also include a wide range of advisory committees. I don't know whether or not you have ever utilized the tool of public participation. It is subject to considerable criticism in Washington. we are trying to determine what is the proper role for hearing the public's voice in TAs, and how it can contribute to the overall value of an assessment.

Mr. MooRE. I believe we have a step process here. As we view a TA, the first step is to ask either our staff or frequently outside qualified people to make a TA such as the one we asked the Jet Propulsion Lab (JPL) to make in the case of solar energy. In that process we don't anticipate having input from the general public. We hope that we have picked the properly qualified people to make a study for us as to that. As I see the second step of the assessment process, it is to review the output of the first step of the TA in order to make adjustments, or to more clearly assess what is the public's general thinking.

I think in JPL or in any organization today we are all in the corporate part of the world more interested in and more conscious today of the questions that concern you; the need for social assessment and understanding of the impacts of pure technology such as apparatus and plants. I just view these as a series of steps, the first one being the generation of a scientific document using a bank of technical information that includes sociological input, just as we are doing now with transmission lines and similar technologies. Then in the second step of a hearing process we will be better prepared to understand what to expect in that second step.

Mr. BROWN. You have devoted several paragraphs to explaining the importance of the regulatory system on your planning for the future. I am continually puzzled in my own mind as to whether or not an analysis of regulatory system operations and anticipated or projected changes in the regulatory environmental mechanisms is a proper field for the Office of Technology Assessment (OTA). Obviously it is a part of your policy pattern or planning. Can we construe that an analysis of the impact of a given regulatory course on the development of our energy system is a legitimate problem for technology assessment ?

Mr.. MOORE, In my opinion it certainly is. This is cause the very foundation of the reformation, the answer to such a question as, "110 we have proper regulatory procedures?" starts with technology. Arriving at a decision based on purely sociological considerations gets you nowhere I think, because the base of the technology, including economics, must be established before determining whether we have proper regulatory procedures. I am certain you are aware that in general the electric utilities have fostered a one-stop regulatory process. This would have no hope of success unless it had as its foundation a TA of the full field involved in the generation and future planning for electric power or any form of energy in this country.

Mr. BROWN. Well, we have almost come to the point where TA is sort of synonymous with the whole field of futures analysis. We appear to be moving in the direction of looking upon our economy or maybe in a broader sense our entire culture as a technological artifact subject to whatever forms of assessment will survive some pragmatic test of usefulness That of course is not a very narrow boundary for the field. The concern of the Board is to develop a focused and operational definition of the TA process. If we take the broad definition that it is legitimate to engage in a TA of an-y aspect of future development that will have an impact on society in a major way, then our problem becomes one of setting priorities rather than defining a field, and that is, of course, an entirely different kind of a problem. I gather you subscribe to a broad rather than a narrow definition of technology assessment.

Mr. MOORE. Yes, I certainly do. I recognize the size of the problem just from measuring the size of the problem that we as an individual utility have today. It is, because of its size, one of selecting priorities. But if you look at the tools with which any question is answered today-other than the human emotional tools that are used on many occasions—the people or the organization trying to find an answer usually turn to computer modeling; almost immediately you have stepped into the world of technology in just trying to get a simple societal answer. So I don't see how we can escape it,

Mr. BROWN. For many years you have had a phase of your operation that deals with load forecasting and with futures analysls or planning centered on the necessity of being able to supply the load that you forecasted. I gather from your paper that you are developing new and more sophisticated methodologies for improving your load forecasting capabilities. To what degree has your operation examined the possibility of whole new patterns in energy consumption? What assumptions do you make for example, about the impact of conservation or more energy efficient technologies?

I recently read Herman Kahn's book '(The Next 200 Years," in which the underlying assumptions are rather interesting. He postulates certain limits based on these assumptions. One of these is a fourfold increase in energy efficiency, which would have massive impact on energy consumption over any reasonable period of time. To what degree does the Edison Co. engage in efforts to project increased energy efficiencies and energy conservation over a reasonably long time frame?

Mr. MOORE. our system planning department, which as little as 3 years ago used to be called a generation planning department, and is now the system planning department because of a broader concept than we had 3 years ago, is made up of an environmental division and a conservation planning group. The man that heads up that organization today is on the officer level in the corporation. Our Edison Electric Institute (EEI), makes what I might call more global type of studies, as well as the Electric Power Research Institute, a separate division of that institute, they are also making studies, but these are more of a direct research type on technology applications.

I certainly have to agree with your comment about an increase in generation in the future, even from the viewpoint of a lack of the conventional energy sources we have had in the past. Because as there is a depletion of these energy sources I believe that you will see a greater usage of electric energy, but possibly more for things such as transportation than we have today with fossil fuel supplies. Part of this belief comes from projections of the type that are made by the EEI.

Something else that has had quite an impact on some of our thinking in the company is that about 4 or possibly 5 years ago, the Joint Committee on Atomic Energy asked for a projection into the future of energy supplies. It came as a surprise that such a study existed, to many with whom we had discussed the possibility of a cutback on fossil fuel supplies, but the document did exist. That made a major input into our fuel purchase planning. So in order to determine whether we will be able to supply low-sulfur fuel to the combined-cycle plants that we will be building in the future, we do have to make more broad global type studies in-house than we have had to do in the past.

Mr. BROWN. Have your operations been impacted by the new institutional arrangements in California dealing with the environment? I am speaking here of the new energy corn-mission that also has a powerplant siting role. I gather that even the Public Utilities Commission, and I am not at all familiar with it, is pursuing a somewhat more aggressive supervision of your utility activities than it has in the past. Have these factors influenced your need to engage in futures analysis and TAs to any degree?

Mr. MOORE. They certainly have. We had hoped that with the establishment of the Energy and Conservation Committee in the State, we would come closer to a one-stop agency. We find that today all that has been done is a proliferation of agency involvement into some of the things we do. In fact, I would expect that that same energy commission from the land use charter they have will attempt to move very heavily into the nuclear field. They established hearings in August of this -year to study the movement of people in the event of a nuclear disaster, a study not of a generic nature but of a very specific nature, that has already been covered by the Nuclear Regulatory Commission (NRC). So we see the generation of additional paper and of additional information that is already available in the public record. We just completed hearings, as far *as* San Onofre is concerned, on the effect of the park that was established in front of the plant. I think that this has to be placed in our planning for the future, which comes back to the word assessment—what are our opportunities, what can be done.

Mr. BROWN. Just one final question. With regard to your futures analysis, to what degree have your forecasts of demand or your load forecasts changed in the recent past, that is over the last 2 or 3 years? Has there been a marked shift m your projection of what the energy demands for your service area will be 10, 15, and 20 years in the future?

Mr. MooRE. We believe that for our 20-year plan, we will see a growth rate on the order of about 6 percent on a long term basis. on a short term basis I can say that we are coming out of a period where the load growth was absolutely flat. I would expect that for the year 1976 we would see growth of about 1½ percent. In the next 5, 10, and 15 years this could go up to about 4 percent, and then in the 20-year period about 6 percent if the supply of natural gas dwindles as predicted and a change in the transportation mode occurs.

One of the unknowns here is the impact of certain industry oil well pumping with the possibility of seeing that it would be more economic to convert to electric power as the market improves for their product. We can see that there could possibly be a slowdown in certain building areas. The impact of solar has been cranked into the energy use, but those are short term.

Now you are surprised that I say solar is somewhat short term. Well, we will see that there is the possibility that with respect to the future development of solar today, the technology is highly dependent on oil for example, for the construction of solar panels. So if we expect to really develop large amounts of solar power there have to be answers developed other than just continuing in the direction of oil, including coal and maybe fossil fuel.

Mr. BROWN. Regarding 6 percent annual growth rate that you have projected for the 20-year plan, is that a substantial lower rate than the past 20 years have been?

Mr. MOORE. Oh yes. We have projected 9 and 10 percent in the past, and we have had rates of growth such as that.

MID. BROWN. We very much appreciate your testimony here this morning, Mr. Moore, and we look forward to hearing more about the activities of the Edison Co. in the field of futures analysis and the TA related thereto.

We hope that if we would like further clarification of the points you have made, our staff can submit additional questions to you for your response.

Mr. MooRE. Thank you, sir. It was a pleasure to be here.

[The following questions were submitted by congressman Brown to Mr. Moore and his answers thereto:]

Question 1. Would you say that technology assessment (TA) has influenced the manner in which Southern California Edison conducts its business? What is done differently now?

Answer 1. The operation of a large electric utility system has always depended to some extent on the use of TA. However, in recent years this has become of greater importance with the advent of new technologies, environmental impact considerations, and economic limitations. In its planning for the future, Southern California Edison has taken into account 1'A in a number of areas. For example, the use, by Edison, of solid waste from the Southern California region has undergone TA, and the company has developed a program that we believe will be beneficial and responsive to the local social, environmental, and political situation. Similarly, a thorough review of solar heating and cooling identified institutional and technical problems that are the focus of Edison's actions in this area for the next few years. Here, the company has chosen to serve as the warrantor for a large number of solar water heating systems installed on new residences. This represents a new direction in Southern California Edison's conduct of business,

The use of TA early in the development of a technology has allowed Edison to develop a better research and development plan in several areas. A number of alternatives have been developed simultaneously for meeting air emission regulations, but at the same time the understanding of the effects of these emissions on the environment is being improved. In general, the use of TA during the planning and conduct of the complete research and development program as well as the siting and construction of generation and transmission facilities has improved the flexibility in responding to problems that arise. Where technical feasibility, and economic and political systems were considered previously, Edison now uses TA to add consideration of social and environmental concerns.

Question 2. In a TA should the impact of a new technology on job structure be examined?

Answer 2. From the standpoint of a single company, the impact of any of its operations on job structure is continuously being examined. The extent to which it is considered, of course, varies with the nature of the operation or new technology. In general, new technologies have to go through a maturing process before they reach commercialization. During this process the job structure may change several times. Only in the broadest sense can the final job structure be predicted. From a Federal Government standpoint, the impact of the development of new technology on employment in general, as well as job structures in particular, should be examined if major changes in the employment market or industrial structure seem to accompany the new technology.

Question 3. What formal structure exists for doing TA?

Answer 3. In considering a particular technology for installation, the licensing procedures represent the closest framework to a formal structure for doing

TA. The need to consider environmental impact as well as the requirement that new facilities be justified based on demand projections, including customer actions, inherently represent a TA by the electric utility. This process can take several years and involve several updatings of environmental, social, and political impact information. For new technology the Southern California Edison Company relies in particular on national organizations for any formal structure for doing TA. In-house efforts are conducted *on* a less formal basis as the need arises. In some cases, the TA is contracted to outside organizations (e.g., the solar heating and cooling assessment was done by the Jet Propulsion Laboratory of NASA).

Question 4. How do you incorporate TA activity into your reports?

Answer 4. Technology assessment activity generally appears in several formal reports prepared by Southern California Edison. If new facilities are to be constructed, a general TA is included in the environmental impact statement that must be prepared. The social aspects are considered in filings with the California Public Utility System for licensing purposes.

In addition, aspects of TA are included in status reports for recommendations for the development of new technologies. These latter reports are not prepared on a fixed schedule but on an as-needed basis.

Questiom 5. What is the most useful manner you have found for getting the public involved in your TA activities ?

Answer 5. The most common method for public involvement in Edison's TA activities has been the use of public hearings in conjunction with siting of new facilities. Since there are several different aggncies involved in the licensing of new facilities, the public involvement during hearings can be on a broad basis. Through the public inputs in these hearings, and the actions of the licensing agency, many of the social and political aspects of the TA can be developed and refined.

Question 6. Do you see any similarities or differences between TA and environmental impact analysis (EIS) ?

Answer 6. TA and impact analysis are closely linked concepts. As part of a specific TA, an impact analysis could be conducted as part of the overall feasibility evaluation. However, depending on the purpose of the TA, an EIS may not be required.

On the other hand, an EIS could be considered to be a type of TA. The impact analysis is in essence an assessment of the feasibility of a technology applied to a particular site and a particular set of environmental and political criteria. A technology that is feasible for one set of circumstances may not be acceptable in another. Accordingly, the technology must be assessed for such unique set of circumstances.

Question 6a. How do you handle EIS's? (The following answer assumes this question refers to how we interact with the process that results in lead agency completion of EISs.)

nswer 6a. Southern California Edison is involved in both State and Federal programs for the conduct of environmental impact analysis. California State requirements result in a document entitled an Environmental Impact Report (EIR) and Federal requirements result in an EIS.

These documents are developed in several ways depending on the agency lnvolved. Following are the general approaches used:

1. The Nuclear Regulatory Commission (NRC) and some other agencies require the applicant to prepare an Environmental Report in compliance with very specific guidelines. This document is used as a reference base for completely independent analysis by the agency of every environmental feature. From their independent analysis, an EIS is produced. This approach results in the most thorough impact analysis though it is quite time consuming.

2. Some agencies require the applicant to submit data not in the form of an analysis report. From these data and the agency's own analysis, an EIS is prepared. This is a relatively ineffective approach because the agency is trying to analyze and interpret data collected by the applicant.

3. Many agencies, including the California Public Utilities Commission, require the applicant to submit a data statement which also includes the applicant's analysis. This report is similar in concept to the report required by the NRC. The applicant's report is circulated by the agency for comments. Comments received and applicant and agency responses are bound with the applicant's report along with a summary evacuation by the agency responsible. This compilation is circulated as the draft EIS. This approach is quite effective because the final document can reflect several viewpoints.

Question 6b. Do *you* discuss impacts and educate the public ahead of time?

Answer 6b. As projects are developed, a public information plan is produced that serves as a basis for public contact Generally, most initial contacts are with civic leaders and others with probable interest The level of efforts in communicating with the general public usually depends on the magnitude of the project and the likelihood that people will be adversely affected.

Question 7. What value do you see in having closer relationships in regard to TA activities in the public and private sectors?

Answer 7. Closer relationship between the public and private sectors in TA activities should enhance these activities considerably. Information as to what is plausible and what is impractical from both points of view need to be included in TA activities but seem to be lacking in many cases. As an example, an assessment of on-site solar plants by a research agency under contract to OTA did not consider, initially, the availability of materials and the ability of industry to construct facilities in the quantity being suggested. With input from the private sector this matter was resolved without loss of credibility for the entire study. Continuing interaction of this type will result in more useful assessments. The same is true for the input of the public sector in terms of potential regulations and legislation. In private sector TA, this will result in more meaningful developments.

Question 8. What limits do you see to the concept of TA in its utilization and application in the government and private sectors?

Answer 8. Since TA depends in part on predictions of future actions by society, it is limited by the nature of the assumptions used for the future of the Nation and international relationships. Technology assessment as I understand it, is only a method for assessing alternatives and their impact, and should clearly be limited to this. The determination of direction must come from other simultaneous assessments of National, social, and economic goals in the governmental sectors, and industry goals in the private sectors. In terms of technology, the use of TA often pre-supposes success in the development of new concepts. As is evident from much of the history of science, success at research is not guaranteed. This must be recognized as a critical limitation on the utilization of the results of a TA.

Mr. BROWN. Our next witness is George E. Mueller, chairman and resident, System Development Corp. Dr. Mueller, we welcome you here this morning and I am sorry that we proceeded out of order with you. I hope it doesn't infringe too much on your time schedule this morning. I am pleased that you could be here this morning and help us to some degree refine the concept and process of technology assessment. This is the purpose of these hearings as they relate to our Technology Assessment Office in Washington, a new arm of the Congress. The Board hopes to make it as useful to the Congress as possible.

You may proceed with your statement in whatever form that YOU wish.

[The biographical sketch of Dr. George E. Mueller is as follows:]

DR. GEORGE E. MUELLER, PRESIDENT AND CHAIRMAN OF THE BOARD, SYSTEM DEVELOPMENT CORPORATION

B.S. electrical engineering, University of Missouri; M.S. electrical engineering, Purdue University; Ph. D. physics, Ohio State University.

Research at Bell Laboratories; electrical engineering faculty, Ohio State University (10 years). Early space projects on which associated include: establishment of the U.S. Air Force SPAN satellite tracking network; development of Pioneer I space probe; and design, development, and testing of the Atlas, Titan, Minuteman, and Thor ballistic missile programs. Senior vice president of General Dynamics Corporation prior to assuming present position.

Professional affiliations include: a member of the National Academy of Engineering; a Fellow of the American Association for the Advancement of Science, the American Astronautical Society, the American Geophysical Union, the American Institute of Aeronautics and Astronautics, the Institute of Electrical and Electronics Engineers, and the Royal Aeronautical Society; and an Honorary Fellow of the British Interplanetary Society.

Honorary degrees received from Wayne State University, New Mexico State University, University of Missouri, Purdue University, and Ohio State University; and awards include three NASA Distinguished Service Medals, American Astronautical Society Space Flght Award, the Eugen Sanger Award, the American Academy of Achievement's Gold Plate Award, and the National Medal of Science, for his many individual contributions to the design of the Apollo System.

STATEMENT OF GEORGE E. MUELLER, PRESIDENT AND CHAIRMAN OF THE BOARD, SYSTEM DEVELOPMENT CORP.

Dr. Mueller. Thank you, Mr. Chairman. It is a pleasure to be here this morning and to address the subject of technology assessment (TA) as it is practiced at system Devclopment Corp. (SDC) ; its role, how we use it, and some of the results obtained from TA. In our business? which is the development and production of data processing systems and services, technology has very significant impacts. The data processing industry has grown, and will continue to *grow,* because of rapid technological changes and innovations that create new product opportunities and open new markets.

At SDC, our TA program is used to anticipate and plan for the impacts of technology changes on our products and operations. We evaluate technology trends with respect to basic customer needs to find new product opportunities. We examine technological advances in terms of our internal operations to look for better ways to produce our current products. In short, our TA program is an essential ingredient of our long-range business planning, investment policy, product planning, and market development.

Technology assessment is a continuous process that is quantified and documented annually as a part of our 5-year planning cycle. Some of the important technology trends listed in our current strategic plan are as follows:

First, rapidly decreasing hardware costs. This trend will have an increasing impact on SDC's business and products. It will keep intensive pressure on reducing software costs and will cause some functions now performed by software to be done by hardware. Software costs will respond to this pressure and decrease during the next 5 years. As this happens, pressure will build on the reduction of operation and maintenance costs, which like software are labor intensive. Our software factory program, which I will discuss later, is in response to this trend.

Second, is increased data communications capability. The availability of long-range communications links will be greatly expanded by communications satellites. The cost per bit per mile will continue to decrease. These factors, coupled with the availability of minicomputer and microcomputers will cause increased emphasis on computer networks and distributed processing.

Third, is the growth of minicomputers and microcomputers. The availability of small, inexpensive computers will open up new application areas. You will see one example of that later. Their use *will* continue to grow and expand both as small stand-alone systems and as an element of distributed processing networks.

Fourth, is increased requirements for protection of computer-stored data. As the applications of computer-based systems expand, both industry and Government become more dependent on these systems.

The data stored in them become more valuable and more sensitive. In addition, with the expansion of distributed systems, data in transit is more vulnerable to abuse in the shared communications systems. Current and anticipated privacy legislation will place additional requirements on protection, accountability, and system accreditation. These factors will increase emphasis on the application of computer systems security technology in both military and commercial systems.

Fifth, is the increased use of online systems. Online systems provide substantial improvements to users in terms of a system's responsiveness and the timeliness of data. However, they tend to be more costly in terms of hardware utilization. As hardware costs decrease, usage of these systems will continue to grow to the point where they will completely dominate the industry 5 years from now.

Sixth, is increased use of computer-based systems by nonprogramers. The use of online systems has removed the programer as the interface between the real user and the data processing system. As online systems expand, the number of real users interfacing directly through "smart" terminals will grow. This trend will demand that the systems we develop be much more secure, reliable, available, and usable, providing the user with a work station suited to his needs and training without assistance from programers.

I have chosen three brief case histories to provide examples of our TA program, and the results of applying this kind of a long-range assessment-m our business, 5 years turns out to be a long-range assessment rather than 20 or 200 years—to give you some idea of how we actually apply TA.

The first case is a product called Text II. In 1971 technology advances in three key areas were identified and assessed to have a significant potential impact on the manner in which material was composed for printing. The first important technology advance was the development of the phototypesetter that used photographic techniques to set type. This device was capable of replacing the hot metal linecasting machines and was much faster and more accurate.

The second important advance was the development of low-cost, highly reliable minicomputers. These devices had the processing power and storage capability to prepare copy for input into the phototypesetters, and in addition. automate many of the office and accounting functions of publishing houses.

The third area of technological development identified was the video display terminal. This device permitted the capture of the original keystrokes for direct entry of text into computers and the rapid display of entered text for editing, corrections, and review, thereby eliminating the need for time-consuming and error-prone retyping of the text.

These technical advances were evaluated in terms of the needs of the publishing industry. At that time, we found that the preparation of information for printing was costly, labor intensive, and error prone. The requirements for the industry has grown in direct relation to the '(information explosion" of the previous two decades. The methods employed in the composition of copy for printing had remained virtually unchanged for some 50 years after the invention of the linecasting machine in the late 1800's.

In the 1950's computers were first introduced into the publishing industry to prepare copy and to create paper tape to drive automatic linecasters. This was an important step. It did not, however, appreciably reduce the human effort required, since the original copy had to be rekeyboarded for entry into the computer.

Our assessment of the new technology available to provide an improved solution to the needs of an industry triggered the development of a new product-an all electronic publishing system we call Text II. Software programs were developed that linked video-display terminals, a minicomputer, and a phototypesetter into an integrate system for the entry, editing, and setting of text, as well as the automation of related office and accounting functions.

Our first system was installed in 1974. Today, we have five systems operational and a substantial backlog of orders. The most widespread use of these systems to date has been among newspapers. Virtually every newspaper in the United States with a circulation of more than 25,000 is planning to automate its production methods as a means of increasing efficiency in order to remain competitive with other media. In the next 10 or 20 years it is expected that electronic publishing systems will materially improve the efficiency of preparing material for printing in all areas of government and industry.

The second case is a software factory, and addresses quite different problems. Over the past 20 years the capability or power of computer hardware per unit cost has increased dramatically. A recent advertisement by a computer manufacturer stated that:

> While the cost of just about everything has risen dramatically in recent years, the cost of doing things by computer has been a noteworthy exception. Although computers have become increasingly useful as their speed and capacity have multiplied. their cost per operation has declined sharply since the first commercial computer was installed less than 25 years ago.
>
> For example, in 1952 it cost $1.26 to do 100,000 multiplications on an IBM computer. Six years later, the cost had dropped to 26 cents. By 1964. those same 100,000 multiplications could be executed for 12 cents and by 1975 for 5 cents. Today they can be done for a penny. All this against the current of inflation that has been seeing an $0 percent rise in the Government's Consumer Price Index over the past 20 years.
>
> This astonishing reduction in a computer's perfunction cost has led to important savings in the overall cost of doing a given data processing task. It has been brought about by technological advances such as the miniaturization of computer circuitry. Such advances have made possible vast increases in computation speed-from about 2,000 multiplications a second on an IBM computer in 1952 to more than 2 million a second today.

Widespread and inexpensive availability of powerful computers has led to the development of ever more complex systems. As a result of these technology trends, our TA program concluded in 1973 that software costs would rapidly dominate data process system costs, that intense pressure would be brought to bear on reducing software costs, and that we at SDC must find new techniques for producing software and reducing costs. Consequently, a program was initiated to develop an innovative approach to software production. This approach, called the software factory, consists of three fundamental components—a new organization concept. rigorous production standards, and production tools. The organization approach involves the use of dedicated organizations to perform key software production functions; for example. design, development, and test. Thus each new software system passes through a series of organizations that coincide with succeeding phases of production, very much like a factory assembly line. This, when contrasted with the usual approach of one group of people performing all of the production functions from start to finish, has the advantage that increased benefits accrue over time if essentially the same people are responsible for specific activities. Familiarity and facility with methods and took is gained with repeated use; general purpose libraries of reusable software modules are built Up; and specialized centers of technological knowledge can be maintained and applied to all projects as needed.

Traditionally, software has been produced at customer locations, field sites. or wherever the system hardware is located. This new organization approach requires the software to be produced at a central location—the "factory" where the workers can easily move from one project to the next, and have ready access to all production tools.

The production standards constitute the software factory's methods component, and are embodied in a manual that provides a common definition of the software development cycle with detailed standards and procedures for ever-y required activity. The detailed procedures provide a consistent and highly visible standard production approach m which the system development process starts as a set of general requirements and production plans, and passes through standardized production phases to add more and more detail to the evolving system framework. Each phase, when completed, increases the degree of detail one dimension to establish the foundation upon which the next phase of the software system production cycle can proceed. This approach provides visibility and traceability to the developing system, both from a technical and management point of view, and exerts a strong and desirable structuring influence on the system architecture. It is the consistent and universal use of this concept that makes the software factory approach unique, and it is this concept more than anything else that will help achieve our goals of increased productivity, lessened risk, and more reliable products.

The third major component of the software factory is an integrated set of production tools that save programmer time and effort, and provide a framework for implementing the procedures -just described.

Work on the software factory was initiated in 1973, and is currently being completed and put into operation. We expect this program, triggered by TA, to provide major Improvements in our software production capability to meet the demands of our data processing systems for industry and Government.

The third case I would like to describe is a product called FOCAS, which is a quite different area, and represents a quite different application of computer systems. Here the technology trends of lowering hardware cost, and the increased availability of low-cost, online systems through the use of communication satellites and "smart" terminals are identified in our current strategic plan as I have indicated earlier. The world energy shortage has led us to assess these trends with respect to the transportation industry in a search for new information system products that would improve the efficiency and effectiveness of transportation systems. One of the results of this activity is a new product we call FOCAS.

FOCAS is a computerized system designed to meet the special needs of the shipping industry in its daily activities required for controlling the movements of containers and cargo. A typical shipping company has a number of locations at which important business is conducted, each location developing and handling critical data. In Containerized shipping, the need occurs daily at nearly every location to obtain a consolidation of data from all locations. FOCAS addresses this need by creating and utilizing a single set of information; the data base. This avoids the creation of multiple, often conflicting files, at various locations.

The centralized information is made instantly available to all locations through the use of low-cost, simple-to-operate terminals at all of the locations, tied to the data base at a central computer with high-speed data communication links. Transactions that are performed at the terminal are the nucleus of the system operation. They keep the data base information up-to-date and provide immediate, consolidated information at the terminal in response to inquiries. Functions performed by the system include container management, ship management, lease control, sales and accounts receivable, tariff analysis, agent commissions, and intracompany communications.

FOCAS is now in operation providing service to two major shipping companies. Its effectiveness is illustrated by the fact that both of the companies have been able to reduce container requirements significantly.

In summary, we at SDC use TA as a way of survival. We have used it both to make an assessment in terms of *a* specific perceived requirement, and as a method to generate requirements of a customer's need in terms of our international operations. We are using it to identify new products and to define better ways of doing business.

Mr. BROWN. Thank you very much, Dr. Mueller.

How do you or do you identify the TA function as a separately identifiable organization unit or is it merely integrated into your management and policy-planning activities in general?

Dr. Mueller. We have felt that technology assessment is something each of the major line operations must participate in if we are going to have an effective cross section or view of trends of technology.

We do have an R. & D. organization, whose primary charter is to maintain us in the forefront of the applications of technology, and we do have a chief technologist, whose duty is to be sure that we are aware of and are following the trends in the development of new technology throughout the country. So we charge everyone with the responsibility but we have focused it in the office of our chief technologist.

Mr. BROWN. Since your company's business is technology in a general sense, and more specifically computer technology, what in another company would be ordinary production planning is technology planning for you.

Dr. MUELLER. Our supply literally depends u on our ability to maintain current understanding of technology anZ being right about our forecast.

Mr. BROWN. What most interests me about the examples that you have given of the impact of your technology developments, for example in the printing business is that they appear to substantially reduce the need for manpower, particularly the old skills---the craft skills and the printing trades—and possibly the overall manpower requirements. Obviously this reduces the costs and has other positive economic effects, but It has the negative effect of creating a problem of displaced manpower. Is that a part of your overall analysis in these fields This is an externality that your company is not responsible for, but it is a kind of problem for which we in the political policy-making area think we have to be responsible. Otherwise we wouldn't have legislation like the Humphrey-Hawkins bill and other similar legislation before us.

Mr. MUELLER. You are quite right. And yes, we do consider that.

I would say that although computer-based systems are generally credited with increasing the efficiency and reducing the requirements for manpower, there are very few computer-based systems that have been installed either in industry or in Government which have actually resulted in the reduction of manpower. Computer-based systems have certainly provided efficiency in terms of producing more output for a fixed cost, but they have not resulted in significantly reduced manpower in any area in the information-based systems, which is the primary business area in which we operate.

On the other hand, in the case of the newspaper-publishing business, the skilled craftsmen necessary for carrying out the production of newspapers using hot metal can be reduced in number. 'The introduction of the new technology has helped sustain a reasonable growth in the publishing industry by solving problems created by increasing costs in combination with shortages of resources both in terms of men and in terms of material, and the increasing amount of printed material that we are experiencing in every year. Our experience has been that we have tended to improve the output rather than to decrease the manpower.

Mr. BROWN. I am not trying to advert to what used to be a very popular view that technology was reducing the number of jobs available in our society and at some point down the line people would not be required to do the work of society. That has not occurred in any area of technological development., but there has been, as you indicate, the increased efficiency coupled with a changed type of skills required to operate the system. This has created certain problems, which are sometimes exaggerated.

Dr. Mueller. I will say this. that it is a very good point that the skill mix has changed as a result of the introduction of new technology, and in many instances it has required a higher level of skill. I think that as we learn more about how to use computers, we are going to see a reversal of that trend. It is true that today relatively untrained people in the newspaper business are capable of using this Text II terminal. whereas a few years ago that would have been quite impossible.

Mr. BROWN. I seem to recall that in the area of transportation we have seen the development of new forms of labor contracts that recognize the inevitability of the decreasing need for longshoremen and similar types of skills. It has created a contract, that provided protection for employees during their lifetime but it has not been able to retard the employment of new technology.

According to my recollection of the new labor contract at the Washington Post, which went through a traumatic experience a few months ago, they developed a somewhat similar type of contract aimed at protecting the economic well-being of craftsmen too old to retrain and who the company don't want to throw out on welfare or something of that sort.

May I ask a question similar to the one I raised with the previous witness about the impact of the public in the TA function as we put greater emphasis on the communication revolution that is occurring and we see certain policy developments taking place. You made reference to the question of privacy, which arises because more and more computer files are being maintained. Some of these will contain personal information on individuals. The public will have a concern about access to these files. There is the possibility here that public reaction against new computer developments might arise somewhat similar to what we have seen with regard to public reaction against nuclear power or other energy technologies.

It is obviously important that questions of desirable public policy be considered in the deployment of these new communications technologies. Is there on element in your TA process that allows you to evaluate these possible reactions ?

Dr. MUELLER. We certainly try to anticipate problems. As it turns out System Development Corporation (SDC) was one of the organizations that recognized the problem of both privacy and security some 5 years ago, and has been working in this area for some time. We have a group in Washington working on privacy, and a group here working on computer security. We have just undertaken the development of an electronic transfer system for a group of savings and loan companies. One of the key ingredients is providing security for the data so that when the remote terminals access the data base they do it through a link that is secured and cannot, be penetrated without having some access to the actual keys. I believe that more and more of the data bases will have that kind of protection built into them as the use of online systems arise, in order to prevent unauthorized access to data.

Mr. BROWN. Do you have that built into the FOCAS systems that you described?

Dr. Mueller That is not secure in that sense. In fact, I know of no truly secure computer-based system, with online terminals in the country today. Now, there are various levels of security. FOCAS has what is called password security, which is also capable of preventing unsophisticated access to the data base, but—

Mr. BROWN. That doesn't help much when everybody is becoming more sophisticated, does it ?

Dr. MUELLER. I believe that is one of the key problems. As more and more people, as more and more college students learn how to use computer terminals, the challenge of penetrating private data bases becomes more and more intriguing to them.

Mr. BROWN. You did describe a system that is secure for the movement of cash for savings and loans?

Dr. MUELLER. Yes.

Mr. BROWN, That, is not what you call an online system?

Dr. MUELLER. It is an online system. It is secured using a new special security device employing the National Bureau of Standards data encryption standard.

Mr. BROWN. Could that same kind of device be applied to the FOCAS system if you felt it was necessary to do so?

Dr. MUELLER. Yes. It could. And I have no doubt eventually it will.

Mr. BROWN. It is probably not quite so important to maintain the security of the system when it just involves data having to do with Congress as it does with the actual transfer of funds. However, I can visualize the possibility that in an intense competitive situation a competitor might make an effort, for example, to get into a particular FOCAS system for whatever purposes.

Dr. Mueller. You are quite right. I am sure that eventually somebody will think of a way of using data improperly. On the other hand, I don't believe that the data we have now in the FOCAS system is one that lends itself to competitive advantage.

Mr. BROWN. The point that I was trying to make is the degree to which the public perceives these systems as having either beneficial or adverse public policy implications for whatever reason. This public reaction may pose a problem with regard to the deployment of these systems, in which case the attitudes of the public have to become a part of the TA process.

Dr. MUELLER. There is no question in my mind that more and more of our use of our a placations of new technology is going to be influenced by the way the public feels and expresses its concerns.

Mr. BROWN. It a pears already that we are going to have a technolo devoted to determining how the people perceive what is good for them and what to do about that. Of course, that will replace politicians when that comes.

Dr. MUELLER. 1 doubt very much if we are going to replace the political scene in the near future.

Mr. BROWN. Dr. Mueller, we are very grateful for your statement this morning. It will make a valuable contribution to the record of our hearings. If further elaboration on some of your remarks is required, I hope you will allow us to communicate with you in writing about these and continue to cooperate with that in that respect.

Dr. MUELLER. By all means. It was a great pleasure to be here, and I appreciate the opportunity of addressing you.

Mr. BROWN. Thank you very much.

[The following questions were submitted by Congressman Brown to Dr. Mueller and his answers thereto:]

Question 1. What limits do you see to the concept of technology assessment?

Answer 1. Technology assessment (TA) is used as a forecasting technique at System Development Corporatlon (SDC) to predict requirements for new products. The accuracy of the forecasts is limited by our ability to forecast technological advances and to interpret the results in terms of product requirements and new product opportunities. When technology trends progress in a relatively continuous manner, the accuracy of the forecasts is quite good. When a technical breakthrough occurs, there are discontinuities created in the technical trends and the accuracy of the forecasts is degraded.

Question 2. Has the use of TA influnced the way SDC does business? How do you incorporate the results of your TAs into your planning, decision-making and policy processes?

Answer 2. At SDC, our basic business strategies and policies are established and updated annually through our long-range planning process. This process involves a series of planning, review, and presentation sessions conducted by the senior managers of the corporation and the corporate chief technologist. The end result of this process is our long-range plan that documents the basic strategies, policy decisions and results expected over the next 5 years. Our TA program provides one of the important inputs to the long-range planning process and is used to anticipate and plan for the impacts of technology changes on our products and operations. We examine technological trends with respect to basic customer needs to find new product opportunities. We examine technological advances in terms of our internal operations to find methods of increasing productivity and product quality.

Question 3. What formal structure exists for doing TA? What steps are usually taken in the TA process? How do you decide when it is necessary to do a TA?

Answer 3. Our TA program is focused in the office of our chief technologist. He, in conjunction with the manager of the research and development division, determines the 5 or 6 key technology areas that are likely to have the largest impact on our business over the next 5 Years. A senior technical specialist is appointed Technical Area Manager (TAM) for each key technology, and charged with the responsibility to conduct our TA program and plan the technology development in his designated area. The TAMs provide inputs to the line managers for the long-range planning process near the end of each year, and for our annual operating plan at mid-year.

Question 4. In your opinion, in a TA should the impact of a new technology on a job structure be examined?

Answer 4. One of the more significant impacts of the introduction of new technology is to change the skill mix required of the organization involved. Therefore, I think an examination of the impact on job structure is an important aspect to be examined.

Question 5. When you do a TA on a certain problem, how do you involve the public?

Answer 5. Our internal TA program does not usually involve the general public directly, however we encourage our TAMs and other technical specialists to participate in professional societies, industry associations, government study panels, and similar activities that involve a broad cross-section of opinion, and consider technology progress from the public point of view.

Question 6. In the TA process, do you discuss with the public possible positions or negative impacts ahead of time?

Answer 6. Yes, in the professional societies, industry associations etc., mentioned above.

Question 7. What value do you see in having closer relationships between the public and private sectors?

Answer 7. At SDC, technology advances are a basic ingredient of our business. New products and better ways of doing business are created by new technology. These changes often create problems too; problems for our customers using a new product; problems of standardization across an industry; and problems of changing skill requirements in our internal operations. I believe a closer relationship with the public sector would help us to better anticipate and plan for these problems, and in some cases, avoid them.

Question 8. How do you incorporate your TA activity into reports?

Answer 8. As indicated above, our TA program results are reflected in our long-range and annual operating plans.

Mr. BROWN. Our next witness is Prof. Don E. Kash, who is director of the science and public policy program with the University of Oklahoma. Professor Kash has been active in the field of technology assessment (TA) for a considerable period of time and has been of great value to the Technology Assessment Board. We are very pleased that you could come here today all the way from Oklahoma in order to contribute to our hearing record. You may proceed with your statement in whatever fashion you wish, Professor Kash.

[The biographical sketch of Dr. Don E. Kash is as follows:]

DR. DON E. KASH, DIRECTOR, SCIENCE AND PUBLIC POLICY PROGRAM AND GEORGE LYNN CROSS RESEARCH PROFESSOR OF POLITICAL SCIENCE, THE UNIVERSITY OF OKLAHOMA, NORMAN, OKLA.

Born, May 29, 1934; married, two children. B.A., 1959; M.A. 1960; Ph.D. 1963; political science, the University of Iowa.

Instructor, Texas Technological University, 1960-1961 ; assistant professor, Arizona State University, 1963-1965; assistant professor, The University of Missouri at Kansas City, 1965-1966; associate professor, Purdue University, 1966-1070; visiting professor, the University of Oklahoma, Advanced Programs, 1967; visiting associate professor, Indiana University, first semester, 1969–1970; professor, The University of Oklahoma, 1970-present.

Director, Purdue University Graduate Education Project in Science and Public Policy funded by the National Science Foundation; Purdue Coordinator, Joint Indiana University Purdue Project for Curriculum Development in the Study of Science and Society funded by the National Science Foundation; Director, Program in Science and Public Policy, Purdue University; Director, Science and Public Policy Program, The University of Oklahoma, 1970-present.

A member of: Review Committee on Energy and Environmental Systems Division of the Argonne Universities Association (AUA is the university consortium that governs Argonne National Laboratory) ; Office of Technology Assessment Panel on Outer Continental Shelf Oil and Gas Policy Advisory Group; Committee on Science and Public Policy, American Association for the Advancement of Science; and Marine Board, Assembly of Engineering, National Research Council.

Congressional testimony on: Technology Assessment before Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, December, 1969; on A National Science Policy submitted to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, August, 1970; before U.S. Senate Committee on Interior and Insular Affairs, May 8, 1974; with Michael D. Devine, testified on energy R&D needs associated with offshore petroleum development before the subcommittee on Energy Research, Development, and Demonstration of the House Committee on Science and Technology, July 11, 1975.

Panels on which served in 1974-1975 were: "A Report on Technology Assessment of of OCS and Gas Operations," presented at the American Political Science Association, Chicago, Illinois, September 1974; "Lease Management and Resource Conservation," presented at John Wesley Powell Federal Building Dedication, U.S. Geological Survey Symposium on Earth Science in the Public Service, Reston, Virginia, July 10, 1974; "Government Stimulated University Research Organizations for Carrying Out Social Problems Research," prepared for Symposium on Application of Science to Society's Problems, AAAS annual meeting, San Francisco, Calif., February 25, 1974.

Membership in: the American Political Science Association; American Association for the Advancement of Science; American Association of University Professors; Southwest Social Science Association; and International Society for Technology Assessment.

Over 20 articles in journals and books on such topics as science policy, science and public policy, energy resources, and technology assessment.

Grants received for: *The Politics of Space Cooperation* from the Kansas City Association of Trusts and Foundations, 1965; Curriculum Development in the Study of Science and Society, to Indiana University from the National Science Foundation, 1960; the support of program in science and public policy at Purdue UniverSity from IBM, 1907; Educational Project in Science and Public Policy to Purdue University from National Science Foundation, 1907; a Technology Assessment of Offshore Oil Operations from National Science Foundation, 1971; A Technology Assessment of North Sea Oil and Gas from Council on Environmental Quality, 1973; a study to develop a methodology and documentation for consistent analysis of energy alternatives for environmental impact statements from Council on Environmental Quality, 1974; an Energy Systems Analysis of Alternative Resource Options from National Science Foundation, 1974; a Technology Assessment of Western Energy Resource Development from Environmental Protection Agency, 1974-present; Support Services for OTA Analysis of Federal Energy Research and Development from Office of Technology Assessment, June 1975-present.

STATEMENT OF DON E. KASH, DIRECTOR, SCIENCE AND PUBLIC POLICY PROGRAM, UNIVERSITY OF OKLAHOMA

Dr. Kash. Thank you, Mr. Chairman.

I appreciate the opportunity to testify before the Board.

My comments today are derived from the experience we have had in the Science and Public Policy program (S. & P. P.) at the University of Oklahoma. The program is an interdisciplinary research organization established at the University of Oklahoma in 1970 for the express purpose of doing technology assessment (TA). Organizationally, it is located under the Assistant provost for Research and has the equivalent standing of an academic department. S. & P.P. has a hard-money budget sufficient to support its permanent faculty and support staff. Large-scale research efforts depend on external funding that currently averages about $500,000 per year. Although the S. & P.P. has a present staff of 16—and that staff, by the way, includes five engineers and a biologist, a systems ecologist, and various and sundry social scientists—the expertise of the entire university is tapped as needed by bringing in individual faculty members on a consulting basis.

The capabilities of S. & P.P. in TA are best measured by the results of three previous studies: (1) Energy Under the Oceans: A Technology Assessment of outer continental shelf oil and Gas Operations; (2) North Sea Oil and Gas Implications for Future United States Development; and (3) Energy Alternatives: A comparative Analysis.

Energy Under the Oceans and North Sea, Oil and Gas were TAs of offshore oil and gas development. As such, they included descriptions of the physical and social technologies for developing these resources. Both also included problem and issue identification and descriptions, the identification and evaluation of policy alternatives, and an extensive policy implementation analysis.

Energy Alternatives, which was supported by the National Science Foundation (NSF) and an interagency committee describes the coal, oil shale, natural gas, nuclear fission, nuclear fusion, tar sands, geothermal, solar, organic wastes, and hydroelectric energy resource systems as well as the electric power generation and energy consumption systems. This study also proposed procedures for calculating and comparing the residuals, energy efficiencies, and economic costs of technologies or strings of technologies. It also suggested procedures for relating residuals to ambient conditions, expanding energy efficiency analysis to the level of determining energy balances, and extending the economic analysis to include economic impacts.

In addition, S. & P.P. is currently completing an energy R. & D. study and recently prepared a draft report entitled "An Analysis of Energy Supply R.D. & D. Options." This study, sponsored by NSF, describes alternatives for supplying various forms of energy, and identifies and assesses physical. environmental, and social issues and constraints. Particular attention is focused on identifying R. & D. priorities. Finally the program is also 9 months into a 3-year TA of Western Energy Resource Development funded by the Environmental Protection Agency (EPA).

S. & P.P. was one of several organizations asked to participate in the, OTA's review of the Energy Research and Development Administration's (ERDA) fiscal 1976 budget. Subsequently, program personnel have participated in reviews of ERDA's revised plans and budget.

By definition TAs are a class of policy studies. They are distinguished from other policy studies primarily by a central assumption. It is that a set of activities covered by the label technology, cause or have significant influence on social change. I might note as an aside from the testimony here that my own view of TA is that it starts with hardware. I am uncertain about starting from other assumptions.

I don't want to write it off, and some of my colleagues disagree with me on this, but it seems to me it is the hardware that holds these studies together. Technology assessments give technology a much greater role in influencing change than is common in other policy studies.

Technology assessment then, is distinctive in its perspective. Put in figurative terms, what technology assessors do is stand on the technology and look out. They ask, What are the impacts, consequences, or effects that will result from the use of a technology, in addition to the impacts that are being used to justify its development?" For instance, what happens in addition to the production of energy if we develop synthetic liquids from coal ? In general, the goal is to determine not just immediate first-order impacts, but also the domino or higher-order impacts.

The answer to the first question is then followed by a requirement to ask a second question. It is, do the various impacted parties or groups see themselves as affected beneficially or adverswly? And the effort is made to determine how intensely they feel about the impacts. I make a note in this connection, I don't think you can do assessments without involving the interested parties from day one.

The answer to this second question must be followed by a third question. What can be done to enhance beneficial impacts and to mitigate adverse impacts? Answers to this question provide the main grist for the policymaker. That is, assessments may identify alternative technologies or technology modifications that offer a more attractive balance of beneficial and adverse impacts. Or assessments may identify a plethora of legislative. management, financial, and so forth, alternatives that can modify impacts.

In fact, the most successful assessments identify packages or mixes of technological-social options that can modify impacts. This point deserves special emphasis because technologies need to be viewed in the context of their interaction with the physical. biological. and social environment. It is this process of interaction that is the central concern of assessments. Trchnologies make certain demands on the environment for inputs. They also produce outputs that affect the environment. The consequences of both of these are the foci of an assessment.

Our experience in carrying out assessments suggests that several points need emphasis. T might note in this connection. Congressman. that I spent some time writing around in circles and decided what I wanted to say required making several points. These points are that assessments: (1) are inherently interdisciplinary, and that means they involve engineers, natural scientists and social scientists and perhaps people in the humanities; (2) involve dealing with people's preferences or values; (3) are neither scientific activities themselves nor are there any demonstrably successful methodologies available for carrying them out; and (4) special efforts are required to insure that their findings are usefully communicated to policymakers.

When I use that term I am talking about more than just Congressmen. I am talking about the people from whatever the particular technology area, who are involved in making decisions. In the case of a utility company—utility companies are policymakers also.

Based on the characterization of TA that I have just sketched, and our experience in carrying out these studies, I would like to build the rest of my testimony around three recommendations to the OTA Board.

First, any proposed assessment that is characterized as being primarily dependent on a formal methodology should be rejected.

Second, all draft papers reduced as a part of OTA-funded studies should be widely circulated, and such circulation should not require Board approval. That is, you should not have to sanitize these papers before they are floated to the interested parties.

Third, the Board should make every effort to assure that the Congress undertakes a self-conscious program of long-term institutional support for TA research organizations. That is what you call a vested interest recommendation, but I also think it is the case.

Recommendation 1: My first recommendation results from two conflicting sets of facts. The first set is that there is a very weak record of useful assessment coming from studies organized around such techniques as input-output analysis. Delphi simulation, and the 200 types of cost-risk-benefit analysis, The second set of facts is that both within the research community and the executive funding agencies there is an almost compulsive attraction to such methodologies. The reason for this attraction is that by general agreement TA requires interdisciplinary work but no one really understands how to do it.

It is inherently high-risk research and, therefore, may create a lot of political flack. That is, without a guiding theory or methodology this policy oriented research can easily become little more than unsubstantiated special pleading. Methodologies allow the value issues to be hidden one level below the surface and they therefore offer safety in this very uncertain research situation.

In fact, TAs need to focus on the value or preference questions. The way. to insure quality and protect against special pleading is to insure that the research is truly interdisciplinary, and that. it is subjected to continuous review by the potential parties-at-interest. That is a second check, In summary, useful credible TAs depend on organizational and procedural arrangements not on methodologies.

This is why an interdisciplinary team approach, including the extensive use of external reviewers, should be stressed. Both are a means of attempting to insure that all germane factors are considered and that appropriate criteria and standards are applied. In short, the proredural approach, which I argue is essential, is basically a substitute for the lack of established TA theory and/or methodology.

Reviews by both an interdisciplinary team and external reviewers are necessary to overcome inherent limitations such as bias, narrowness of perspective, and insufficient knowledge. The goal is to see to it that these limitations are not allowed to go unchallenged, When team members are drawn from a. variety' of disciplines and encouraged to develop an intellectually challenging working environment!, the team as a group is less likely to permit the limitations of individual team members to shape the assessment. But, since there is an upper limit on the number of persons that can be included in an interdisciplinary research team, limitation in terms of perspective, bias, and knowledge cannot be completely overcome. This, together with the possibility that the team has an institutional bias, is why a variety of external review mechanisms are an integral part of a good assessment. external reviewers should include consultants, anf a advisory committee, and a broad range of persons chosen to represent the interests or values that are at stake.

Consultants should be selected to perform two primary functions: to provide perspectives and expertise not available within the interdisciplinary team; and to provide in-depth critiques of various papers and reports produced by the team.

An advisor committee should be constituted for each assessment to provide for balanced representation of the interests and values at stake. In energy resource development, for example, these might well include representatives of industry, labor, Indian tribes, various levels of government, and so forth. Members of the committee also provide a communications link between the interdisciplinary team and the community of interests that the committee member was chosen to represent.

To be manageable, the size of the advisory committee must be limited. Therefore, it is unlikely that all interests or values that the team should consider get represcnted. Consequently, on the basis of its own knowledge and the advice of the advisory committee and others, a broad range of other external reviewers should be asked to critique the interdisciplinary team's papers and draft reports. Many of these should be parties-at-interest, but some of these reviewers should be selected because they possess expertise that the team wishes to utilize.

The procedures to minimize bias broaden perspective, and overcome knowledge deficiencies described above are displayed in figure 1.

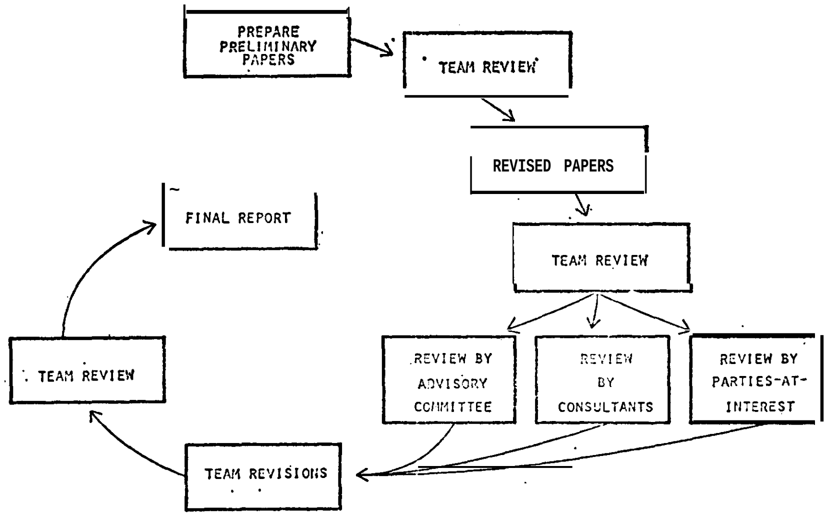

FIGURE 1

Recommendation 2: The reason for my second recommendation, which calls for the wide circulation of even early draft papers produced by OTA studies, are Implicit in my comments on the first recommendation. To extend those comments, however, it is important to note that policy is usually evolved within policy communities. Assessments should be used to inform the diverse interests in these policy communities at the earliest stage possible. The requirements of many Federal a aencies that high-levelfformal approval be obtained before wide circul ation takes place impedes that process. In sum, I am arguing that every step of the assessment process should be open.

Recommendation 3: My third recommendation, which calls for institutional support for an OTA research organization, is linked to the previous two recommendations. These have said that there is a need for a particular kind of interdisciplinary research capability and a need to make its research credible and useful to a diverse range of interests.

In practice, there are very few organizations that can produce both competent and credible assessments. The competence problem is heavily the result of the addiction to methodology. The need is to focus on organizations that can put together interdisciplinary teams that will make prudent judgments and subject their work to continuous review by the range of parties-at-interest.

Credibility requires the same recognition. Since assessments must be broadly credible, if they are to have major utility, those who do them must be free of any economic or regulatory interest in the outcome of their research. Unlike scientific research, where performance standards are widely agreed to, assessment standards are unclear. There is substantial disagreement over how to measure the social impacts of technology. Under these circumstances the biases of the researchers must be a ma "or source of concern.

At present. most of the organizations that do TAs are heavily funded by Federal agencies with promotional or regulatory interests in the technologies, or alternative y by industries with economic interests. Regardless of the quality of the research, it is open to serious challenge when it comes from such organizations. Only a new sustaining funding structure will assure the availability of research organizations with characteristics necessary to provide the Congress with the kinds of assessments it needs—that is credible assessments.

That is the conclusion of my statement. I would be happy to respond to questions.

Mr. BROWN. Well, I find that to be a very direct and useful set of recommendations, Professor Kash.

I am not quite clear with regard to the emphasis you put on the interdisciplinary nature of the assessments. I understand the significance and importance requiring a number of disciplines but you seem to be saying that it goes beyond that. You indicate the need to have a point of view with respect to technology assessment (TA) that rises above special interests, disciplinary, economic, or any other kind of special interests. What is that interest that. rises above these?

Dr. KASH. Well, I don't think it is possible to identify that interest. I think you have to go at it from a negative point of view. That is, if you ask me to identify what that ideal set of interests is I can"t tell you. I can tell you that at this stage of the game those of us who are practitioners of the various disciplines have built into our perspective a bias that is every bit as serious as that of the AFL--C1O. the National Association of Manufacturers (NAM), or Southern California Edison. One of the things that is necessary is to have an interdisciplinary group to challenge the conventional wisdoms of the particular disciplines . Those biases are terribly serious.

One of my concerns at the present time is with the addiction to methodologies. As the man from System Development Corp. indicated, there is this tendency to plug every study into a computer. What you do is convert all the variables into a common unit of some kind. In the process you make a fundamental value judgmen& one that is as dangerous to informing complex political decisions as if the study were written by NAM,.What I am saying is, if you don't know what the danger is you at least try to adopt the traditional wisdoms of this political system. You build counterpoints in from day one.

Mr. BROWN. You appear to be lending great weight to what in the legal system is referred to as the adversary process.

Dr. Kash. I am, and I guess the difference that I would emphasize is-and you understand now that I am an observer from a substantial distance-that most of the decisions made in this society are really made by evolving a consensus. A number of policy decisions are made in the Congress, where issues are joined, and you fight them out. YOU make them by majority vote. But those decisions represent a very, very small part of policymaking.

Most decisions percolate upward through an agricultural community, or a defense community, or a nuclear community or a biomedical community. Those communities evolve a consensus within a group of people who share a common interest. They may fight among themselves, but they grab hands to protect themselves from outsiders. I think you have to have some outside looks into these communities, and that is one of the things that TA does.

Mr. BROWN. I am trying to develop this thought as fully as possible. From a theoretical standpoint, if a number of biased parties are brought together in the hopes that the interdisciplinary nature of the group will overcome their individual biases, you may end up merely with what is an amalgam of biases; Such a product is the 1east unsatisfactory to all of the parties, and does not reflect either any substantially different interest or a new result, which would have some different criteria for its achievement.

Dr. Kash. I understand your point, and I think it is a sound one. First. it may very well be that the best you can hope for is that amalgam of biases, bad as it may be. There is no ideal, but I would make a difl'erent point.

I think that TAs are of marginal utility if the issues they address are already joined. One of the advantages of doing assessments is to identify issues before people have chosen up sides, and it seems to me that the few instances in which assessments have worked well have been because they helped to identify both the issues and the options. The assessments got their early. Once it has become an issue on the floor of the House of Representatives it seems to me the ballgame changes a bit.

Mr. Brown. To again seek to refine this by example, a situation ma-y exist where there is a policy community within the business community and a policy community within the labor community. These communities arrive at different policv decisions or views as thev involve a matter of common interest. This has happened over find over again. What sometimes evolves is accommodation between those two communities, and the public be damned.

Dr. KAsh. Those who aren't part of the communities.

Mr. BROWN. Yes.

Dr. Kash. I think that regularly happens

Mr. **BROWN.** This does happen and It is possible to suggest of situations. I am not picking on labor and maria point was made by that distinguished philosopher, Ivan IlliCh, in his latest book dealing with the medical community. In it he contends that we are now subject to a new form of disease, which he calls iatrogenic disease, created by doctors. He claims this stems from a policy consensus on the part of the medical community probably in combination with sick people, that they need fantastically expensive medical capital equiqment and medical processes in order to provide assurances of goohealth. Illich's point of view is that this is absolutely wren , but it is the consensus that society has evolved with regard to health. How do you get out of such a trap, if indeed it is a trap? How does TA, or the-interdisciplinary approach as you seem to imp y, provide a method for getting out of this trap?

Dr. **Kash.** Well, I think it can provide a method. There seem to me to be two schools of thought with regard to TA. One of these schools is that what you do is bring in people who are expert in the particular area and then try to counterbalance them with other sorts of interests

The other approach and the one that we have adopted is to try to take people with different or diverse educational and experience backgrounds who really don't know anything about the technology, who aren't a part of that community. We have done this on four different occasions. A couple of things impressed me.

One is that moderately intelligent people given a year or so can learn a good deal about even relatively complex technologies. That ***is,*** it is not beyond the ability of people to get a handle on most of these technologies or at least it "isn't beyond their ability to get enough of a handle so that they can read the literature and out where the problems are. My own perception, and one of the reasons that I argue for distinctive TA organizations, is that I think if you are golng to get meaningful assessments, you have to get people not Imbued with the values of that technical community. For example, you don't want a bunch of people that have grown up in the nuclear community and who understand all that jargon and can tell you about everything down the line.

Now that is a problem in almost every area. So I think what you have to do is get organizations that aren't a part of that community that don't live and breathe it. You understand that what I am suggesting here is not just a concern with economic vested interest. A man who spends hls time going to graduate school and working within a community develops a real commitment at a gut-level professional commitment. You have to get people who are from the outside, and I think professionals who are f rom the outside.

Mr. BROWN. Going back to the medical example, there was an interesting recent article in the press about a study done in England that indicated that cardiac patients receiving intensive **care** in hospitals have a higher death rate than people with heart diseases who are at home without 'acute cardiac care. In a TA of intensive cardiac units, using standard methodologies, I wonder how you would come to a conclusion that this might be a desirable ***way*** to develop. As a practical matter, I think that the study reported in the press is in fact a form of TA that will probably lead to some basic policy changes within the British health system.

Dr. KASH. Well, I notice that two or three of the people who had testified in these hearings in Washington had identified that TA wasn't a decisionmaking process.

Mr. BROWN. Right.

Dr. KASH. Now, there are a couple of things that strike me. One is that technology is now by definition something that is managed. If it is understood at all, it is understood by organizations, not individuals. I am inclined to think that I can understand about as much about things as most people can, and what strikes me after working in the energy area for 5 years is just how I don't understand it. I don't believe anybody else, any one person, understands it.

So what you have are organizations that manage. They manage knowledge; they manage technology. We do not have similar organizations tfat try to look at what happens with the technology in addition to those things that the organizations that are promoting the technologies say is going to happen. I think we have got a real organizational question on our hands. We have to recognize that there are no technological renaissance, men who can have a total understanding. You have to have an organizational capability. It seems to me that the reason you want that organizational capability is to alert the Congress and other interested parties of consequences that, have simply not surfaced before. lt is really an information-providing mechanism, but it provides information generated from a different perspective.

Mr. BROWN. Well, I want to go back and emphasize the point that you made about TA not being a decisionmaking or a policy-articulating process. Instead it is a prior step that provides data for decisionmaking. At the subsequent step, where the decisions are made, the assessment has to be combined with value judgments. It is the TA that enables one to make a policy decision. I think it is important to recognize that TA is not a panacea. We have a very human tendency to look for panaceas as some magical tool that will allow us to do something without hard work and without plugging values into the equation.

Dr. KASH. Well, there is the statement by one of those Yngoslav emigres who is in Sweden now, who talks about activities of this kind, and he says the purpose is to reduce the present irrationality from 99 to 98 percent. We are talking about pretty small ranges. I would make one other comment. It would seem to me that TA ought to be thought of as being particularly important in informing decisions about that set of activities covered by the R. & I). budget. We are spending some $20 billion a year now of the Federal money to buy R. & D. My perception is that you can look at that $20 billion and say that is the design money for the future of this society.

If you want to have some control over the design of this society what you have to do is make some discriminator-y jndgments about which technologies you buy and which ones you don't buy. I don't know how in the hell you do that. And so we are really talking about a new kind of information that we self-consciously go after. We don't wait around for a few happenstance people like Ralph Nader to come along and put their fingers on this or that.

This is an organizational societv. The problem is that most of the organizations in society are committed to developing technologies. There is very little organizational capability that is geared up to ask, "What happens in addition to ?" There is in most organizations a fairly shaky professional future for people who do TA. If you think you can go out and buy this capability by a lot of one-shot contracts or grants you are wrong. It takes a kind of organizational capability that is just damned rare at the present time, and I am suggesting that the capability ought to exist in all the sectors; that is, it ought to exist in Government, industry, the nonprofits. and universities. We ought to use the same kind of mix of organizational skills that we have used so successfully developing technologies, and I guess now that I am on my platform I think it important to emphasize that while we know how to do technology wc don't understand it.

There is an old story about a medieval blacksmith who had a knight come in and say, **I hate been out trying to lop off the heads of my opposing knights, and every time I hit them the damned sword bends. I want. you to do something about this." So the blacksmith stuck his sword in the forge, and he heated it up, and he beat some metal in, and he said, "Take It out and try it." The guy came back and said, "It still bends."' They went through the process three or four times, and he came back in and said, "It took the head off nicely." The blacksmith said, "That is great. I am going into the headsword business." He didn't understand the metallurgy, but he understood how to beat a chunk of this and a chunk of that in.

Now that it is the way in which we have developed complex technology, and that is the way in which we are going to develop meaningful TA. The idea that you are going to understand this process in the same way that you understand quantum mechanics is just poppycock. I mean maybe someday, but if it is available at the present time, I haven't been able to find it.

Mr. BROWN. In addition to this interdisciplinary focus that you stress, we may be reaching a point where we need a new discipline to be included in the equation. We may need, for example, to include someone who has a greater background in general problems of philosophy or the philosophy of values. Do you think that is completely unrealistic ? There are people who are spending more time looking at the way people set priorities and establish values, and this is something that is normally not a component of most interdisciplinary teams of any kind that I know of.

Dr. KAsh. Well, Congressman Brown, I think that kind of person is an essential ingredient in any TA, but I don't think you ought to talk about developing a new discipline. That new disciplin e requires that the guy understand physics, mechanical engineering, biology, presumably sociology and philosophy and there just aren't that many people in the worId who are that much more able than I am. I have one heck of a time getting my head around very small parts of this.

So if you want TAs what you have to do is take disciplinary apples and oranges and put them together. We have a great story that we like to tell in our organization, about a hell of a battle that went on for 2 days over a down-hole safety valve. It finally came down to a confrontation within the group between a political scientist and a mechanical engineer, and they were arguing over whether it would work. Finally, the mechanical en engineer said," amen it you are wren and the political scientist said, 'Why?) The en gineer answered, Because I am a mechanical en " engineer an I know.)' And the political scientist said, "That won't sell. Now, what I am saying is that these discipli- nary communities are just like my hometown in Iowa. They are full of little conventional wisdoms, which when you mouth them, everyone nods his head.

The design of offshore structures to withstand a 100-year storm is a case in point. Our first question was what is a 100-year storm. It turns out that somebody put together a 100-year storm out of clouds, and thought, and computer runs. All of that is perfectly fine, and is a reasonable basis fordesigning a platfom, but an implication that you are measuring 100-year storms is not correct. You have to build into these things people who don't buy the conventional wisdoms— philosophers, la era, all sorts and types.

Mr. BROWN. There is a professional meeting scheduled here in a few weeks, composed of architects, planners, and various others, that is focusing on the design of the energy conserving city or community. This is a technological problem in a sense, and one can assess the characteristics and impacts of an energy conserving city. It is a rather large problem in some ways, particularly if it is a large city; but I bring]t up to raise a question. In the earlier part of your statement you said you preferred to narrowly draw the line around TA basically starting with the hardware aspects of it. A technological city, which is an energy conserving city, is a hardware concept. Yet the immediate impacts will be very, very broad in terms of various aspects of sociology, psychology , and economics. Can you really draw a line that would limit TA to hardware In the process of analyzing the domino effects, second, third, and higher order, aren't you immediately drawn into much more than the hardware aspects of technology

Dr. Kash. Yes. And I think clearly the purpose of t% 'assessment is to go beyond that, but the difficulty if you are looking at terribly complex systems of that kind is where do you start, and w at track do you follow.

The reason that I ha pen to be particularly attracted to looking at the hardware or the physical side of the. city as the starting point is not that this is the most important ingredlent, but it is the one tangi- " ble thing that you can start with. If you look at an energy-conserving city, what you do is look out and see what sorts of impacts and what sorts of demands a city of that kind makes on people or on the sur- rounding environment. If you are going to get together people as di- verse as mechanical engineers and political scientists, they can't talk to each other. Now, what they can do however, if they spend some time, is share a common physical reference system. It is]ust about that crude. It is like that medieval blacksmith. If I were going to do a study of that kind I would start with recognizing that what -you are really interested in is what it means for man and his values. But you know the difficulty is that we deal with a conceptual system that is the sys- tem of science. This is a cause and effect system. I don't even know how to think in other terms, so I have to start someplace, and I say this is the cause.

1 think that the reason OTA exists, and these hearings are being held, is that there is a growing perception that something called technology, a physical thing, has become causal. Technology assessment says the way you approach society is different from the way an economist approaches it, which is as a relationship between labor and capital, and sometimes natural resources.

Mr. BROWN. You can look at this both ways. It is possible to start with the technology and say how this is going to affect or impact human systems, procedures, and health and welfare. You can also start with the other end and see how the development of human systems, values, methods, and styles of life affect technology. Let me give you an example.

During the 1930's we developed the Federal Housin~ Administration and a system of insuring home loans, which made It possible for middle income people to move to the suburbs. This led to t e development of transportation schemes, suburban centers, and other things, technologies you might say. The net effect of this host of events was the decay of the inner city. We are now trying to take a technological approach in our attempt to figure out **how to reverse** the decay of the inner cities. Maybe we need a kind of assessment that looks at human value systems and how they impact technology rather than starting with technology.

Dr. **KASH.** Well, I think that we need that. You made the point earlier that TA is no panacea. You also asked the previous two witnesses, where should you start, what should be the boundary conditions ? My reason for sticking with hardware is a very pragmatic thing. It Isn't that 1 wouldn't like to be able to do the other thing; it is just that I think lt is potentially possible to do assessments if you start with the hardware. I just don't know how to deal with those others. It isn't that they are not needed. I just think that they are less dual.

Mr. BROWN. Well I have reached the same conclusion, but I don"t like it.

Dr. KASH. No, I don't either.

Mr. BROWN. Because it seems to me that policy decisions ought as a matter of course, to contemplate a much broader base than just technology. What I like about TA is that it gives us a handle on these other things. I have supported it for that reason, but I really would like to see the concept on as broad a base as possible.

This has been a very stimulating discussion, Professor **Kash,** and we appreciate the contribution you have made to it. We hope that if we would like further clarification of the points you have made, our staff can submit additional questions to you?or your response.

Dr. KASH. I thank you.

[The following questions were submitted by Congressman Brown to Dr. Kash and his answers thereto:]

Question 1. How does technology assessment (TA) compare with the environmental impact analysis process?

Answer 1. Technology assessment differs, in two ways from the process normally associated **with** preparing environmental impact assessments, First, TA has as a perspective the assumption **that it** is the causal **factor or force. Technology assessment is a process of policy analysis that figuratively involves etand-@g on the technology and looking out. The causal assumption is not a necessar~**

ingredient in environmental impact assessments. The second major difference is that TA generally takes a broader perspective. In particular, it carries the investigation for the analysis to the point of identifying alternative policy options. This point is regularly lost in the debate. A meaningful TA will not only assess the impacts of a given action but it will attempt to identify and assess alternative ways of accomplishing the action. In substance, it will attempt to identify alternative policy options.

Question 2. What should be the basis for deciding to do a TA instead of some other kind of analysis?

Answer 2. My view differs from that of many people who are involved in doing TA. I think that TA is distinctive because of the causal assumptions that underlie it. Those causal assumptions are a set of phenomena labeled technology, which cause or drive social change or have social impact. A TA then is required when one wishes to control the social consequences of a situation in which technology is going to have a major influence.

Question 9. What is the best way to get the public involved in the TA process?

Answer 3. I believe that two routes are most fruitful. One is to insure that a representative group of the interested public be included on oversight or review committees put together for each individual assessment. Second, the group doing the research for the TA must view the interested public as a major source of information and data. This means that the research group must seek information, counsel, and criticism from potentially interested parties at every stage in the process. The pursuit of information from the interested public means that you don't just ask them what they are concerned about. It means that you get the interested public to review and critique every draft of the papers prepared in connection with the TA. We found that you usually need to hire representatives of interested publics or consultants. Essentially you pay them to critique your work, to tell you where you are wrong, and to tell you where your emphases are right. An important point is that there is not a single public. For each T.A there are specific interested publics.

A TA is a failure if the investigators do not identify those publics. It is also a failure if those publics are not an integral part of the research process. If they are an integral part of the research process the people doing the TA have covered 90 percent of the distance necessary to disseminate their results. That is assessors can't separate their research from the people to whom they will communicate their research.

Question 4. What value do you see with respect to TA in closer relationships between the public and private sectors?

Answer 4. In a technological society it is extremely difficult to maintain the distinction between the public and private sectors, particularly in areas of rapidly evolving technology. The interdependence of the public and private sectors is given. In practice, my view of the policy process assumes a decision is made in seemingly public, private POlICY communities. Energy Policy is a result of a combination of public and private decisions. It is inconceivable to me that a policy study such as a TA would not have to be as concerned with the decisions in one sector as they are in the other. My view is that most legislation is only the result of complex evolution through these policy communities.

Question 5. Do you think the concept of TA has affected the way the government and corporations are now doing business in comparison to their practices 6 years ago?

Answer 5. I think the answer is pretty clearly, yes. One needs to emphasize that TA is really a label that covers an effort to respond to a broad set of societal demands. These demands are the result of a growing recognition that the use of technology exerts a major influence on the character of the society. People now want to know what happens when a technology is utilized, in addition to those things that proponents of the technology use to justify its development. Corporations as well as government now have no choice but to attempt to answer those questions. The environmental movement is only one manifestation of the demands for such answers. That demand is so pervasive and has developed so rapidly that I find it difficult to believe anyone could answer this question other than you.

Question 6. When conducting a TA do you think a corporation should look at the impact of a new technology on job structure?

Answer 6. Sure, yes.

Question 7. In your opinion, how do human value systems affect technological development? What role should the analysis of value systems have in assesing impacts of technology on society and the environment?

Answer 7. I can't separate the answers in two parts. I don't know how one can label TA as a kind of policy study without recognizing that value assessments are implicit Policy choices include questions of fact and questions of value. In practice what an ideal TA does is tell you what values the development of a given technology will promote in the future. TA can't tell you which values ought to have social priorities. It can tell which values are likely to he promoted and which are not likely to be promoted. The traditional democratic political process must make the choices among the values.

Question 8. What limits do you see to the utilization and application of the TA concept in the government and in the private sectors?

Answer 8. I would repeat a comment I made in connection with an earlier question. I differ from many of my colleagues in seeking that TA should start from a physical or hardware base. I do that because I think TAs are inherently interdisciplinary. What one can do is use a common hardware or physical system as a glue to hold an interdisciplinary research group together. My own thinking—and I emphasize that for the moment—is that TA should be carried out around physical or hardware systems.

Mr. BROWN. Our next witness is Dr. R. Rhoads Stephenson, systems analysis manager, Jet Propulsion Laboratory, California Institute of Technology.

You wish to bring your colleague with you?

Dr. STEPHENSON. Yes; I would like to have one gentleman, Mr. Thomas A. Barber with me here. I think he will primarily participate in the question and answer period.

Mr. BROWN. We welcome both of you. You may proceed with your statement in whatever fashion you wish.

[The biographical sketch of Dr. R. Rhoads Stephenson is as follows :]

DR. R. RHOADS STEPHENSON, MANAGER OF THE SYSTEMS ANALYSIS SECTION, JET PROPULSION LABOR~TOBY, CALIFORNIA INSTITUTE OF TECHNOUMY (JPL-CALTECH)

Ph. D. mechanical engineering, Carnegie Institute of Technology, 1961.

Worked in plasma physics and magnetohydrodynamic (MHD) power generation research, energy conversion laboratory, Martin-Marietta, 1961-1962; military service U'.S. Army, 1962-1964, assigned to JPL to work on nuclear electric power generation, thrusters, and mission analysis. Joined JPL 1964, worked on Blariner and Voyager planetary missions; as assistant manager of The Tracking and Orbit determininaticm section conducted research and developed computer programs in astronomical, space navigational, and mathematical areas related to planetary missions; since 1970, manager Systems Analysis Section, which performs mission analyses for advanced space missions and systems analyses of civil sector projects in the areas of biomedical engineering, transportation, law enforcement, energy systems, and environmental analysis; and from December, 1973 to August, 1975, was Principal Investigator for a $500,000 grant study from Ford Motor Company to study alternative power systems for automobiles in the 1980's. The broadly based study included engine technology, vehicle design chanxe% fuel and energy consumption, patterns of automobile use, and industry practices.

Advisory activities: appointment as a member of the Advanced Powerplants Committee of the Society of Automotive Engineers; and NASA representative to the Vehicle Design Panel of the Interagency Task Force on "Motor Vehicle Goals beyond 1980."

STATEMEI?T OF R. RHOADS STEPHENSON, MANAGER, SYSTEMS ANALYSIS SECTION, JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, ACCOMPANIED BY THOMAS A. BARBER

Dr. Stephenson. Thank you, Mr. Chairman. It is a pleasure to be asked to testify before the Board.

I am Dr. R. Rhoads Stephenson, manager of the Systems Analysis Section at the Caltech Jet Propulsion Laboratory and principal investigator of the recently completed automobile power systems evaluation study or so-called APSES.

I have asked Mr. Thomas A. Barber, who prepared the industry practlces **portion Of the study, to** accompany me em to **Participate** m the question-and-answer period.

The topic under discussion today is the 'practice and uses of technology assessment in industry, Government, and other sectors." To this end, I have been asked by your staff to use as a case study the evaluation of alternate automobile engine technologies, which is documented in our two-volume report, "Should We Have a New Engine? An Automobile Power Systems Evaluation."[1]

I do not intend to repeat here the technical basis of the evaluation or the specific recommendation-these are documented in the report and in other congressional hearings. Instead, four topics will be discussed: (1) the background reasons for conducting the study; (2) the lessons learned about how to conduct such studies; (3) the post-report-publication activities; and (4) the possible impacts of the effort.

I. BACKGROUND

The concept for the study was established during the spring of 1973 within t e Ford Motor Co. They, along with the rest of the auto industry, were encountering a long and continuing series of adversary interactions with the Government-primarily in congressional hearings and Environmental Protection Agency (EPA) emission control suspension hearings. They were frequently confronted with questions 1" e "why don% you use this new carburetor development?" or "Why don't you intro duce a steam (or electric, or gas turbine, or* *) engine order to meet the 1976 emission standards ?" They would answer these questions. However, the credibility of the industry was very low because in part, they have a vested interest in the outcome.

Someone within the Ford organization proposed the idea that one way to break out of this defensive position would be to give a substantial study grant to an outside, competent, nonprofit research organization that did not have a vested interest in the outcome. An internal steering group was formed to develop a statement of objectives and to select the study organization. Letters to solicit interest were sent to half a dozen research or animations thought capable of performing the work. After a two-phase elimination **process, cal**tech's Jet Propulsion Laboratory (J L) was selected to perform the stud .

After some very minor negotiations, the statement of objectives and grant agreement was signed off. It is documented as appendix A of volume I of the final report. The important of the form of this agreement cannot be overemphasized-it establishes: (1) the core question Should there be a new engine and when (2) the **Concept** of a moving baseline of Otto engine technology; and (3) the charge to consider the national point of view. A broad charter was established that allowed us to examine any topic that we felt was relevant. I

1 Available through the Society of Automotive Engineers, 300 Commonwealth Drive, Warrendalq P& 15096.

do not feel there were any arbitrary ground rules or limitations in scope that would bias the results.

The rant agreement also established a hands-off relationship between Ford and JPL. Obviously, their purpose would not have been served if there were an suspicion that JPL was influenced by their position. There were to be no progress reports or technical direction b-y Ford oral, nor were they to review the final report. The final report was to be totally public, widely distributed, and released to al interested people at the same time as Ford received their copies.

We feel that this agreement was very important to the conduct of this effort, and the reception of the resul ts. It is also rare, and in retrospect we realize that we probably would not have been able to publish our final report in its current form, with its specific recommendations, if it had been sponsored under a typical contract with a Government agency o, private company we recommend that the office of Technology Assessment (C)TA) and other Federal agencies seriously consider a similar grant approach to beet serve the interests of an o n, unbiased public forum. Certainly, if *a* private institution can a fford the risk of such an arrangement, the F ederal Government should also be able to. The Ford Motor Co. must be recommended for this most unusual, enlightened, and venturesome approach

II. LESSONS LEARNED ABOUT THE CONDUCT OF SUCH STUDIES

There are various aspects about the way in which the study was conducted that allowed US to grasp an extremely broad and complex problem, and derive conclusions and s specific recommendations which in the large, have held up to scrutiny. t hey are Iisted and commented upon below.

No. 1, team selection: The initial selection and formation of the team (and formulation of detailed task breakdowns) took 4 to 8 weeks, and drew from the skills of JPL and the Environmental Quality Lab. over the next 6 to 8 months the composition of the team evolved as we learned more about the problem and focusd on the key issues. With a few exceptions the staff worked full-time on this project.

No. 2, team recess: The project acquired a set of contiguous offices and most members were colocated for the duration of the effort. We also had a project secretary, a library, and reproduction machines in the same office complex. The importance of this physical integration cannot be overemphasized in terms of promoting interaction among the various task areas and facilitating the synthesis and integration of the final product. We did use subcontractors, but, in a limited way. and as consultants to specific team members. We could not identify pieces of work that could be successfully performed in isolation. The lack of integration is one of the major shortcomings of large studies that are broken down at the outset into separate panels, or farmed out to separate contractors.

No. 3. getting immersed in the problem: Most of the team members had only limited knowledqe of the automobile industry—mainly that of the interested technical layman. To achieve quick exposure to technical and nontechnical aspects of the problem it was necessary to quickly build a comprehensive library covering all relevant subject areas, read a lot, establish contacts, and conduct visits to key people within the auto industry, regulatory agencies, research agencies, and independent research organizations. Initial contacts were used to explain what we were up to, solicit cooperation, gain perspective, and to acquire background information.

Subsequent contacts, usually at a working level in the organizatio~ covered details of analysis, test data, potential solutions to problem areas, and further established trust and o en communications. The trust and mutual respect that developed al owed us to gain access to some proprietary data, which have us confidence in certain of our statements even though we COU8 not reference the source or supporting data. Later in the study when the topical chapters of volume II were drafted, these same contacts provided us with valuable technical review and comment.

No. 4, getting the technology right: This seems Iike an obvious rule for a technology assessment (TA) but, frankly , many of the TAs I have seen suffer from an inaccurate or incomplete characterization of the technology .

Gathering data and opinions, as discussed above, was a necessary first step, but inadequate if one is to assess a technology 10 to 20 years into the future. To do this, it was necessary to perform independent technical analyses and make self-consistent projections based on physical and thermodynamic principles. Of course, engineering judgment is still required, but usually at a component or materials-technology level where experts can communicate and usually agree. The technology must then be viewed and evaluated in an economic and institutional framework.

No. 5, providing flexibility in scope and depth of analysis: Any complex subject, like automobiles, which affects many people's lives, is essentially boundless. You can start with automobile engines and be led to almost any other aspect of our society-all of which are interesting. However, all of these aspects of the problem cannot be addressed competently in any reasonably sized, fixed-duration study. We had to keep continually refocusing on the core question, "Should we have a new engine ?," and explored impact areas far enough to determine their relevance and importance, and then to study only the key issues in depth,

For example, we found very earl-y that organized labor was not likely to be an impediment to the introduction of a new engine technology, and somewhat later, that it was not essential to have an accurate estimate of car sales or vehicle miles traveled in 1990. Fairly wide bounds on such variables would lead to the same conclusions. Conversely, the automobile's role in the air quality of our cities, its energy consumption, the industry's ability and time-scale to convert, were all key issues on which the conclusions are quite dependent. This adaptable, variable-scope, variable-depth approach stands in contrast to some TA methodologies that attempt to examine systematically and exhaustively all potential impacts upon and from a given technology. Such a general approach borders on a model of our entire economy and society, and would be a mammoth (and probably ill-fated) undertaking. If such models are attacked, perhaps they should be done independently and made available to researchers working on specific TAs. Related Points are that such studies must be adequately funded to get a quality product. and flexibility must be provided on the schedule as well as the directions to be pursued, and their relative emphasis.

No. 6, review process: Because of our unusual, hands-off relationship with the funding source, our need for an external guide led us to invent our own sponsor-surrogate in the form of a review board. This group was composed of senior JPL managers and Caltech campus faculty members. It was formed at the project's inception, and met with the team an average of once a month. They provided an important management and technical review function, served as an additional source of ideas, and kept the team oriented to the study context and progress that is all too often lost in the day-to-day grind of " getting the work done."

&e did not form an outside oversight committee made up of representatives of all affected interests. It was felt that such a group would not be able to come to consensus (which is true, but not necessary). I personally feel we should have had such an oversight committee, but there is not full agreement on this view. The likelihood for frequent changes of emphasis and extensions of scope would probably result in wasted effort and the inability to maintain schedule and budget. Without such a group we identified and contacted individually the various affected interests. The report critiques and followup activities now serve the oversight function starting from a well thought-out and documented position.

The technical meat of our report, the topical engine chapters of volume 11, were reviewed by selected industry and other outside experts. However, volume 1, which contains all of the intercomparisons, synthesis, and recommendations, was not reviewed outside the Caltech/JPL family. This was done to insure that outside feedback and pressure would not be brought to bear to try to change the recommendations, and to maintain a credible separation from the position of Ford, the rest of the auto industry, and regulatory or R. & D. agencies, consumer groups, or any other advocate.

No. 7, synthesis and final report writing: We brought together various pieces of the study and drew our conclusions and recommendations as a team process. Each member came with his particular information and point of view, and interacted in long and sometimes painful meetings. It seemed very inefficient and frustrating at times, but out of this grew an appreciation of different aspects oft e problem, and members gradually identified with the total team product-not merely their own pieces. After several early drafts the shape of the product began to take form, and one of the team members, Mr. Gregory Nunz, drafted the summary volume. This draft then formed the core which was carefully reviewed and revised by the team and converged to the final product.

The summary was virtually complete before all of the pieces of the supporting material (volume II) were in final form. It was decided not to publish the summary until all of the backup material was finished, which, while it caused a delay of several months, greatly increased the credibility and impact oftie final product.

III. POST-REPORT-PUBLICATION ACTIVITIES

one frequently thinks that the project is over when the report is completed. In this case where we were studying a topic of great interest to the general public, motorists, the industry, and government, there was an immediate and intense interest in the report. We initially printed 2,000 copies of the report-about half of which were distributed immediately to a distribution list of individuals known to be interested that was compiled during the study.

A short press release was prepared and sent through normal channels. That initiated widespread articles in newspapers, and requests for radio interviews, news interviews, and for more in-deptho articles" Within 3 weeks it was clear that we would need a second printing of the report. As the second printing was completed, we made arrangements for the Society of Automotive Engineers to handle subsequent distribution. They are now into a third printing, and the report set is one of their most highly demanded reports ever-despite a price tag of $16.50 a set.

The team also gave 3-hour verbal briefings to the organizations most directly concerned with the results of the study, the Big Three auto manufacturers, the Energy Resource and Develome Administration (ERDA), the Department of Transportation (DOT) (with the Federal Energy Administration (FEA), OTA, and other Federal agencies), and at the Society of Automotive Engin"news National meeting. Shorter presentaticms were given to the Office of Management and Budget (OMB), university seminars and at local meetings of professional and service organizations.

Testimony was solicited and given to three congressional committees and one State of California committee, and four of the APSES tam members provided advice to OTA in setting up their technology assessment of "Changes in the Use and Characteristics of Automobiles," which is currentl y getting underway. In short, there has been a strong demand for the written report as well as verbal presentations ranging from one-half to 3 hours in duration.

We solicited and received critiques of the final report from the auto industry, government agencies, and anyone interested. As you might imagine there was not universal agreement or endorsement of our findings. The loudest complaints came from the manufacturers, who felt we overstated the near-term potential of the conventional Otto engine to meet the statutory emission standards with no loss (even a small gain) in fuel economy, and from the independent developers of those engines that we did not assess as having an attractive long-term future.

The ERDA Transportation Energy Conservation Division has contracted with JPL to digest and respond to those critiques, to extend the scope of the study in specific areas, and to ultimately updata the report to incorporate these changes and additional test and development results that will be forthcoming over the next year or two. This is a unique opportunity to respond to these very constructive critiques and thereby provide a dynamic, rather than a static, report that will continue to be of value to government and industry planning. The Energy Resource and Development Administration should be commended for its foresight.

One of the lessons learned is the large magnitude of activities that took lace after the report was published. Some of these were initid by ourselves but many were U r a b w q" f o y m i d e" It would have been inap propriate, and reduced the impact of the report, to turn i ese requests dowm Yet it put great strain on us personally, since we all had other assignments to carry out. A suggestion is that this post-report interaction phase be recognized as an integral and legitimate part of a technology assessment, and that it be provided for in both the plans and budget.

IV. POSSIBLE IMPACTS~ AND USES OF THE REPORT

It is presumptuous of us to attempt to assess what the impact of our report has been or will be. First of all, we are obviously biased since we are proud of our effort. Second, it is premature to make such an assessment. A third observation is that the very process of asking about its impact can affect (positively or negatively) its real impact (observing a social system affects its behavior). Finally, any change or decision is obviously. based on a wide variety of data, intuition, strategy, and considerations (properly) beyond the scope of our effort. At best we could hope to illuminate only a small portion of the rationale or data for a complex decision by a regulatory agency, Congress, or a large industry.

The report has certainly caused a reexamination of the case for, and role of, an alternate engine for cars. The huge potential payoffs and justifiable levels of R. & D. expenditures are perhaps realized by many more people. Professional interest in new engines is expanded, perhaps giving new hope and stature to those involved in automotive R. & D. Some colleges have considered using the technical material from volume II as graduate school course material on alternate engines. The possible revitalization of automotive engineering has the interest of some engineering schools.

Our report and congressional testimony may have had some small effect on the mandatory fuel economy bill, some of the pending emissions legislation (although our emphasis was farther out-the mid-80s and beyond), the proposed electric vehicle R. & I1 bills, ERDA's budget in automotive engine R. & D., and the Automotive Transport Research and Development Act of 1976, which was passed by the House on June 3. Both DOT and ERDA have testified that they agree that the recommended Brayton and Stirling engines are the best longer term choices, and ERDA has partially refocused its program on three alternatives.

The effect on the industry is less certain. They certainly have studied our report very carefully and objectively at engineering as well as at top management levels. In this process they have reexamined their previous positions on new engine technologies What specifically has happened, or will happen, is unclear. I do not know if oompany R. & D. budgets or priorities for alternate engines have increased. The industry does seem to be publicly more receptive to an expanded government role in automotive R. & D.—provided the program stays far away from production prototypes

Three of the team members anticipated as National Aeronautics and Space Administration (NASA) representatives to three of the panels of the DOT-led Government study on “Motor Vehicle Goals Beyond 1980.” Some of our data was used, but the final recommendations are expected to be rather different than those of APSES. I feel that the differences we fundamentally due to their emphasis on the short term and a very conservative (more conservative than in the auto industry itself) view of the rate of development of alternative engine technology.

It is important to note that the major product of the study is not its final report but rather the interaction, discussion, and followup by *8* team of people thoroughly involved in the subject matter of the study. We have also found that we have credibility in both Government and industry circles, and have been able to facilitate communication and understanding between these frequent adversaries.

I have summarized how we did the study, what we learned, and some of the potential impacts of having performed the study. I hope from these observations t at we have contributed to the state-of-the-art of technology assessment. Mr. Barber and I will be happy to answer any questions you may have.

Mr. **BROWN. Thank you very much,** Dr. Stephenson, for that detailed analysis of your experience, which I am sure will be of great value to the Technology Assessment Board. May I ask you if you can spell out in a little more detail the disciplinary backgrounds of the team that prepared the report? Also, have you used to any extent, other than the review processes that you mentioned, inputs from university community consultants or other resources?

Dr. STEPHENSON. Yes. Most of the members of the team had an engineering background, and were either from JPL or from the Environmental Quality Lab at the Caltech campus.

We sought to have an economist involved in the transportation projection part of the task. When we were unable to 1ocate the right type of person, one of the engineers took on this responsibility. We felt that the use of a consultant or a subcontractor in that area would not be a productive way of proceeding. It was also at this time that we realized that our conclusions would not be sensitive to the precise estimate of future transportation usage.

The second part of your question related to use of subcontractors and consultants. We did this on a limited basis. We had three such individuals involved. One was involved in the industry practices, manufacturing, and costing substudy. Another was an expert on air quality and emissions, and the third was a general consultant on engine studies and related previous work to us.

These consultants were paired on a one-on-one basis with one of our internal team members, worked directly for that person, and helped prepare the material for which that particular team individual was responsible.

Mr. BROWN. Can you give me an idea of the man-years involved in the team work Is that possible?

Dr. STEPHENSON. I think it is in the range of 12 to 15 man-years.

Mr. BROWN. I was struck by your statement that you can proceed from an analysis of a problem of this sort to an analysis of almost the entire problems of society. Hence you have a boundary definition problem. Can you elaborate on that a little bit? It seems tome that this same process will occur as you grapple with almost any problem of any magnitude in our society. And there needs to be, if it is possible, some rational way of determining boundaries. I suppose ultimately the scope and depth of problem analysis is resource limited, Because resources are limited the boundary is defined in such a way that the problem can be covered fairly well with available resources. Is that a general principle that can be applied, or are there other kinds of principles that you can use in making these limits?

Dr. STEPHENSON. Well, I agree with your point that a characteristic of any broad problem is that you can get to almost any aspect of society from it. Thus, it becomes fundamentally a resource limitation problem and also a problem of keeping relevant focus. I am not very optimistic about trying to set those boundaries at the beginning of a technology assessment (TA) project. I think that the team doing the effort has to be given the freedom to explore those paths that are identified initially as being important and seeing where they lead. Then the primary and secondary impacts can be examined in an appropriate amount of depth, depending on their relevance, rather than trying to uniformly cover all possible outcomes.

Mr. BARBER. Mr. Chairman, if I might address this?

Mr. BROWN. Yes, Mr. Barber.

Mr. BARBER. I believe that although there may be no specific content you can identify previous to a study's start, there might be at least one methodological, if I maybe so bold to use the word, way of going at it. I am referring to the principle of affected interests. This is a method that is well known to the politician and one that is being discovered by us TA neophytes. I recall that we found out what was important by finding out the first thing that was important from someone, anyone, and that person steered us to another thing that they thought was important. We essentially worked our way through the whole web of involvement in that particular kind of a problem, in this case the automobile engine. We received much assistance from all of the people who were truly involved in the solution of the problem. Then it is a matter of understanding how to set priorities for those things that you find out.

Mr. BROWN. Yes.

Mr. BARBER. And to deal with them. .

Mr. Brown. A significant element is finding the boundary of a problem which can be extremely broad. Hence you need to set priorities for the elements within these boundaries. Then using resource limits or whatever, establish certain levels of priorities and concern that are needed to deal with and rationally dispose of the lesser priorities in a cursory fashion. That decision frequently can only be made after you have gotten well into the problem.

I am very much interested in the point that arose earlier this morning about the development of the Volvo technology as an extension of the Otto engine technology. This is going to have a substantial impact upon the course of the deliberations of the Congress, it seems to me, dealing with the extension of the Clean Air Act and other matters relating to environmental pollution in the near future. I am wondering how we deal with this matter.

Could either one or both of you deal for a moment with how you perceive this development as it relates to the findings of your own study, and its impact upon these policy issues with which we are going to be grappling in the next few weeks?

Dr. STEPHENSON.. Well, I will say a few things. We tried to assess the potential of the Otto engine from fundamentals and predicted a mature technology that is very similar to what was recently announced by Volvo.

Mr. BROWN. Was this done on theoretical grounds!

Dr. STEPHENSON. Yes. With the major judgment being relative to the question of the durability of the catalyst for 50,000 miles. A great deal of progress has been made there, and our assessment from a materials point of view was that that desired durability would be achieved within the next few years, and would result in a viable technology.

Mr. BROWN. Did you make this conclusion in the absence of knowledge that the catalyst manufacturer was probably developing a three-way catalyst at the same time that you were preparing your report?

Dr. STEPHENSON. We did not have specific information on the Volvo development at that time. However, we did have interaction with several of the major catalyst manufacturers, and were led to the view that these problems would be overcome with development. I think the thing that is most surprising about the Volvo technology is that it came sooner in a production vehicle than many of us would have presumed. They also went further than they needed to go to meet the 1977 California standards and actually came within, well within, the statutory limits that were set for later on. But this is technologically very predictable and not surprising. It is an example of the kind of technology toward which we feel the Otto engine will evolve.

Mr. BROWN. If it wasn't surprising to you standing outside of the industry, do you think it should have been a surprise within the industry?

Dr. STEPHENSON. I am not sure it was a surprise to them except perhaps that the Volvo catalyst and system durability demonstrated improvements that had not been demonstrated on the fleet tests of the U.S. manufacturers. Perhaps Tom Barber would like to elaborate on some of these questions.

Mr. BARBER. I would like to go back over and relate our experience and our interaction with the automobile companies on the catalyst issue. First of all, it was one of the bones of contention when we published the final report and was directly challenged by several members of the automobile industry. Their statement was that they did not now have a catalyst that will do what we projected. In fact, they went into great technical detail and to great lengths, in highly revolved technical discussion. They indicated precisely how far they had been able to go with their catalysts and precisely the problems that remained. These facts agreed substantially with what we knew to be the facts at that time.

The crux, the basic bone of contention, was our willingness to extrapolate that set of facts based on our experience in technology development. All of us have had a large amount of experience in hardware and other areas of technology development. We had the willingness and the char to extrapolate these facts to a success within a given time period. We said it is our judgment that it is a matter of development, not an invention, that no discovery is required and no basic law of physics needs to be violated, in order to have the emissions system work; it is a matter of just putting enough time, money, and manpower into the issue, and it will be solved. The industry kept saying that they didn't have the answer at hand, and I think that puts the difference between our statements and their statements in a nutshell. I don't know if it is a matter of surprise. It is just a matter of point of view. They kept saying, "We have to build them. You don't." Both points of view are legitimate when viewed in context. However, for the purpose of illuminating future possibilities, our view has proved to be richer.

Mr. BROWN. Well, there are some important aspects of this which go beyond TA. I think we are going to be having a large amount of continuing discussion on this. We had Ford and General Motors as witnesses last, week in Washington. I saw no indication that they have changed their point of view, that they can meet the current standards even with this Volvo technology, or that the accept the Volvo technology as a valid production-read technology to accomplish the goals. So I am sure that there will be some debate over this as we go along.

Getting back to the methodology of assessments, you have suggested that this unique project on the automobile engine might provide a desirable model for other kinds of TAs. You referred to the relative autonomy that you enjoyed in making this assessment, as well as the internal methods that you utilized here. Is it your view that these can be readily carried over to a broad range of assessments, and that they didn't have some particular or unique utility because of the nature of the problem you were working with?

Dr. STEPHENSON. I think the principles are general and can be used in man different situations.

Mr. BROWN. The methodology used by the Technology Assessment Board, and I am not contending that it is by any means ideal, has relied more heavily on external review or review committees, fairly carefully selected to represent the various contending interests. The panels have provided some input during the course of assessments and may even actually do a considerable amount of work on the assessment. Do you see that methodological approach as an equally valid, less valid, or more valid method of approaching some of these problems; or is there any way of determining without first looking at the problem itself?

Dr. STEPHENSON. Well, there are different views on that general topic of how and how much to involve the affected interests and what the boundaries should be. I would not suggest that you go to the last step that you listed of actually having such a board do the assessment. I don't see how that can be competently done. I think the value of such committees is in making sure that you identify the affected interests and the key problems, and are addressing them.

Mr. BROWN. And the key impacts?

Dr. STEPHENSON. Yes; the key impacts and the interactions that you might overlook. I think if on went into a brand new area that has been relatively unstudied, the need for external review committees might be considerably greater than for a problem that has been looked at a great deal such as the automobile and the engine. People who are familiar with the literature have a pretty good idea of what are the affected interests, key problems, and the issues. So I think how much of an oversight committee or affected interest type of committee you would want to have should depend on the area in which you are doing TA. The problem of going too far in that direction is; how do you keep the stud bounded in scope, and how do you get done an where near within budget, or within the schedule that was originally established.

Mr. BROWN. You get involved in a selection process when you want to do a major assessment. You have to in fairness examine pretty much the universe of capable performers in this area.

Dr. STEPHENSON. Yes.

Mr. BROWN. In order to get one that is at least near the to in the ability to give the results that you want or give the quality of results that you want.

Dr. STEPHENSON. Yes.

Mr. BARBER. Mr. Chairman, if I may. I think for the issue of public review there is more of a distinction in when the review happens rather than whether or not it happens. For example, in the case of the Automobile Power Systems Evaluation Study (APSES) report, one of the reasons we put so much emphasis on the post report activity is due to the fact that we didn't have the policy review and oversight committee incorporated into the actual performance of the study. It is a matter of when these issues are addressed. It is my opinion that the policy issues are best reviewed publicly after the study has had a chance to amass the facts and folklore on the subject at hand.

Mr. BROWN. I think that was a useful procedural observation. It is helpful to recognize the extended life of these studies and provide for, at least to some degree, the post-report analysis and followup, including distribution, review, and comment. If a report truly performs a vital informational service, it needs to be utilized as an educational tool by a very broad public, which may be a hard requirement to work into the assessment process. Apparently you shifted this problem over to whomever wants to take it on, in this case the Society of Automotive Engineers, for the distribution of the report, and to various institutions that may want to incorporate it in their educational recesses.

I suspect that you have to put some definite limits on how far you go into post-report activities, just as you do in preparing your report itself, but it is obviously a very, very useful component of the total process.

Thank you very much, gentlemen. I would like to explore this at considerably more length in view of the additional repercussions that you have pointed out in your statement. We still ho e to et that R. & D. bill through the Congress in the next couple of months. You may be called upon for some further activities. However, this is as much as we have time to go into this morning, and we again express our appreciation to you for your help. There are a number of additional questions that we will be submitting to you and we would appreciate your written responses.

Dr. STEPHENSON. Thank you very much.

[The following questions were submitted by Congressman Brown to Dr. Stephenson and his answers thereto:]

Question 1. In the conduct of your study did you feel that it was important to have a truly interdisciplinary team? Please explain. Did you have a sociologist and psychologist on the team? Why or why not, ?

Answer 1. I Welcome the opportunity to elaborate on my testimony relative to the question of team composition. The appropriate team composition is dependent upon the problem being addressed and the approach taken to the technology assessment (TA). For example, the core question in the Automobile **Power Systems Evaluation Study (APSES) was a technical one relating to**

new engines for automobiles-and it was essential to get the technology right in order to address that question. Also, in our methodology, we based our comparisons on Otto Engine Equivalent cars-that is, vehicles powered by alternate engines that were functionally indistinguishable to the consumer. We were also studying a time frame for introduction of the new technology in the 1980's and an impact-time horizon up to the year 2000. For these reasons, we appropriately needed a team heavily oriented toward engineering skills and it was not appropriate to have sociologists or psychologists to assess the acceptance of or impacts on individuals.

The composition of the APSES team was multidisciplinary, primarily in engineering and science (Mechanical Engineering, Chemistry and Chemical Engineering, Electrical Engineering, Metallurgy, Physics, and Operations Research). Some of the team members had additional degrees in Business Administration and Policy Science. Many had extra schooling in social sciences, and several had previous experience in working on applications of technology to societal problems. For TAs where there is not a close analogy or example of the technology currently used in society, it is necessary to have a much broader, and different set of disciplines on the team.

Question 2. How did You involve the public in your assessment? Was the study reviewed by consumer and public participation groups? In general, what kind of reactions were received?

Answer 2. The public was not involved in a formal way in our study, but they were represented by each of us on the team and review board through our experiences and reading. We also acquired books and public literature in relevant fields including air pollution, energy conservation, role of the automobile, dealers publications, highways and transportation, and publications of consumer advocates. Personal contacts were also made with several consumer groups who have studied the automobile and/or environmental questions.

As stated in my testimony, no pre-publication review of volume 1 (which contains the comparisons, synthesis, and recommendations) was made by anyone outside the Jet Propulsion Laboratory-California Institute of Technology (JPL/Caltech) community. The final report was distributed to known consumer and public participation groups and to my knowledge we have not yet received any comment—positive or negative-from them.

Question 3. What limits do you see to the utilization and application of the concept of TA in the Government and in the private sectors?

Answer 3. I see two kinds of limits-one in terms of what can be done within a TA and the second in terms of what TAs will be requested by the Government and other funding sources.

The first limitation—the state-of-the-art of TA—is very severe. As I suggested in my testimony you can start with almost any problem and be led into nearly all aspects of society. It is hard enough to get the first order effects "right," and nearly impossible to determine the response of our "open system," and then the secondary and tertiary effects. Another problem is that it is often difficult to label an effect "good" or "bad" even after having described it.

The second limitation is the willingness of funding sources to support TAs. This results from the fact that such studies are very expensive (as studies go), take a long time and as indicated in my testimony, don't end when the report is published, and frequently will lead to a negative or cautious result. It seems that many technology assessors are primarily concerned with "impacts" and that the harder and further we look the more that are found. Frequently there is an implicit assumption that the status quo is fine and any change is bad, or that the natural environment in the absence of man is the ideal. More emphasis is needed on the benefits side. In some cases change itself may be beneficial.

Question 4. With respect to TA, do you see any value in a closer relationship between the public and private sector?

Answer 4. Yes, in many TAs it is the private sector that has the detailed information on the technology, including marketing and manufacturing. It has a great deal of data, and in many cases, will become the implementor of the technology being assessed. Thus it is essential that the private sector be closely involved with the assessor and the Government agencies that may be involved in the regulation or funding of the technology.

Question 5. What should be the basis *for* deciding to do a TA instead of *some* other kind of analysis?

Answer 5. Other types of studies that come to mind include cost-effectiveness, cost-benefit, and environmental impact studies. These are usually done for a specific technology, frequently at a specific location, and usually are limited to the intended effects of a given technology. A TA would be a more appropriate type of analysis when it is expected that the application of the technology may become very widespread (e.g. automobiles), or its effects may be very large or perhaps irreversible (e.g. nuclear waste), or it is expected that there may be very important, unintended (or secondary or tertiary) effects.

Question 6. How do human value systems affect technological development? What role should the analysts of value systems have in assessing the impacts of technology on society and on the environment?

Answer 6. I expect the major ways that human value systems affect technological development is through the political process (in terms of what gets funded or regulated) and through the value systems of those actually doing the technology development (and their associated decisionmakers). For TAs in which people's values are very important and unknown, then a specific analysis of values is needed. I am not sure whether a generalized analysis of value systems would be beneficial to any specific TA.

Mr. BROWN. We have one additional witness this morning, and I would like to complete his, testimony if we may. He is Mr. Selwyn Enzer, Associate Director, Center for Futures Research, University of Southern California. We are very pleased to have Mr. Enzer here, and I hope to learn more about what the Center for Futures Research is doing, and how it incorporates technology assessment (TA) as a component of its activity. Without objection, the full text of your prepared statement will appear in the record and you may proceed with our oral statement in an way that you wish.

[The biographical sketch of Mr. Selwyn Enzer is as follows:]

MR. SELWYN ENZER, ASSOCIATE DIRECTOR, CENTER FOB FUTURES RESEARCH, GRADUATE SCHOOL OF BUSINESS ADMINISTRATION, UNIVERSITY OF SOUTHERN CALIFORNIA

B.S. civil engineering, The City College of New York, 1951. Additional courses completed in: advanced mathematics, economics, operations research, statistics, and quantitative business models at Brooklyn Polytechnic Institute and the University of Southern California.

Professional experience prior to 1969: the design and analysis of commercial and industrial structures, powerplants, steel mills, chemical plants, and related projects; structural engineer, Republic Aviation Corporation; determination of mission and systems requirements for future space programs, Advanced Systems Division, Space Division, Rockwell International ; technical director of space studies, McDonnell-Douglas Astronautics Company.

Professional experience from 1969-1975: Senior Research Fellow and Treasurer of The Institute for The Future, research on development and application of forecasting methods for assessing the long-term social impacts of changing bankruptcy laws, no-fault insurance, and exploring alternative future issues for corporate clients; and Chairman (2 years) of the National Advisory Board Committee on Technical Aspects of Critical and Strategic Materials.

Professional experience 1975-present: at the Center for Futures Research, preparation of long-term transportation scenarios for the State of California (CALTRANS) ; director, 2nd annual 20-year forecast of world food problem sponsored by NSF: principal investigator for research on interactive modeling techniques sponsored by CALTRANS; and member of the National Materials Advisory Board Committee on Contingency Plans for Chromium Utilization.

Numerous publications and papers presented at conferences on various aspects of technology assessment and futures research between 1970-1976.

STATEMENT OF SELWYN ENZER, ASSOCIATE DIRECTOR, CENTER FOR FUTURES RESEARCH, GRADUATE SCHOOL OF BUSINESS, UNIVERSITY OF SOUTHERN CALIFORNIA

[The complete statement of Mr. Selwyn Enzer is as follows:]

STATEMENT ON SOME PROGRESS AND PROBLEMS IN TECHNOLOGY ASSESSMENT BEFORE THE CONGRESSIONAL BOARD OF THE OFFICE OF TECHNOLOGY ASSESSMENT BY SELWYN ENZER, ASSOCIATE DIRECTOR, CENTER FOR FUTURES RESEARCH, GRADUATE SCHOOL OF BUSINESS, UNIVERSITY OF CALIFORNIA, LOS ANGELES, CALIF., ON JUNE 14, 1976.

Technology assessment (TA) is an old idea whose time has finally come. The need for TA is as old as the story of Adam and Eve, because if Eve had assessed the full range of consequences associated with apple-eating, we might all still be in the Garden of Eden. Yet how could she know of the consequences ? The apple was sweet and its rewards were immediate, while the future, then as now, was distant and uncertain, notwithstanding the fact that she was advised of the consequences by a Prophet with impeccable credentials.

In the intervening centuries, technological progress has been a truly irresistible force. Neither individuals nor their social institutions have been able to hold back the forces of technology no matter how perilous a future the technology portrayed. Immediate needs and the promise of further technological progress always seemed to win out. So we went from stone to iron, from arrows to bullets, from horses to machines, and from wood to coal to oil without excessive concern over the indirect consequences of those changes.

Now after centuries of experiencing undesired, unintended consequences of technological change, the inevitability of the technological imperative is being challenged. The challenge is coming not from the TA movement alone, but also from informal and concerned citizens in general. It appears under such names as consumerism and environmentalism, but all address the same basic weakness in our system of checks and balances. As a result, technology will no longer be evaluated on the basis of immediate needs alone: the full spectrum of alternatives and their consequences will have to be considered.

No *one* opposing a new power plant, highway, or oil pipeline argues that the development does not respond to some desire or satisfy some need. Environmentalists recognize the need for more energy, more food, etc. The questions that they raise are concerned with whether or not we have considered all of the alternatives and whether our choices appropriately assess the full range of consequences we face. Decisionmakers similarly recognize the need for these assessments. The issue is not one of disagreement as to what has to be done, but rather concerns what can be done and how to do it.

The founders of TA recognized that formal program analysis was based exclusively on immediate needs. With coats and benefits based on immediate needs, program analysis reduces exclusively to the consideration of technical feasibility and economics, and on this basis technology indeed becomes an irresistible force. Therefore, they expanded the issue to ask about what else may happen, and whether or not we would welcome those happenings. This gave rise to a new type of analysis that some have called a new discipline. What distinguishes TA from previous analyses is that TA stipulates the desirability of the innovation with regard to immediate needs, and systematically explores the longer range consequences that may follow from the successful implementation of the proposed innovation.

Even though they recognized that TA was an art form that could never be handled in a truly scientific manner, the early technology assessors were generally *systems* analysts schooled in operations research, and the methods of scientific inquiry. They attempted to use methods of scientific inquiry to assure comprehensive coverage of the issue and its impact areas, Of course the application of scientific analytic procedures to TA is at once a paradox, Scientific analysis depends upon positive data and a complete understanding of underlying processes of *change*, whereas the future is fraught with uncertainty and non-scientific issues involving human values. As a result, the sciences have always avoided decisions on the desirability of technology, relegating these choices to the political process. The early technology assessors recognized that this dichotomy had grown too large. Technology affects all aspects of society, and if the political process was to be effective in making technological choices, a more cooperative posture between the physical and social sciences had to be developed.

Now, after a number of years in which many TAs (and many so-called TAs) have been performed by government agencies, industrial organizations, think-tanks, and universities, it can be useful to take stock of the progress made in developing TA into a useful analytic tool. However, we must remember that we are dealing with an ancient problem and are reviewing only our initial efforts. Hence, we must not be too hasty in judging what is success and what is failure. Yet we must be able to discriminate positive findings from spurious conclusions. To do this, there are several caveats that should be borne in mind.

Much of what is reported as TA, is really not TA at all. The reason for this confusion is partly definitional and partly due to a misunderstanding as to what TA really is, or more precisely what it is intended to be, and how that differs from conventional Investigations of possible new technological applications or even market studies. After all, most market researchers investigating the business potential of a new technology regard their activities as assessments of the business potential of that technology. Similarly, many systems analysts regard their studies as TAs because systems analyses are typically concerned with all possible technological options and outcomes. And while it is true that these analyses are similar to TAs in many ways, they differ in a number of key aspects. Hence, the first caveat is that many of the so called TAs are frequently something else, and it would be erroneous to evaluate TA on the assumption that all analytical efforts that are called TAs are true TAs.

There was and still is considerable *disagreement* as to the specific nature and understanding of TA even among those who are fairly well in tune with the goals of TA. This is the sort of evolutionary situation that one would expect with a new analytic tool. However, the lack of early definition and understanding led many assessors to adopt analytic procedures in the conduct of TAs that ultimately proved unsatisfactory. In post-mortem reviews of many TAs, the assessors can frequently identify assumptions or constraints that were introduced in an attempt to improve the analysis, but that proved counter productive in the end. A TA workshop sponsored by the Academy for Contemporary Problems and the National Science Foundation (NSF) in 1974, cited many examples of this situation. Thus the second caveat is that many TAs contain basic deficiencies that the researchers recognize but that may not be evident in the final report. These weaknesses should be identified, and care should be exercised in evaluating the utility of the results of assessments containing such weaknesses.

The final caveat is concerned with the expectations of the sponsors of TAs, and the impact these expectations have had on the research itself and the recommendations that followed from the assessments, Although it is obvious that the only value realized from a TA is in the program changes it promotes, change is always resisted by incumbent interests. Furthermore, when the recommendations for change are basin on indirect and higher order impacts, the need for change is easily attacked on the basis of uncertainty. This is amplified by researchers engaged in TA who are generally conditioned in the scientific method, and regard making recommendations based on value judgment as sinful behaviour. As a result, specific policy recommendations, which are so important in political circles, are meticulously avoided by the usual cadre of personnel involved in TAs. Instead. TA results generally present a menu of alternatives and possible impacts, which in attempting to be exhaustive and objective, include considerable trivia and avoid the value judgments that in the long run are most important.

This problem is still very much a part of the current state-of-the-art of TA. In order for this condition to improve, sponsors will have to expect recommendations that are controversial and that may run counter to their ongoing programs. Technology assessors must recognize that the value sought from their deliberations necessitates stimulating the forces of change and that these changes will be resisted.

The need for TA as a constructive tool in guiding forces of change in our society is obvious. It is reinforced every time we observe undesirable side effects from programs intended to satisfy a societal need. But just as it is hard for a child to see a stomach ache in ice cream and apple pie, it is difficult for a technocrat, government administrator, legislator, or business leader to see problems emanating from socially needed programs to which he or she is dedicated. Therefore, we must develop a greater appreciation of the fact that the best laid plans can go astray, and that collaborative efforts between innovators and assessors can reduce the frequency of these undesired outcomes.

WHAT IS TECHNOLOGY ASSESSMENT?

If people familiar with TA were polled, a surprisingly large number of different definitions of TA would be found, and an even greater variance in how a TA should be conducted. The definitions generally boil down to a search for unintended consequences that may follow from the successful fulfillment of a technological program--so that we can deal with unintended consequences before they become social issues themselves. This distinguishes TA from other forms of ‘technological investigation and it also increases its complexity enormously. Ideally a TA team must be able to assuree that a particular program (in say energy, transportation, etc.) is completed as planned, and must then proceed to investigate what further consequences may occur as a result of that success, while still retaining perspective on other changing societal conditions. There are no constraints or guidelines telling the assessors where to look. On the contrary, identifying such higher order, indirect impact areas, is an important part of the “l'A. There are no constraints or guidelines as to how far ahead the assessors should look. Generally the technological change being assessed will take years to reach its successful fulfillment and the indirect consequences may take many more years to manifest themselves. Hence, TA is inherently future-oriented, and as a result involves considerable uncertainty.

Technology assessment is not limited to physical or biological techniques. Many social innovations have been responsible for unintended impacts of immense societal consequences. Legislation creating the land grants colleges, social security, and no-fault automobile insurance are a few examples of social technologies that have been the subject of assessments or have been suggested as candidates for assessment.

Each of these innovations poses different methodological problems in the detailed conduct of a TA, but they share two common characteristics that present enormous complications—they are entirely open-ended and they do not have any singular “right” answer. By their very nature, problems of this type defy rigorous solution. Understanding them involves imagination, conjecture, and judgment applied in a way that is in opposition to the way we were trained to think and to solve problems.

These considerations, more than any specific methodological problems, are responsible for the difficulties in promoting the development of the discipline of TA as an art form. They also represent a major source of difficulty on the part of policy makers who generally look for more positive conclusions from analytic -results.

THE CRITICAL NEED--AN ASSESSMENT ORIENTATION

Our educational system teaches us to think along discipline structured lines and to solve problems that have precisely determinable answers. Technology assessment demands that we think in an interdisciplinary fashion, and that we are able to appreciate not only the different outcomes that can result, but also how differently these outcomes are likely to be viewed by various social groups. Not only are we ill-equipped as analysts to cope with this type of problem, but also *as* users of information we find that such results can often increase rather than reduce our uncertainty.

It has been said that the more we know, the more uncertain we become. This is certainly true in TA. Yet the situation is not hopeless. On the contrary, with the proper orientation, we will recognize that the improvement we seek is not easy to obtain, and cannot be relegated to a group of planners who will tell us what should be done if we wish to avoid undesirable indirect social consequences from technological progress.

It is self-evident to say that we are surprised only when things we did not expect to happen actually occur. (This also includes the converse, that is, when things we did expect actually do not occur.) Generally however, not all of us are surprised. Frequently, there was some minority viewpoint that did anticipate what the majority regarded as unlikely. General Billy Mitchell of the Air Force has often been cited as the leading modern example of such minority opinions. The problems we face as analysts and users of TAs are how to nurture these imaginative minority viewpoints, and how to deal with them in a socially responsible manner.

Several responses are possible. One is to study this minority viewpoint further, an approach that some contend is a death sentence, an alternative to action. Another response is to assume the minority viewpoint to be correct, and to evaluate possible policy responses and their timing. It may be that key early warning signals can be identified and monitored to determine whether or not the situation anticipated by this minority opinion is developing. It may even be possible to make some policy adjustments that retain the original objectives while also accommodating the minority viewpoint.

The point is that conventional attitudes seek unique optimal solutions to problems that do not lend themselves to such simplification. In order for TA to be effective, we must expand the range of options, and our understanding of the full range of consequences these options contain. If this orientation is achieved, TA mechanisms and public debate will elevate to a point where more effective management of change will become a reality.

METHODOLOGICAL PROGRESS AND PROBLEMS

Many methods have been developed in the past few years that are useful in pursuing the goals of TA. These methods address both the macro- and micro-aspects of the assessment; that is, they describe a sequence of steps that must be taken to assure comprehensive coverage of all critical aspects of the assessment, and offer detailed procedures that can be of value in the conduct of one or more of the individual steps.

The macro-procedures have been presented with as few as 5 steps and frequently with more than 10 steps. On close inspection however, all of these procedures contain 5 essential tasks. These tasks and the subtasks they include are presented in Table 1. A detailed review of these tasks is not appropriate for our purposes, but some points are worth noting. First, these methods are structural rather than substantive. That is, they provide a systematic sequence of steps to be taken, but they provide no specific formula, the application of which would be sufficient to assure high quality results. This is consistent with the contention made earlier that TA is an art form, not a science. The application of these methods does not replace the need for highly creative and imaginative deliberations. These are necessary to produce quality results. It is important to note however, that there is general agreement about the steps that are essential for the proper conduct of a TA.

TABLE I—GENERAL TASKS IN TECHNOLOGY ASSESSMENT

1. DEFINE THE ISSUE AND ITS CURRENT STATUSl

issue characteristics (problems, opportunities, alternative innovations, key questions, etc.).
Factors affecting the issue (stakeholder groups, values, external changes, etc.).
Goals and objectives.
Scope (impact areas to be included, time period).
Indicators (performance, effectiveness, satisfaction, criticality).
Current status, trends, and expectations.

2. DESCRIBE THE NOMINAL FUTURE COURSE OF THE ISSUE

Projections of issue trends and indicators.
External changes that may affect the issue (probability, time, impact).
Interactions among external changes and issue projections.
Alternative issue scenarios (exclusive of societal intervention).
Initial impact projections.

8. IDENTIFY POTENTIAL *ACTIONS*

Alternative actions,
Conditions that might dictate actions.
Resource needs (economic, institutional, human).
Timing.
Impact on alternative issue scenarios.

4. DESCRIBE AND EVALUATE SCENARIOS

Candidate action programs.
Resulting scenarios.
Changes in expected impacts.
Assessment of outcomes (from viewpoints of stakeholder groups).
Preliminary identification of attractive alternatives.
Key branch points, milestones, monitoring signals.

6. ASSESS COMPLETE SPECTRUM OF IMPACTS

Indirect and higher order consequences.
Stakeholder groups affected by consequences.
Action programs that enhance indirect impacts.
Program recommendations.

NOTE: Frequent iteration among all of these tasks is an essential feature of TA. Aside from expediting the assessment process, this agreement facilitates communication between the assessors and the sponsors (or users) of the assessment.

It should also be noted that some assessors emphasize certain tasks and minimize others. The issue over which there is the greatest disagreement is the degree to which the assessment team should seek to make value judgments and policy recommendations. This is partly the result of the unscientific nature of such evaluations, and partly to preserve the sense of objectivity with which the assessment was conducted. While the hazards associated with making value analyses are real, and do tend to crystallize the assessor's position, they are essential to some degree if the assessment is to confine itself to meaningful options and avoid theoretically possible, but trivial alternatives. More importantly however, recommendations are an important means by which the findings of a TA are communicated to decision makers and interested parties in general. Of course all recommendations must be supported by the analytic results. These must show which choices were considered at each step in the assessment, the assumptions, and the evaluation criteria used in selecting among the choices. An exhaustive menu of alternatives and their impacts presented without preferences can easily be disregarded by political forces.

The nature of the subtasks is likely to vary considerably to suit the issue being evaluated. In certain cases, only qualitative evaluations may be possible, while in others highly quantitative analyses may be needed. A wide variety of methods are available to insure comprehensiveness in each of these steps. These methods range from complex simulation modeling techniques to exploratory brainstorming sessions. Considerable progress has been made in these methods over the past few years, but as with the macro-techniques, all of these methods are structural rather than substantive. While it is not appropriate to present a detailed review of the micro-techniques available for each of the tasks in the assessment process, Figure 1 gives some indication of the variety of different methods, and their utility for each of the five tasks presented earlier.

Figure 1 - METHOD / ANALYTIC TASK MATRIX

METHOD	ANALYTIC TASK: 1. ISSUE DEFINITION	2. NOMINAL FUTURE COURSE OF ISSUE	3. POTENTIAL ACTIONS	4. ALTERNATIVE SCENARIOS	5. IMPACT ASSESSMENTS
1. MULTIDIMENSIONAL SCALING	**				
2. MORPHOLOGICAL ANALYSIS	*		**		
3. RELEVANCE ANALYSIS	***		**		***
4. POLLS	**				
5. BRAINSTORMING	**		**		***
6. CONFERENCE & SEMINARS	**	*	**	*	*
7. INDIVIDUAL INSIGHT	*	*	*	*	*
8. DELPHI	**	**	**	**	**
9. SCENARIO WRITING		*	**	***	***
10. EXTRAPOLATION	**	**			
11. QUANTITATIVE MODELS	*	***	*	***	*
12. QUALITATIVE MODELS	**	**	*	***	
13. SIMULATION & GAMING	k	*	*	***	***
14. CROSS-SUPPORT MATRICES	*		**		
15. CROSS-IMPACT ANALYSIS		***	**	***	***

* = USEFUL

** = VERY USEFUL

*** = KEY METHOD

Notwithstanding the structural nature of these techniques, their value in TA should not be underestimated. A relevance analysis, for example, is an extremely powerful tool for developing a systematic definition of the issue involved in the assessment. Not only does it promote comprehensiveness, but it also facilitates interdisciplinary collaboration among the assessment team because it

highlights those areas where the social, physical, economic, and other aspects of the issue interact.

Similar experiences have been realized with the other techniques described in Figure 1, although many of them tend to be more specialized and hence less flexible than relevance analysis. Indeed, one of the areas of greatest progress has been in the development of methods that aid in the investigation of the open-ended problems found in TA.

The principal problems currently associated with the conduct of TA and some thoughts on how these may be approached are discussed below.

1. BOUNDING THE ASSESSMENT

This problem has 2 components. The first is concerned with the definition of the technology itself, while the second is a methodological problem that occurs in all TAs. A good example of the first type of problem is the energy crisis. A complete assessment of that issue would be far too large to be practical for any one organization to handle. Breaking the subject into small components, for example by energy sources, may introduce wasteful overlap and possible inconsistencies. However, this problem is generally manageable by the sponsoring agency's project monitoring team.

A more difficult problem comes about during the conduct of the assessment itself, and is concerned with the systematic identification of indirect and higher order impacts. In a world where everything is said to be connected to everything else, this is truly an open-ended problem. Furthermore, since the search is intended to include higher order impacts-which are the result of the interaction of different impacts emanating from different causes-the critical elements of this aspect of the search may be only peripherally included in the basic assessment.

Current methods for systematically screening possible areas for important impacts simply do not exist. All approaches to this critical problem are based exclusively on judgment. Most current approaches are variants of brainstorming sessions involving people from different disciplinary backgrounds and varying points of view. This approach may overlook not only important, obscure, indirect impacts, but may easily overlook important higher order impacts that may not have been difficult to pin-point if a systematic screening procedure were available. Basic research into procedures that can be used to screen possible impact areas can be of immense value in assuring comprehensive identification of important indirect and higher order impacts.

2. *INTERDISCIPLINARITY* IN TECHNOLOGY ASSESSMENTS

As indicated earlier, our education system and hence our intellectual orientation is structured along disciplinary lines. On the other hand, most of the impacts that concern us in TA are the result of a change in one discipline acting on other disciplines--e.g., the effect of the use of persistent pesticides on wildlife, the impact of spray propellants on the upper atmosphere, the impact of new communications devices on social lifestyles and regional development, etc. Aside from our disciplinary orientation, communication difficulties and the lack of incentives work against the establishment of interdisciplinary cooperation.

Successful TAs have employed teams composed of experts from the key disciplines involved in the technology being assessed. These team members act as spokesmen for their disciplines obtaining appropriate data from the literature and other experts in their fields. These data are then integrated for the purpose of the TA by the team members. However, the creation of such interdisciplinary teams are quite time-consuming and Institutional incentives to encourage such efforts are often lacking.

In a university where a broad range of skills are generally available, competent experts in such fields as economics, law, political sciences, find that multidisciplinary research contributes very little toward their career development. Tenure and promotions are largely based on individual achievements along discipline lines that receive peer group acclaim. This situation makes it difficult to entice young faculty members into TA teams. (Senior faculty are generally too immersed in their specialties to be reoriented for interdisciplinary work.) And, in those cases where it has been possible to create interdisciplinary teams, the team was generally short-lived because of the lack of discipline-oriented recognition these efforts received.

To encourage interdisciplinary research, The Center for Future Research at USC has attempted to establish part-time interdisciplinary teams so that each member retains some contact in his basic field. We have also supported the individual preparation of discipline-oriented position papers on the various aspects of our assessment studies. These position papers provide the research products needed for faculty career development as well as the input data necessary for the TA.

Institutional changes that will enhance interdisciplinary research within a university are occurring, but at a very slow pace. This process can be accelerated if support for TA efforts were available on a more continuous basis. This unfortunately is not the case in the current environment where TAs are generally awarded against Requests for Proposals (RFPs), and are structured to match annual funding cycles. (Responding to RFPs is particularly difficult in universities where often there is no proposal preparation budget and no means of recovering the cost of such efforts in overhead rates.)

Another reason interdisciplinarity often suffers in TA is because eminent research personnel frequently hold such efforts in low regard. Much of the resistance to engaging such people in interdisciplinary research can be overcome by governmental agencies than sponsor substantial amounts of discipline-oriented research. If for example, the United States Department of Agriculture (USDA) were to encourage personnel (whose research they typically support) to cooperate with TA activities, these personnel would find it difficult to refuse. This can prove quite valuable if the researcher in question has unique insights of importance to the TA.

In summary, the problems of interdisciplinarity in TA are both institutional and intellectual. The problems can be overcome, but there are considerable start-up costs that must be borne in creating effective interdisciplinary teams from scratch. Because the university contains a broad spectrum of skills, it provides an ideal setting for such activities. However, because of the degree to which universities are institutionalized along disciplinary lines and because of their funding constraints, they require special consideration regarding continuity of support to attract and retain their team members.

3. POLICY RECOMMENDATIONS THAT MAXIMIZE THE DESIRABLE CONSEQUENCES OF TECHNOLOGY WHILE AVOIDING UNINTENDED NEGATIVE SIDE EFFECTS

Technology assessments frequently avoid value-laden issues that do not lend themselves to objective analysis. It is a difficult task to accurately assess the "social costs and benefits that accrue to various interest groups within a society, but this task is clearly part of a TA, and most assessment teams will accept this responsibility. It is far more difficult to choose a set of actions that distributes these costs and benefits equitably, yet some assessors regard this as an essential part of the assessment process. We at The Center for Futures Research consider it an important aspect of any assessment. However, converting these recommendations to operational policies that are implementable within governmental and industrial institutions is another matter.

In an assessment of no-fault automobile insurance, in which I was the principal investigator, it would have been easy for the assessment team to analyze the costs and benefits of the various schemes that could be devised and to present recommendations as to the desirable alternatives However, we could not draft the legislation, nor could we identify the institutional adjustments that would be required to. implement our recommendations. This is not within the competence of a TA team, and any attempt to move too far along those lines is likely to produce naive results that can only serve to discredit the entire effort.

What is needed for the policy formulation is an interdisciplinary effort that differs somewhat from the one presented earlier. This interdisciplinary effort should be between the assessment team and the staff of the Office of Technology Assessment (OTA) or other sponsoring agencies. The point is that the institution that sets policy is best qualified to draft the appropriate policy mechanisms. The assessment team can only advise in these matters.

This approach presents serious difficulties when the sponsor is not the policy setting agency per se, such as is the case with NSF-sponsored assessments, or when implementation of the appropriate action requires a policy change on the part of a third organization. Here too, actual policy information should not be attempted by the assessment team alone, but with the involvement of the sponsoring agency, even if that involvement consists of negotiating for the cooperation of the appropriate third parties for this purpose.

4. LIMITATIONS IMPOSED BY DIFFERENT TYPES OF SPONSORING INSTITUTIONS

Technology assessments are currently being sponsored by various government and industrial organizations. In some cases the sponsoring organisation performs the assessment in-house and in some cases all or part of the assessment is contracted to outside institution--profit or nonprofit think tanks, or universities. In any case, the sponsoring organization is primarily concerned with meeting the needs of its stakeholders or customers, rather than any idealized version of society. When the sponsor is a government agency, the dichotomy between the sponsor's constituency and society in general is less than when the sponsor is an industrial organization. This is not intended to imply that industrialists are anti-society, but rather that their operating goals are motivated by profits. rather than the commonweal or the quality of life, and these goals are not always entirely the same. A similar argument could be made for government agencies with special interests such as the USDA, the Federal Aviation Agency,. or State and local governments. These agencies have considerably narrower charters than that of the Congress, which OTA serves.

The point is that the sponsor exerts considerable leverage in scoping the effort. Industry-sponsored assessments will respond to interest groups that affect their profitability. These typically are the consumerist and environmentalist groups. (Industry has always been concerned with meeting existing regulations and product safety requirements; hence these are not singled out as anything new that has to be covered by a TA.)

IN CONCLUSION

The objective of TA, namely guiding change on the basis of a complete understanding of alternatives and their consequences, can be found in many social demands including the consumerism and environmentalist movements. As a result many government and industrial organizations find themselves having been engaged in TA activities before they had any awareness of TA. The demand for better guidance *of* change in our society is now so pervasive that despite the methodological, institutional and intellectual difficulties, TA will continue to grow and expand although it may do so under a variety of different names.

Technology assessment is inherently open-ended and hence will never be amenable to closed-form rigorous analysis. It is an art, not a science. Methods have been developed that greatly facilitate the practice of this art-form, but they are no replacement for imaginative and creative inputs. We must promote the orientation-divergent thinking and interdisciplinarity--necessary to maximize our TA talents. This is as important for the assessors as it is for the users of the results of the assessments. The assessors must be able to think in terms of expanding sets of possibilities and impacts, whereas the users must be able to cope with unlikely impacts. After all, it is only from the occurrence of unlikely outcomes that we get the unexpected side effects that TA attempts to control.

The difficulties associated with trading off immediate payoffs for low probability future possibilities, are of both an institutional and an intellectual nature. The tendency is to discount undesirable future impacts even if the probabilities. of their occurrence are great. After all Adam and Eve made the wrong decision even after being given perfect information. Technology assessment will never provide decisionmakers with perfect information, but with the proper orientation on the part of the decisionmaker he will make better use of it than Adam and Eve did.

Mr. ENZER. I would just like to skim through my statement, highlighting some of the more important points. The concept technology assessment (TA) really addresses a very old problem. What we are concerned with is changing or even compromising present needs or present objectives or goals, in light of uncertain possibilities or consequences that may occur in the future. This is a very difficult task for society to undertake. Our history shows that we have traditionally deferred the future; that the present has driven the future out. It has often been said that we have moved from technology to technology without really worrying about the longer term consequences, trusting -that future generations or future technologies will take care of these consequences. But today we have come to regard these consequences as a challenge. Technology assessment is a formal response to that challenge; that is, it is the formal mechanisms by which we can look at the indirect consequences of change, to explore our alternatives more care-full-Y rather than to gravitate to one that is most readily at hand or most easily applied to the situation.

We see what in essence are TA demands coming from many social groups--from the consumerist's movement, from the environmentalist movement, and so on. These people don't oppose electric power plants, highways, pipelines, or the like because they feel they are not needed. The grounds on which they contest these changes are always their indirect and higher order consequences. This, of course, is the thrust of TA. Hence these demands are the result of TAs of a sort. There is really no disagreement between the environmentalists and the technology assessors on what has to be done. Any disagreement is more the result of differences in approaches rather than substance.

I think the founders of TA recognized the open-ended nature of the assessment problem, and built the search for alternatives into the analytic mechanism that we are trying to evaluate now. Technology assessment explores problems that have no unique answers. Since there are no right answers the analysis cannot be scientific, but rather has to be an art form. It is really not a scientific discipline even though its initial practitioners were trained as scientists and operations researchers. This posed an immediate paradox in the design of TA methods. We are trying to analyze situations for which there are no data or certainties, and only partial understanding of the system that is shaping the possible consequences. There are many, man-Y difficulties associated with problems of this type, but if we bear in mind that it is an art form rather than a science we can develop the orientation that I think is ‘essential for coping with TA.

My written statement elaborates on some of the questions concerning how an evaluation of TA should proceed. But I would like to highlight several caveats that should be kept in mind. One of them is that many TAs aren’t really TAs at all. The-Y are called TAs because it was the “in" word to use, Occasionally the term was used to obtain the funds for the investigation and occasionally to give the results a title that made it sound as vital as possible.

The second caveat I would like to caution you about is that there was considerable disagreement over what TA is and what it should do, especially in the early assessments. The early assessors experimented with methods that occasionally proved counterproductive. So we may occasionally be looking at results where fundamental mistakes were made, and even though we may have learned from the mistakes, we may not have had the wherewithal to correct the results.

The final caveat, perhaps a little bit more important, is that the interaction between the user or the sponsor of a TA and the assessor was not clearly defined, particularly in the early TAs. This led to misunderstanding regarding what an assessment should produce, and what the -sponsor should do with the results. This weakened the impact of the TA as measured by the changes it promoted. We know that changes are often resisted by incumbent interests. These forces that tend to resist change were nurtured by the lack of understanding between analysts and sponsors, making the assessment vulnerable to attack. And such attack was relatively easy to muster on the basis of uncertainty, **because** the consequences to be avoided were always in the future-that elusive time zone about which we can never speak in factual terms. Another factor that has made TA most vulnerable to criticism and perhaps contributed to its lack of utility, is the degree to which the assessment teams have avoided the value laden normative issues of what should be done. This is largely a result of the scientific conditioning of the assessors.

In TA we are talking about subjective choices that are not really amenable to scientific analysis, so the assessors prefer to avoid these issues. Therefore, the results of a TA often read like a menu of alternatives that is extremely long and nauseatingly detailed. Value judgments (preferences), which in the long run are most important, are generally avoided. This is a problem that is still with US. It is very easy for the political process to ignore a document that really doesn't take a stand, especially when it is extremely detailed and voluminous. Notwithstanding these problems, the TA movement is almost certain to grow. Whether this growth comes about under the rubric of TA or some other rubric, is unimportant, assessments are going to be with US. Furthermore, they are not going to be limited to physical or biological technologies. We are going to assess all innovations that have large social consequences, The big problems that we are faced with are the complexity of these innovations and the open-ended nature of the assessment process-the fact that assessments pose problems that do not have unique “right” answers.

The critical need in making TA work in our society is to develop an -assessment orientation. This ma sound like motherhood, and it is in a sense. But it is easier to cope with the thought of an assessment orientation than it is to put it into practice. Our educational system teaches us to think along discipline lines. We have to solve problems that have precise, determinable answers. If you look at the modern textbooks you find the answers to most problems in the back of the book. We are taught to think convergently to a single answer. Technology assessment demands the opposite from us. It demands that we think divergently, and in an interdisciplinary fashion. It demands that we explore the myriad of alternatives and their consequences, and that we understand how these might be viewed differently by different interest groups, rather than trying to identify the “best” answer. With the proper orientation we can do a far better job of TA than we can do without it, but we are fighting our entire educational system. 1 think this is a very key factor.

An orientation that helps us think about alternatives will also help us cope with uncertainty, and thereby help reduce the occurrence of unwanted and unexpected side-effects. It is obvious that we get surprised (or we incur undesirable side-effects) only when things we didn’t expect actually happen, or when things we did expect don’t happen. But we never get surprised when things that we expected ‘happen. Therefore, if we are going to avoid these unexpected unwanted consequences we are going to have to deal with assessment results that are alerting us to things that we don’t expect will occur. Our system really does not know how to co e with criticism of that type. The warning of Billy Mitchell of the Air Force is probably the most frequently cited example of this particular situation. He stated the need for air supremacy as he saw it. He was heard, but his opinion was contra to the majority, and we didn't know how to deal with it. At least today we recognize that minority opinions can be most important, and if we can develop the right orientation we can perhaps nurture these opinions so that we can deal with unwanted consequences before they are fully manifested as problems.

The interesting part about this problem of orientation is its dual nature. It is not just a problem that the assessors face. It is a problem that the users of the TAs also face. A policymaker, a decisionmaker, has to be able to cope with low probability occurrences--occurrences that he may not expect and, as a matter of fact, that the assessor also doesn't really expect. It is from such eventualities that we are going to get unintended consequences, and unless we can deal with these in a proper manner, TA will prove highly ineffective,

Regarding methodological progress and problems, the text cites some of the macro and micro aspects of the TAs that have been developed over the years. I think there is considerable agreement as to the general approach to an assessment. Many detailed variations exist, but all of the variations cover the same steps. Some may put greater emphasis on certain steps, use a different sequence, but they address the same tasks. Furthermore, these methods are procedural rather than substantive. This reinforces the contention that we are dealing with an art form. There are no formulas such as are found in physics or chemistry, which if employed guarantee that the answer is true. There is no truth. We are dealing with open-ended questions. We are exploring unbounded issues. The development of methods means trying to come up with procedures that we can follow that insure that we are as systematic and as creative as we possibly can be. None of these methods will replace creativity. We have to have imaginative creative, interdisciplinary persons working in these tasks if we are going to get useful results. I don't by that statement mean to belittle the significance of the techniques. They are extremely powerful when carried out properly.

For example, one of the methods listed in Figure 1 of the text is called a relevance analysis. This method has invariably been proven to be an extremely powerful technique by promoting interdisciplinary considerations of complex subjects, and by virtue of its applicability to a wide rangeof subjects. Further development and application of techniques like this will improve the quality of TAs enormously.

I won't dwell on any particular methodological problems here, but I would be glad to answer any questions that may come up later on regarding any of these techniques. I would like to address myself to a number of basic assessment problems for which no satisfactory methods exist. One problem is that of bounding the assessment. I don't mean defining how to breakup a complex TA, such as the energy problem, which is too great for a single assessment to handle. Technology assessment can handle this aspect of the bounding problem quite well. The problem I am concerned with is the one the assessors face when they sit down and try to identify where they should look for indirect and higher order impacts.

Everything has been accused of being connected to everything else, and I am afraid that that statement may be true. If we try to look under every stone and turn every corner we are likely to identify a larger number of obscure impact areas, but we are also likely to end up doing little more than merely identifying them. We do not have any systematic procedures for efficiently pursuing this problem. It would be very useful if we could have some basic research that could identify methods that could screen a large set of candidates for possible indirect impacts so that we can focus on our attention areas that are likely to contain these higher order impacts. Right now what we do is conduct brainstorming sessions with people with different backgrounds. We also use oversight committees. These approaches are useful indeed. They are the best things we have, but I don't think we should overlook their deficiencies in identifying impact areas. We have an important need for an approach that could perhaps do this job better.

Another problem that requires a significant amount of attention is to improve our skills at making TAs more truly interdisciplinary. I alluded to part of this problem earlier. In addition to orientation problems, there are substantive problems, and lack of incentives for interdisciplinary work. It is common for a TA to begin by creating a team made of people from different disciplines. These people presumably have an orientation toward interdisciplinary work, and make a sincere effort to communicate more effectivefy with each other. Development of such teams is very time consuming. It also is very difficult to provide the institutional incentives for creating interdisciplinary teams, particularly in a university, which is an ideal setting for an interdisciplinary team because of the variety of skills that are generally available there.

The reason for the lack of institutional incentives is that career development at a university is structured along disciplinary lines. "The key components used to determine promotions and the granting of tenure are individual contributions that receive peer group acclaim. Hence disciplinary research is most important for university people. This makes it difficult for us to entice young faculty members into teams, and when we get them into assessment teams we find it very often hard to retain them. To encourage Ion term associations we try to share our research personnel with discipline-oriented functions. By so doing, the team member is half professor and half researcher. We support efforts by the individual in the preparation of discipline-oriented position papers even though such efforts may only be marginally useful to our projects. If we have an economist doing an economic analysis for a food study we encourage him to document his results for peer group presentation; that is, in economics journals that can give him the kinds of acclaim that he *needs.*

Another factor that presents difficulties in a university is the fact that TAs are generally procured on a competitive basis on annual or 18-month cycles. This cyclic nature inhibits team stability, and creates recurring proposal costs. Both of these aspects are very difficult for *a* university to cope with. At the University of Southern California (USC), for example, we have absolutely no budget for proposal preparation. Since we have no way of covering these costs preparing proposals are entirely ad hoc functions performed during limited personal time.

Another factor that constrains TA activities is that eminent specialized research personnel very frequently hold interdisciplinary activities in low regard. Specialists typically are very much into their thing whether they are physicists, economists, lawyers, what have you, and they are generally not too interested in pursuing interdisciplinary research. I would think this is an area where the government can use its influence to insure people who have unique insights make themselves available to TA teams. For example, if we were dealing with an assessment in agriculture I would think that the U.S. Department of Agriculture (USDA) could see that some of the researchers whom they support on a regular basis make their services available to a TA team when needed. I don't think they would have to do this very often. After stimulating such collaboration I think they would find it becomes self-sustaining. In total, our ability to perform open-ended' interdisciplinary research is extremely important. We are presently not very good at it, and we are not making satisfactory progress along these lines.

Another concern I have with TA is the lack of a precise definition for the kind of policy recommendations that assessment should produce. Here the community of technology assessors is very much divided. Some assessors don't want to make any recommendations at all. Some of the users would like TAs to develop detailed recommendations, and even implementation procedures for policy changes. I don't think that TA teams ought to be responsible for drafting implementation procedures or legislation. I think that is an area where they are eminently unqualified. Perhaps this is an area on which the TA team and the Office of Technology Assessment (OTA) ought to collaborate. At the end of an assessment they can get together and in an interdisciplinary manner combine the insights available from the assessment. Administrative insight available at OTA should be used to develop policies that would be rational and implementable, and that would promote the type of change that should follow from assessment.

As a final thought I would like to point out the kinds of imitations that frequently result from different sponsoring institutions. An obvious example is the difference between the results when the sponsor is government in contrast to industry. Here I think we will find that the degree to which the results of assessments sponsored by these different organizations fulfill the noble goals of TA is related to how closely the goals of the organization overlap or are congruent with societal goals. In the case of OTA and the Congress, I think the overlap is very close. In the case of business organisations, this overlap is not very close. It is not that businesses are antisocial organizations, but that they are not attempting to respond to the same set of stakeholders. When an industry conducts an assessment on a new product for example, these stakeholders are the groups that affect their profitability. These used to be consumers alone. Now they include other activist groups as well. But they will not be concerned with the quality of life in the same terms as Congress. To this extent we could expect substantial differences in the kind of assessments on the same subject that would be performed for industry versus for a sponsor like the OTA.

In conclusion, I again remind you of the importance of developing the proper assessment orientation for policymakers who have to learn how to cope with this tradeoff of immediate payoffs to avoid low probability future impacts. We have both institutional and intellectual problems in developing this orientation.

Mr. BROWN. We thank you very much for this extensive presentation, Mr. Enzer.

I wonder if you could tell us a little bit more about the Center for Futures Research. I have not been familiar with its existence. I presume it is a relatively new development on the campus. What were the factors that led to its creation, and where does it play its most important role?

Mr. ENZER. The Center for Futures Research has been in existence for over 5 years. It is situated in the Graduate School of Business at the University of Southern California (USC). Like most things that take place on a university campus, it is a product of need as perceived by certain key people on the campus. The leading figure in this regard is Burt Nanus, who is the director of the Center and who is also its creator and founder. He saw the need for it and went through the necessary procedures to convince others that this was an important activity for a university-and in particular for a business school to have—and here we are.

What we do is conduct interdisciplinary research primarily into the methods of understanding future alternatives and long-term change, as well as adapting these methods to business and social problems, which are after all quite similar. We apply these methods in the areas of social and business concern. We don't do business consulting or perform research with a narrow focus. We have had a large number both of business and Government sponsors. We have done research for example, for the California Transportation Department in helping them develop their long-range plans. We also hold seminars to teach this art form to practitioners and potential practitioners from business and Government. We have such a session going on today, we have 30 people that we are putting through a 3-day crash program.

Mr. BROWN. In other words, it has a close relationship to the need for policy planning in the business community, and it relates to what you might call futures analysis or research as an aspect of planning?

Mr. ENZER. That is correct.

Mr. BROWN. I was struck by a statement earlier in your paper that led me to believe that you felt that it was important to include value judgments in the technology assessment (TA) process, and that there is a value in coming out with policy recommendations. I think you commented in a point or two, that there seems to be a difference of opinion here. 1 am not sure how real it is. I don't think you can avoid having value judgments in any policy-planning processor any aspect of it, but it does seem to be a fact that many technology assessors want to minimize the overtness of my value judgment within the study. They want to present options rather than policy recommendations. Do you see any fundamental conflicts in these two points of view?

Mr. ENZER. I did refer to this briefly as an area of difference that has polarized the assessor community. I feel that to some degree value judgments can't be avoided. In order to avoid them you have to put in all of the nonimportant alternatives, and then you end up with something that is extremely large and extremely boring.

Mr. BROWN. Now you are talking about a priority-setting process here, rather than necessarily making value judgments. We were talking about this with previous witnesses. You can identify universal impacts and then discard those that are less significant, not necessarily trivial, but obviously everything isn't equally important. That does involve a value judgment.

Mr. ENZER Precisely.

Mr. BROWN. In order to establish priorities.

Mr. ENZER. That may be a lower level value judgment than those involved in assessing benefits and drawbacks. But a number of assessors begin at that level because they feel if they are going to be objective they have to be fully objective, and the list gets very long. I think many assessors are willing to take value-laden analysis and make recommendations from the points of view of various interest groups or stakeholder groups, so that they can then say that group A would regard this as a negative impact, whereas group B would find it a positive impact. These ratings are easily quantified . I don't think you would get too much objection from the assessors if evaluations of this type were part of the assessment itself. There would be a big disagreement however, if given all of these individual group analyses, the assessor were asked to recommend what course of action should be pursued. Given that group A would like it, say, plus 10, and group B would not like it by minus 3.5, what should I recommend that society do? I believe that the assessor ought to take a stand here, as well. He should evaluate options and state his choices.

The reason I feel this way is because I went through an assessment that specifically did not do these things. It was an assessment of no-fault insurance. After the assessment, I was called upon, as would be expected, to speak to a number of groups about the results of that assessment. While I could discuss the consequences of the assessment and its significance to various groups, I had to beg off on the issue of recommendations. I was always challenged at that point. Some people even demanded that I take a stand. I felt very uncomfortable having to indicate that I really had made no attempt to evaluate no-fault insurance from a benefits-disadvantages point of view, and was not really in a position to offer such a recommendation. This had the effect of weakening the significance of the assessment results.

Mr. BROWN. You make reference to the postreport phase, which we were discussing with the earlier witnesses regarding the auto engine study conducted at the Jet Propulsion Laboratory at the California Institute of Technology. From your experience you obviously feel that an assessment is not completed when you submit the reports but that there is an ongoing process that should be considered when funding -the assessment or whatever other considerations are given to it, if it is going to have a full utility.

Mr. ENZER. I agree with that. That is something that is difficult to put into place, but I have always felt that perhaps 10 or 15 percent of the resources assigned to an assessment should be earmarked for post-assessment dissemination. I think that the time period between the completion of the assessment and the implementation of policies with regard to that assessment, is not zero. In this time the results of the assessment should be used to elevate the level of public debate. I think one of the key factors achieving general consensus on policies where not everyone can be a winner, is greater public awareness and greater public debate over the consequences. I don't envy the decisionmaker who has to make a choice between a program or a nonprogram, or keeping an airport or closing it, or putting in a powerplant or shutting it down. He knows he is satisfying some interests and not other interests. This process is lubricated by public debate, and one of the most important roles of TA should be to enrich that public debate. That takes time.

Mr. BROWN. I think that is an extremely important point. It needs to be emphasized over and over again, particularly in our own environment in this country where the public decisions generally are the final decisions. It must be as a process of encouraging informed public debate so that we reach decisions that have stability to them. I have frequently felt that people who feel that they can present a series of objective professional judgments or options? shall we say, and then wash their hands of things are missing the key element of the social process that exists in this country. Most of these options, whether we call them TAs or whatever, are *culturally bound, that is* they are enmeshed in the particular background of the individuals making them, whether they think they are objective professional or not. The key to their success is input to a decisionmaking process on a broader basis.

Mr. ENZER. There is an approach that we have used in the past and I think will continue *to* use, that you might say is a form of interdisciplinary analysis, in which we stipulate that there is no such things as objectivity. But we can identify the key biases and then try to reflect these in the assessment by repeating the assessment from the perspectives of the different biases. In other words, saying that the best approach to objectivity is to see each of the biases separately side by side so that the areas of commonality and differences can be highlighted.

Mr. BROWN. There is also this concept of webs of abstraction. You can look at a problem, analyze the biases, see who wins and loses amongst the stakeholders, and all of that is postulated upon a certain framework. Then you move to a higher objective, to a higher or different, shall I say, framework, and the picture becomes completely changed. Some of the winners become losers, and some of the losers become winners. We sometimes are unable to move from one level of abstraction to another in any helpful way, and it makes our policy decisions somewhat limited.

I would enjoy pursuing this further, but" in the interest of time, I think that we had better bring this to a close. If there is a need for you to clarify any aspects of your testimony or to answer additional questions we hope you will respond within the limits of your time and ability.

Mr. ENZER. Be glad to.

Mr. BROWN. Your contribution this morning is appreciated, and is a very valuable input toward helping us to do a more effective job in the TA process in the Congress.

[The following questions were submitted by Congressman Brown to Mr. Enzer and his answers thereto:]

Question 1. Based upon your experience, what is the best way to involve the public in technology assessment (TA) ?

Answer 1. Involving the public in TA has proven to be a difficult task to accomplish. It is obvious that the public has a role to play in the issues involved in TAs. They are the stakeholders and are often immediately impacted by the decisions, but perhaps even more importantly, support for policy recommendations that follow from a TA depend upon public consensus. Thus, as a minimum, the public should be involved in identifying critical areas for an assessment and in discussing the alternatives and the policy recommendations that result from a TA.

To make this process more effective, it would be desirable to promote direct involvement of the public in those aspects of the assessment concerned with structuring the issue and establishing priorities. However, present channels of communication are woefully lacking when applied to this type of interaction. Perhaps the best means of obtaining such inputs is through citizen interest groups, although these may not always be locally available for a particular assessment, and it may not be appropriate to involve remote national citizen organizations. Perhaps the best that can be done at this time is to have the assessment team conduct hearings on the preliminary definition of the issue early in the assessment. These hearings should be less formal than those held here, and should be kept as free of technical considerations as possible to promote general public participation. This will probably encourage the post-assessment discussions since they are apt to be found more relevant to public interests. It may also lead to the development of better means of interaction as the public becomes more aware of the assessment process and the utility TA can serve in protecting their interests.

Question 2. Do you see any relationship between the TA and environmental impact analysis process?

Answer 2. Methodologically speaking, environmental impact analysis is a subset of the TA process. There is considerable commonality between the two activities in that both are concerned with long-term indirect consequences, but since environmental impacts are entirely physical, the nature of the analysis is structured along scientific and economic lines. The difficult issues of psychological, social, and emotional impacts and the degree to which society should intervene in these processes are part of a TA, but rarely come into play in environmental impact analysis.

Question 3. What value do you see in closer relationships with regard to TA between the public and private sectors?

Answer 3. The concept of TA has been adopted by both governmental and industrial organizations. Assessments performed by industrial organizations are generally concerned with new products, the important considerations being the identification and analysis of indirect consequences that can affect the profitability of the new ventures. Governmental assessments tend to pursue broader social goals, and are interested in the complete spectrum of impacts that might affect the various sectors of society.

Notwithstanding these differences, there are two benefits that can result from closer relations with regard to TA between Government and industry. First they can share methods and experiences. Second they can assist each other by serving as advisors to each other in their respective assessments. The two-way nature of these relationships is very important. It is as crucial for Government to be involved in industrial assessments as it is for industry to be involved in governmental assessments, if we are to move closer to an even-handed view of the consequences of change.

A substantial portion of the benefits sought from TA are likely to result from the change in our institutional approach to evaluating technology. The change in approach will be enhanced by the interdisciplinary aspects of the assessment. A two-way relationship between Government and industry in the assessment process will provide those benefits in a most effective, low-key manner.

Question 4. Do you think that technology is the limiting factor in TA? What limits do you see to the utilization and application of the TA concept in Government and in the private sectors?

Answer 4. There are more potential candidates for TA than there are resources available to perform the assessments. A critical need exists for screening these candidates down to that set that is most sorely in need of assessment. There as a potential trap in screening on the basis of importance. The trap is that we tend to focus on the most pressing current problems. The ease with which we can fall into this trap is increased by virtue of the fact that OTA is a congressional service agency, and Congress, of necessity, must spend the major portion of its effort in addressing current needs.

An absolutely essential ingredient for a TA is the ability to maintain an even-handed posture during the interdisciplinary analyses involved in the assessment. Such an even-handed posture is virtually impossible with issues that have been fully tempered by the pressures of urgency. Experts, like other citizens, take stands on current issues and can no longer be counted on to perform the deliberations necessary for effective TAs. Therefore, issues that demand immediate solutions should be addressed via conventional political methods, reserving limited assessment resources for emerging problems.

The current issues trap also leads to a second trap, that of attempting to add insights into issues that have already been "studied to death. " Technology assessment is intended to identify macro-alternatives and to discriminate among the indirect consequences of these alternatives, This task is almost impossible once we have become so immersed in the details of an issue that we no longer can see the forest for the trees. There currently exists a large number of trend monitoring activities that focus on emerging issues. The following table lists a few of these:

Project	*Institution*
Corporate Associates Program	Institute for the Future
Important for the Future	UNITAR
Prospects and Scout Programs	The Futures Group
Trend Analysis Program	Institute of Life Insurance .
Twenty Year Forecast Project	Center for Futures Research--USC

These and similar activities could be a useful starting point for initiating a search for assessment candidates, Part of the OTA function should be to screen these emerging issues to select potential candidates for assessment. By so doing the assessment process will be able to concentrate its limited resources on issues that it is most qualified to address and will thereby be able to make an important contribution to congressional farsightedness.

Question 5. **What role do you see for TA in the decisionmaking, policy, and planning processes in both the Government and in the private sectors? Do you think TA will have a significant impact on the way the private sector does its business?**

Answer 5. As indicated in my response to the previous question, the greatest contribution that TA can make to the decisionmaking process is to increase its foresight. While it is difficult to create good plans, it is easier than trying to redirect poor plans. Once resources and institutions have been mobilized in a specific direction even modest adjustments are difficult.

In addition, we often find many members of society are disenchanted by having been offered too few choices regarding important issues. As the pace of change increases we find that we have less and less time to consider our options. Just as invention is the offspring of necessity, planning is the offspring of early detection. TA will be most effective when there is time for study and time for broad public debate. There is no shortage of issues that have yet to emerge as urgent national problems. These issues should be the focus of TA.

Mr. BROWN. Thank you all very much for being with us.

This hearing is adjourned subject to the call of the Chair.

[The hearing in the above-entitled matter was adjourned at 1:30 p.m.]

APPENDIXES

APPENDIX A, EXHIBIT 1

TECHNOLOGY ASSESSMENT-BELATED ACTIVITIES OF THE BUREAU OF MINES

Technology assessment, as the term is most often used in the Bureau of Mines (BOM), consists of predicting and simulating alternate futures based on contingencies assumed for technological, economic, social, environmental, and other relevant influences. The contingencies and the assumptions for these are identified, quantified, and analyzed through scenarios. These techniques used for the preparation of the scenarios may be described as eclectic because there is considerable flexibility in the use of judgment, experience, and intuition in the forecasting procedure. This method may avoid many of the rigidities of projection by trend extrapolation, such as mechanical curve fitting, or the uncertainties of trend correlation, or econometric procedures where determining or influential variables cannot be precisely identified, quantified, and forecast within a mathematical framework. However, any or all of these techniques may be utilized in developing a specific assessment.

The Bureau has been involved with technology evaluation in one form or another since its establishment in 1910. Proper performance of the Bureau's programs has required that researchers be fully aware of the present state-of-the-art in their technical specialty areas, the directions in which research is advancing, and the needs and impacts of future research. Similarly, each commodity specialist has to be fully informed about the technologies affecting his commodity including exploration technologies for finding it, mining technologies for extracting it, and mineral processing and metallurgical technologies for putting it to use.

The first major assessment effort in modern Bureau history was the Paley Commission study in 1952. This study made a comprehensive effort to forecast supply and demand for mineral commodities. From this base the Bureau developed its publication "Mineral Facts and Problems," which presents a comprehensive assessment data base for 88 mineral commodities. This document, which was first published in 1955, is updated and relined every five years. The most recent edition in 1970, not only presented a thorough assessment of supply-demand factors affecting the commodities through 2000 but also made further refinements of the assessment methodologies. The 1875 edition currently being prepared for publication is about 75 percent complete, The new edition will include forecasts for both 1985 and 2000, and will make predictions of mine production for the first time. There will also be a greater refinement in the probable ranges of supply and demand based on both quantitative and qualitative factors.

Bureau efforts have delineated the current status of worldwide technologies in mining, metallurgy, ceramics, fuels and minerals utilization, minerals recovery and recycling, reclamation of mined lands, and alternate transportation methods for minerals, Other Bureau efforts have forecasted future developments in these technologies and their impact on the mineral economy into the 21st Century to guide government and industry research, legislative and regulatory measures, and national resource development. Still other Bureau efforts have involved assessments of the mineral potential of wilderness, river basin, Indian, park and forest lands, and various special studies. The Bureau's expertise and capability to conduct these assessments represents a unique national resource, and is widely recognized, both in and out of Government.

Some of the studies recently provided to Congress or to other government agencies include:

1. Coal Task Force Study for Project Independence;
2. Petroleum Task Force Study for Project Independence;
3. Critical Minerals Studies for the Council on International Economic Policy;
4. Department of the Interior Minerals Analysis Policy System;
5. Studies on Aluminum, Chromium, Cobalt, Manganese, Iron Ore, Tin, Platinum, Uranium, and Zinc;
6. Mineral evaluations to support implementation of the Eastern Railway System Improvement Plan (ConRail) ;

7. Impact assessment of State Air Quality Requirements on coal supplies; and
8. Impact of proposed Federal Surface Reclamation Legislation on coal and energy supplies.

These and other studies have had considerable impact on the development and implementation of public policy in these areas.

An example of an assessment recently conducted by the BOM is the Critical Minerals Study conducted for the Council on International Economic Policy. The oil embargo initiated in 1973 by the OPEC nations focused high level government attention on the fact that the United States was also dependent on imports for scarce and critical commodities—among these being aluminum, chromium, cobalt, and manganese. After National Security Council attention to the problem, a list of these critical minerals was developed by the Council on International Economic Policy. The Bureau then undertook an assessment of the impact of an embargo or cartel action by nations producing these minerals on the United States economy.

The Bureau's assessment examined the domestic demand and supply for these materials, the possibility of substitution and recycling to meet the demand, and developed supply and demand curves. The impact of new technologies to meet the demands—for example, ocean mining of manganese, or development of the Bureau's process for producing alumina from abundant low grade domestic sources—on these supply and curves was then assessed. The economic impact of various contingencies was estimated, and various policy options were developed along with their costs and benefits. Recommendations for policies with implications outside the Bureau's area of responsibility were made, and the Bureau's internal research priorities were realigned to assure proper attention to the most critical problems.

TA can be a major tool for the management, provision, and assurance of future minerals needs through its use in planning, programming, and decision making. Man is to an increasing degree able to control and determine his environment. With certain limitations, needed technology can be literally programmed and managed into existence. A major portion of the BOM efforts is devoted to precisely this goal. For example, Bureau researchers foreseeing the depletion of the rich iron ore deposits in the Mesabi Range, developed technology for the beneficiating and processing of non-magnetic taconite into useful iron ore. This added substantially to the Nation's reserves of this vital commodity. Other Bureau research has been instrumental in the development of the titanium and zirconium metal industries in which these metals were made into useable products to meet emerging needs. Still other Bureau research has developed processes to remove sulfur from coal prior to combustion and to remove sulfur dioxide from stack gas, allowing abundant high sulfur coal to remain an important energy source without undesirable emission of air pollution. There are many additional examples of the contribution of research at the Bureau of Mines to the solution of problems.

Recognizing that the results of TA could be made even more useful in planning the Bureau's internal programs, the Bureau has recently created the Office of Program Development and Evaluation and its Division of Planning and Evaluation to develop and implement a systematic approach to strategic and tactical planning for the BOM. The Division has already developed a draft strategic and tactical plan for programs at the BOM in the 1978-1981 period. It is also developing a program planning system design to integrate the Bureau's ongoing planning and programming systems into a Bureau-wide, long-range system to better assure that the major problems confronting the Bureau and the Nation's mineral industries are effectively being addressed.

The planning methodology being developed will utilize the concepts of technology forecasting to identify and define the problems confronting the BOM, set objectives for solving those problems, develop alternative strategies for reaching the objectives, analyze the strategies in terms of their costs, risks, and benefits, set priorities, and select the most promising strategies for implementation. Programs will then be developed for implementing the selected strategies, and tactical plans involving all Bureau organizations will be developed. The Bureau's budget request will be a natural product of the planning process, and decisions made by the Department of the Interior, the Office of Management and Budget, and the Congress, will be factored into the planning process as constraints. Ongoing programs of the Bureau will be evaluated for their effectiveness and efficiency in achieving the objectives specified by the strategic and tactical plan, and appropriate modifications to the funding, staffing, organization, and emphasis of the programs will be made. The results of these evaluations will be factored back into the system to guide future planning.

The Strategic and Tactical Plan will be updated annually to reflect changing conditions, progress, and problems. It should significantly improve the Bureau's capabilities to effectively, efficiently, and creatively address the difficult problems confronting the Nation's minerals-producing and consuming industries in future years.

Although the Bureau has yet to produce a study with technology assessment in its title, the Bureau has demonstrated its capacity to conduct such studies. It appears likely that the Bureau will participate in TAs conducted by other agencies such as the Congressional Office of Technology Assessment. Our participation in these studies would be to furnish both the crucial analytical data and the experts needed to interpret and to present the results of these studies. The Bureau is looking forward to such participation.

TECHNOLOGY ASSESSMENT-RELATED ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey (USGS) gathers and interprets earth science and cartographic information supporting a broad range of technical resource planning and development activities *in* the United States and throughout the world. These information products form a necessary basis and *a* data source for technology assessment (TA).

The study and location of minerals and fuels to support the Nation's technology is the Geological Survey's special responsibility. Resource analysis and the development of geological data banks permit the storage, retrieval, and processing of large amounts of information to model the complex interactions of geology and economics, and their impacts on mineral and fuel supply and demand. One product of the information systems provided the Office of Technology Assessment (OTA) all of the background material for the mineral assessment of Federal lands. The Survey's Geologic Division also provides geologic information describing the geologic benefits and hazards involved in the siting of major or special structures such as nuclear reactors, pipelines, buildings, or entire communities. Planning, siting, and building activities utilize topographic maps, orthophotomaps, and other cartographic tools principally developed and published by the Topographic Division.

The Water Resources Division studies and assesses the Nation's water resources for the purpose of planning, policy, and decisionmaking. Assessments made of the quantity and quality of water in the Nation's streams provide information on water development and hazards, and a data base for the design of water supply and control systems. Special assessments are made that relate to specific national issues such as environment, energy, food and fiber, and floods.

The Conservation Division, in support of its mineral lease development activity on public lands, classifies and evaluates the land for its mineral and waterpower potential, provides mineral evaluations of lands offered for leasing, and supervises the activities of industry on Federal leases in order to protect the public interest in these lands.

The Land Information and Analysis (LIA) Office provides scientific and engineering data developed by the USGS and the Department of the Interior (DOI). It is appropriate and readily understandable language and supports land use, land resources, and related environmental planning and decisionmaking at all levels of government and in the private sector. This is part of the TA of those activities of man that are related to natural and earth science. The major functions of LIA provide support for land resources planning and management through: (1) development and application of natural science and geographic technology; (2) mapping current land use; (3) collecting, processing, and distributing remotely sensed data, and applying other aspects of space technology; and (4) activities in the preparation of environmental impact statements (EIS) in accomplishing USGS responsibilities directly related to the requirements of the National Environmental Policy Act (NEPA). The environmental impact statements provide essential inputs to decisions by the Secretary of the Interior on leasing, mineral exploration and development, and plant construction directly related to energy and critical minerals.

The preparation of environmental impact statements by the USGS, and assistance to other agencies in their preparation, is under the direction of the Environmental Impact Analysis Program of LIA. These activities draw upon the expertise in the various fields of science of all of the Divisions of the USGS as well as from other bureaus of the DOI and from other Federal agencies.

The table below lists activity in environmental impact statement preparation in the 1976 fiscal year, where the USGS was either the lead Bureau or shared the lead with another DOI bureau.

Fiscal Year 1976131fl Preparation (Survey-Lead or Joint-Lead)

COMPLETED EIS

1. Oil and gas development in the Santa Barbara Channel Outer Continental Shelf (OCS), off California. Final environmental statement filed with the Council on Environmental Quality (CEQ), March 1976.
2. Proposed plan of mining and reclamation, Belle Ayr South coal mine, Amax Coal Company, Wyoming. Final environmental statement (FES) filed with CEQ November 1975. This FES was a basis for the Secretary's decision (November 11, 1975) to continue surface mining.
3. Proposed surface management of federally owned coal resources (43 CFR, Part 3041) and coal-mining operating regulations (30CFR, Part 211). Final environmental statement tiled with CEQ March 1976 (joint lead with the Bureau of Labor Management (BLM)).
4. Proposed development of phosphate resources in Southeastern Idaho. Draft environmental statement filed with CEQ April 1976.
5. Proposed plan of mining and reclamation, Cordero coal mine, Sun Oil Company, Wyoming. Final environmental statement filed with CEQ April 1976.
6. Geological and geophysical regulations on the OCS. Final environmental statement tiled with CEQ April 1976.

CURRENTLY ACTIVE EIS

Draft Environmental Impact Statements (DEIS)

1. Proposed plan of mining and reclamation, Bear Creek uranium mine, Rocky Mountain Energy Company, Wyoming. (Joint lead with the Nuclear Regulatory Commission (NRC) and Forest Service (FS).)
2. Proposed plan of mining and reclamation, Coal Creek mine, Atlantic Richfield Company (ARCO), Wyoming.
3. Proposed plan of mining and reclamation, Caballo coal mine, Carter Oil Company, Wyoming.
4. Proposed plan of mining and reclamation, Decker coal mine, Decker Coal Company, Montana. (Joint EIS with State of Montana.)
5. Proposed plan of mining and reclamation, East Gillette coal mine, Kerr-McGee Coal Company, Wyoming.
6. Proposed plan of mining and reclamation, North Gillette mine, Amax Coal Company, Wyoming.
7. Proposed plan of mining and reclamation, Rochelle coal mine, Peabody Coal Company, Wyoming.
8. Proposed plan of mining and reclamation, Westmoreland coal mine, Shell Oil Company, Crow Indian Reservation, Montana. (Joint EIS with the Bureau of Indian Affairs (BIA).)

DEFERRED EIS

1 Glen Canyon (Fireflood project), Glen Canyon National Recreation Area. Utah. Awaiting DOI decision on legality and status of project.
2. Proposed plan of mining and reclamation, Youngs Creek coal mine, Crow Indians-Shell joint venture, Montana. Awaiting resolution of Crow Indian lawsuit.

IMMINENT EIS

1. Proposed Federal coal leasing, and proposed plans of mining and reclamation, Regional Environmental Statement, Central Utah.
2. Proposed Federal coal leasing, and proposed plans of mining and reclamation, Regional Environmental Statement, Powder River coal basin, Montana.
3. Proposed Federal coal leasing, and proposed plans of mining and reclamation, Regional Environmental Statement, Hanna basin, Carbon County, Wyoming.

DRAFT ENVIRONMENTAL IMPACT STATEMENT ON IDAHO PHOSPHATE MINING

Preparation of environmental impact statements is the major technology assessment activity of the USGS. The recently released Draft Environmental Impact Statement on the Development of Phosphate Resources in Southeastern Idaho, is an example of current activities. The draft statement was prepared by a Federal interagency task force under the leadership of the USGS with major inputs from the U.S. Forest Service and the Bureau of Land Management. Other Federal agencies providing consultation and/or contribution to the preparation of this statement include the following:

U.S. Fish and Wildlife Service.
Bureau of Outdoor Recreation.
Bureau of Mines.
Environmental Protection Agency.
National Oceanic and Atmospheric Administration.
Mining Enforcement and Safety Administration.

Data, information, and/or other assistance were obtained from the following State agencies:

Idaho Department of Health and Welfare, Division of Environment.
Idaho Fish and Game Department.
Idaho Department of Water Resources.
Idaho Bureau of Mines and Geology.
Idaho Department of Transportation, Division of Highways.
Idaho Department of Agriculture.
Idaho Department of Parks and Recreation.
Idaho Department of Lands.
Idaho Bureau of State Planning and Community Affairs.
Idaho Water Administration Board.
Idaho State Archeologist.
Idaho State Historic Preservation Officer.

Additional participation and assistance were obtained from many sources. The eight companies proposing mining provided data and information on their proposed activities. The Union Pacific Railroad provided, for task-force consideration, much assistance on transportation facilities for ore haulage; the Utah Power and Light Company and the Idaho Power Company did likewise on utility systems. Officials and employees of local and county governments and the Southeastern Idaho Council of Governments also provided data and assistance. Comments of residents of the area, environmentalists, and others were also helpful to the task force in the preparation of the statement. Input to the draft statement in areas where expertise within government was limited, was provided by contract: study of air quality impact was made by North American Weather Consultants, Inc.: Socio-economic impact studies were made by the Southeastern Idaho Council of State Governments; and a study of the archeologic impacts was made by Professor Butler, Idaho State University.

The regional analysis covers potential operations on proposed and potential mining and processing of Federally-owned phosphate deposits in six counties in southeastern Idaho. The phosphate deposits represent 35 percent of total U.S. reserves which are 14 percent of world reserves.

The draft statement provides analyses of the broad cumulative impacts of existing and proposed phosphate resource development—including both mines and processing plants as well as related facilities. The description includes the proposed activities that require Federal action; the environmental impacts, mitigating measures, unavoidable adverse environmental effects, short-term use versus long-term productivity, and commitment of alternatives such as denying, modifying, or postponing development of the Federal phosphate resources.

The summary of the environmental impacts listed in the statement are:

1. Land surface will be altered by pits and dumps, soils and vegetation will be removed from the mining and associated areas, wildlife habitat and populations reduced, and water quality lowered.

2. Ambient air quality will be lowered, particularly in the vicinity of processing plants.

3. Livestock forage will be reduced during mining operations, and productivity of the mining area will he reduced even after reclamation.

4. Population and employment in the region will increase and the socioeconomic infrastructure will be under stress.

5. Recreational resources will be reduced, unknown archeologic values may be destroyed, and esthetic aspects will change.

TECHNOLOGY ASSESSMENT RELATED ACTIVITIES

OFFICE OF BIOLOGICAL SERVICES

The Fish and Wildlife Service has a broad range of activities related to TA. A prime example of these activities is the Office of Biological Services (OBS) with major projects concentrating on the assessment of energy resource development technology with respect to its impact on fish and wildlife habitat. Biological Services projects involved in this effort are in the areas of coal conversion and extraction, oil shale development, western water allocation, geothermal development, outer continental shelf and coastal ecosystems development, and stream alterations and power plant siting.

Continuing technology assessment (TA) of energy development methods is essential to obtain the best scientific information on resultant environmental impact, Relevant information must then be incorporated in planning and decisionmaking processes so that damaging ecological effects of mining, oil production, stream and coastal alterations, urban development and other major changes to the landscape can be minimized.

Elements of TA are involved in the following OBS projects.

1. Coal Project: In this project, research effort is focused on the impact on fish and wildlife habitats of surface mining operations in the Great Plains, Southwest and Appalachian regions. TA of coal extraction and conversion processes is inherent in research on methodologies for surveying and characterizing ecosystems by key variables so that important habitat areas can be readily identified and protected under Federal leases.

2. Oil Shale Project: A mature oil shale industry would affect the environment substantially by the generation of millions of tons of waste shale in the mining process. Consequently the project's emphasis is being placed on evaluating the environmental costs of oil shale development based on present prototype operations. TA is required for methods of dealing effectively with the residues, including contouring. compacting and revegetating to rehabilitate fish and wildlife habitats.

3. Western Water Allocation Project: Water use requirements and waste water disposal for future coal and oil shale operations will greatly tax limited supplies of water in the western United States. This project is assessing and developing scientific information related to stream flow requirements for maintaining fish and wildlife resources. Input is needed for decisionmaking on water allocation and disposal at State and Federal levels.

4. Geothermal Projects: This project involves the assessment of the ecological impact of geothermal electric generating plants to be located on Federal and private lands in the West. The information obtained is being incorporated into lease stipulations and management plans in order to protect specific fish and wildlife habitats.

5. Coastal Ecosystems and Outer Continental Shelf Development Projects: The activities of these two projects are closely related by virtue of the growing importance of accelerated offshore oil and gas development and its effect on the nation's coastal systems. Methods for characterization of coastal areas will be utilized for protection of fish and wildlife resources from the impact of oil and gas development and other forms of coastal alterations. Participation with the Bureau of Land Management in an environmental baseline data program aids in the selection of new offshore leasing sites. The full range of coastal impacts including exploration, drilling, transportation, storage, processing, and facilities support must be considered. TA throughout this range is required to determine what protective measures are needed for marine and estuarine biotic resources.

6. Power Plants Project: Approximately 350 major electric power plants are expected to be built in the United States during the next decade. This project's research efforts are concentrated on minimizing losses of aquatic life in streams, lakes and other water bodies used for cooling purposes in steam electric plants. Means of locating transmission corridors in order to minimize habitat disturbance are also being studied. TA of methods for accomplishing these objectives is required.

7. Stream Alteration Project: The effort in this project involves the environmental impacts of stream and river alterations associated with land and water development activities. Various studies are being conducted to assess the effects of channelization and dredging on different types of fish and wildlife habitats and to develop mitigation procedures. A major research study is a TA devoted to determining the ecological effects of the large-scale removal of gravel from streams for the Alaska pipeline bed and associated roadbeds.

TECHNOLOGY ASSESSMENT RELATED ACTIVITIES

BUREAU OF LAND MANAGEMENT

The Bureau of Land Management's daily management activities and permitting and leasing functions require that it use technology assessment (TA) techniques in order to properly protect the public lands from undue Or unacceptable harm, and to make decisions which are in the public interest. This need is being met on a day-to-day basis through the Bureau's land-use planning system and environmental review procedures. The land-use planning system utilizes procedures that identify and generally evaluate the impacts, both beneficial and detrimental, of potential uses of given areas of the public lands. This evaluation is used to determine how to optimize the values present. Once the determination is made, the land-use planning process allows for constant updating through TA along with other studies and evaluations to ensure that this use or combination of uses is still the most appropriate.

Some specific examples of the use of TA in Bureau of Land Management programs are:

1. Energy Minerals Activity Recommendation System (EMARS) : This system was developed to determine where, when, and how much coal should be offered to meet the Nation's need for energy development. It allows the Bureau to evaluate the effects that energy mineral leasing will have on the environment in the area of such development. It uses the land-use planning system and input from industry, State and local governments, and the general public in the TA of an energy mineral development. When all of the impacts have been examined, a proper decision on whether Federal coal should be leased can be then made.

2. Outer Continental Shelf Leasing Program : The TA function of the Bureau of Land Management's Outer Continental Shelf (OCS) mineral leasing program involves analysis of environmental impacts associated with offshore oil and gas operations. This analysis is, to a large extent, based on an understanding of the technical state-of-the-art for conducting such operations, including exploration, development, production, and transportation.

Each OCS environmental impact statement contains in a separate appendix. a description of offshore oil and gas operations and includes a discussion of state-of-the-art technology. One of the basic assumptions regarding the causes of offshore environmental impacts from oil and gas operations relates to impacts resulting from day-to-day operations under existing operating practices, regulations, economics and technology in all phases of the operation. These basic assumptions are followed by a discussion of specific impacts so that in effect, the state-of-the-art technology forms a base from which specific impacts can be assessed.

In addition to offshore oil and gas operations, the Bureau of Land Management has prepared proposed operating and leasing regulations, and published a draft environmental impact statement for hard-mineral leasing on the OCS. The draft environmental impact statement contains a discussion of state-of-the-art technology for OCS mining, including exploration. mining, transportation, and processing.

3. National System of Transportation and Utility Corridors Study : This study made an assessment of the necessity and desirability of establishing a national system of transportation and utility corridors. Five major systems were examined. The study and the TA inherent in it revealed that in order to minimize ecological and environmental impacts and the proliferation of rights-of-way on Federal lands, while at the same time developing and distributing much-needed new energy sources, a certain degree of flexibility will he needed when planning for corridors. Conclusions were based on a variety of considerations and impacts including, among others, safety and reliability, social and economic impacts, and land use and environmental impacts.

TECHNOLOGY ASSESSMENT-RELATED ACTIVITIES OF THE BUREAU OF RECLAMATION

The Bureau of Reclamation (BOR) has been involved in the technology of water and related resources development in the Western United States for over 70 years. The technology employed in this development includes the planning, construction and operation of dams, canals, tunnels, pipelines, powerhouses, pumping plants, transmission lines, and other related activities.

In 1974 (the last year of accumulated record) projects of the Bureau of Reclamation included 301 storage dams and dikes capable of storing 138 million acre-feet of water, 361 canals having a total length of almost 7,000 miles, 164 tunnels totaling over 220 miles in length, 795 miles of ‘pipelines, 139 diversion dams, 50 powerplants with an installed capacity of over 8 million kilowatts, 127 pumping plants capable of over 2 million horsepower of lift, and 16,230 miles of transmission lines.

The impacts on the physical, social, environmental and economic setting of the United States in general and of the Western United States in particular resulting from these BOR accomplishments have been significant. One only has to visualize the Central Valley of California or the Columbia Basin Project area of Washington without dependable water supplies to realize the impact of such projects. To be sure, there have been trade-offs in terms of adverse and beneficial effects, but where services to meet the needs of people are concerned, the positive accomplishments and impacts have been momentous. Reclamation projects now produce enough food to satisfy the needs of nearly 33 million people.

The planning, construction, and operational phases of water and related land resources development are based on a technology and expertise that has changed with time in terms of sophistication and changing emphasis in meeting current needs. Generally, the project developed entails an evaluation, selection and justification process that addresses in great detail, during the project-by-project investigation stages, estimates of physical, socio-economic, and environmental impacts both beneficial and detrimental and including direct and indirect effects. Congress then authorizes such projects individually for construction and operation. While not formally technology assessments, our evaluations incorporate many elements of such assessments.

The following summary sheets concern a potential water resources development project, the Uintah Unit of the Central Utah Project, located in the Upper Colorado River Basin. This is currently in the process of being reported on to the Congress following detailed feasibility investigations. It is presented here as an example of a **TA of a typical multipurpose public works water and related land resource development project. It is typical of those projects that over the years have produced the technological accomplishments previously enumerated for 1974. This project proposal currently awaits Congressional action regarding its authorization for construction. The summary is supported by a detailed feasibility report and associated appendixes. The final environmental impact statement is scheduled for September 1977, while the draft is scheduled for January 1977.**

SUMMARY SHEETS

UINTAH UNIT, CENTRAL UTAH PROJECT (RECOMMENDED PLAN)

LOCATION

Duchesne and Uintah Counties, northeastern Utah, in the Uinta Basin of the Upper Colorado River Basin.

PLAN

The Uintah Unit would develop flows of the Uinta and Whiterocks Rivers for the irrigation of Indian and non-Indian land, municipal and industrial use, recreation, and fish and wildlife purposes. Flood control also would be provided.

Irrigation water would be made available from the storage regulation of surplus flows of the Uinta and Whiterocks Rivers, the saving of excessive seepage losses through rehabilitation of existing canals, and the increased use of return flows. Storage regulation would be provided in the Uinta Reservoir on the Uinta River within the Uintah and Ouray Indian Reservations, and in the Whiterocks Reservoir on the Whiterocks River within the Ashley National Forest. Irrigation supplies would be released from both reservoirs to the stream , channels below and distributed through new and existing canal systems. Municipal and industrial water would be made available from the project storage for use in the vicinity of Roosevelt, Utah. Treatment and distribution of the water would be the responsibility of the water users.

Part of the storage in the Uinta and Whiterocks Reservoirs would replace the irrigation storage presently provided in 13 upstream mountain reservoirs within the Ashley National Forest. Twelve of the reservoirs would be rehabilitated and stabilized as fishery lakes and part of the capacity of the other reservoir would be maintained as an inactive fishery pool. Minimum pools for fish would be provided in the project's Uinta and Whiterocks Reservoirs and minimum flows for fish would be provided in the rivers below the project reservoirs and in the Powerhouse Canal. Some range lands in the Uintah and Ouray Indian Reservations would be rehabilitated to mitigate losses to big game resulting from inundation by the Uinta Reservoir. Recreational facilities would be provided at the Uinta and Whiterocks Reservoirs and at the upstream reservoirs.

Water Supply (average annual acre-feet)

Project water supply:	
Irrigation water at canal heads:	
Storage supply	42,700
Savings of canal losses	4,700
Usable return flow	4,600
Total	52,000
Municipal and industrial water	1,000
Effects on Colorado River:	
Stream depletion	30,300
Increase in salinity concentration at Imperial Dam (mg/1):	
From pickup of salt load	1.5
From stream depletion	3.1

IRRIGATION SERVICE AREA (ACRES)

	Water right acreage	Land ownerships
Supplemental service lands:		
Indian	34,152	25,152
Non-Indian	11,000	20,000
Subtotal	45,152	45,152
Full service lands: Indian	7,818	7,818
Total	52,970	52,970

[1] Land ownerships differ from water-rights acreages because of ownership transfers after water-rights were granted.

PROJECT FEATURES

	Uinta	Whiterocks
Reservoirs:		
Capacity (acre-feet):		
Active	35,030	26,020
Inactive and dead	12,000	6,000
Total	47,030	32,020
Surcharge	10,220	3,460
Normal water surface area (acres)	736	400
Dams:		
Height (feet)	226	218
Crest length (feet)	3,550	1,550
Volume (cubic yards)	7,100,000	6,160,000

Project costs (January 1975 prices)

Construction costs:	
Uinta Dam and Reservoir	$36,505,000
Whiterocks Dam and Reservoir	33,807,000
Canal rehabilitation	3,258,000
Laterals	1,932,000
Operating facility*	18,000
Other project costs	80,000
Recreational facilities	2,487,000
Modification of upstream reservoirs	170,000
Powerhouse Canal modifications	55,000
Treatment of big game range	10,000
Total	78,322,000
Average annual operation, maintenance, and replacement costs (1972-74 prices)	38,000

BENEFIT-COST ANALYSIS

(100-yr period at 3.25-percent interest)

	Direct benefits	Indirect and public benefits	Total benefits
Average annual benefits:			
irrigation	$1,892,000	$458,000	$2,350,000
Municipal and industrial water	150,000		150,000
Recreation	1,113,000		1,113,000
Fish and wildlife	234,200		234,200
Flood control	33,000		33,000
Employment opportunities for Ute Indians	60,000		60,000
Total	3,482,200	458,000	3,940,200
Average annual equivalent costs..			2,954,000
Benefit-cost ratio			1.3:

COST ALLOCATIONS AND REPAYMENT

(Unit--$1,000)

	Construction Costs	Annual operation, maintenance, and replacement costs
Cost allocations:		
Reimbursable costs:		
litigation	58,784	35
Municipal and industrial water	1,165	1
Subtotal	59,949	36
Nonreimbursable costs:		
Recreation	8,437	
Fish and wildlife:		
Enhancement	6,328	
Mitigation	2,877	
Flood control		2
Subtotal	18,373	2
Total	78,322	38
Repayment of reimbursable costs:		
irrigation (50-yr period):		
Prepayment [1]	245	
Irrigators:		
Indians [2]	5,856	24
Non-Indians	2,194	11
Apportioned revenues of Colorado River storage project	49,838	
Subtotal	58,784	35
Municipal and industrial water (40-yr period--4.371 percent):		
Prepayment [1]	5	1
Water users	1,160	
Subtotal	[3] 1,165	1
Total	59,949	36

[1] Expnditures for investigations from nonreimbursable Colorado River development fund.

[2] Inians' payments toward construction costs would be deferred as long as lands remain in Indian ownership.

[3] In addition to costs shown, municipal and industrial water users would pay $156,000 in interest during construction on the basis of 4.371-percent interest rate.

APPENDIX A-EXHIBIT 2

PROCEEDINGS OF THE SYMPOSIUM

ENVIRONMENTAL IMPACT OF NITRILE BARRIER CONTAINERS

LOPAC®: A case study

July 19, 1973

Sponsored by Monsanto Company with the cooperation of the University Research Institute of Connecticut at the Seminar Hall of Rensselaer polytechnic Institute at Hartford, Connecticut

A complete copy of the above report is available from: Monsanto Company. 800 North Lindberg Boulevard, St. Louis, Mo. 63166.

77-495 0- 77 - 16

APPENDIX A – EXHIBIT 3

A CASE STUDY OF TECHNOLOGY ASSESSMENT IN INDUSTRY*

F. D. Wharton, Jr.
Manager
Environmental Affairs
Container Business Group
Monsanto Commercial Products Co.

&

J. K. Craver
Manager. Futures Research
Corporate Plans
Monsanto Company

ABSTRACT

Technology Assessment techniques were employed to identify environmental, legislative and consumerism issues that might result as a consequence of the introduction of a polymeric beverage container. The assessment followed classical lines involving cress-impact and Delphi procedures. Additionally, panels of individuals chosen for their sensitivity to the issues involved were employed to identify specific events of possible concern. The events so identified became part of the cross-impact matrix.

As a consequence of these exercises, environmental and consumer safety criteria were established and meeting these became an integral part of the development program for the container. Internal studies were augmented by fifty investigations conducted at Independent research institutions and by academicians.

The possibility of adverse legislation or administrative action by regulatory bodies was dentified and a program was devised to communicate the environmental and consumer safety advantages of the Lopac® container to selected individuals who could be involved in such actions.

This presentation details the Technology Assessment techniques employed, discusses the studies undertaken as a consequence of the assessment and enumerates some of the actions taken to meet the criteria which were establishcd as a result of the Technology Assessment. The program devised to externalize these efforts and their results, with emphasis on communication with legislators and environmental organizations, will be discussed.

INTRODUCTION

Ted Mock is credited with the profound observation that "Technology Assessment may be the answer to Murphy's Law--'that whatever can go wrong, will go wrong.'" He further defined Technology Assessment as "the systematic study of the effects on society that may occur when a technology is introduced, extended or modified, with special emphasis on impacts that were unintended or delayed."

This description accurately describes the case history I will present today. A new technology was under development -- a polymeric beverage bottle. A significant amount of corporate resources, both capital and personnel were devoted to this effort. Technical success

● Presented at the International Conference on Technology Assessment, Monaco. October 27, 1975.

A complete copy of the above report is available from: Monsanto Company, 800 North Lindberg Boulevard, St. Louis. Mo. 63166.

APPENDIX A – EXHIBIT 4

A PRACTICAL METHOD FOR TECHNOLOGY ASSESSMENT

PRESENTED AT THE

FIRST INTERNATIONAL CONGRESS ON TECHNOLOGY ASSESSMENT

MAY 27 JUNE 2, 1973

THE HAGUE, THE NETHERLANDS

BY

J, KENNETH CRAVER

MONSANTO COMPANY

ST, LOUIS, MISSOURI

A complete copy of the above report is available from: Monsanto Company, 800 North Lindberg Boulevard, St. Louis. Mo. 63166.

APPENDIX n – EXHIBIT 1

المؤتمر العربي الثاني للبتروكيماويات
أبوظبي (إتحاد الإمارات العربية)
١٥ - ٢٢ مارس
نظم بواسطة
جامعة الدول العربية وهيئة التنمية الصناعية
للدول العربية

Secon Arab Conference on Petrochemicals
Abu Dhabi (United Arab Emirates)
15 to 22 March 1976
Organized by
The League of Arab States
and
The Industrial Development Center
for Arab States

Single Cell Protein: Its Status and Future Implications in World Food Supply

by

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Dr. Donald O. Hitzman[2]
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Mr. Ned L. Case[4]
Mr. Harold M. Hawkins[5]

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(2) Senior Microbiologist, Phillips Petroleum Company
(3) Senior Microbiologist, Phillips Petroleum Company
(4) Chief Agronomist, Phillips Petroleum Company
(5) Senior Process Engineer (deceased), Phillips Petroleum Company

FIGURE 11
Single cell protein (yeast) "budding" and dividing. Approximately 15,000 times magnification using electron scanning microscope. (Phillips-Provesta)

FOREWORD

The moat critical single factor in world food supply is protein, vital to human diet. Many nations cannot produce or import enough for their minimum needs. Others face serious shortages and prohibitive costs. Today millions suffer protein malnutrition. Tomorrow, as populations rise geometrically the problem will grow far worse, unless vast new protein sources emerge. Some time ago the Food and Agricultural Organisation of the United Nations predicted an annual protein deficit of 10 million tons by 1980, rising to 22 million tons by the year 2000. Other world estimates suggest even greater shortages.

odem man still uses primitive man's circuitous, grossly inefficient path to producing protein. Fields are tilled, seed sown, prayers addressed for rain and sun, and crops grown, first ravaged by insects, birds and forces of nature. What remains is harvested. Animals are fed the grain, then slaughtered. Finally, a fraction of their carcasses reaches the ultimate customer - man.

Single cell protein (SCP) is a giant' stride forward in simplifying and improving the efficiency of this protein food chain. Groins and meals convert to meat on the table at extremely low "total energy cycle" efficiencies. SCP converts at magnitudes greater, A cow weighing 1,000 pounds creates perhaps 1 pound of effective protein or less per day. In contrast, 1,000 pounds of SCP can produce 100,000 pounds of protein or more per day. And by using SCP instead of grain in animal feeds (later also for direct human consumption) there will be an important "domino effect" because by such means the world would release, for direct human use, vast amounts of grain and legumes now fed to animals.

Through many years of research and development by Phillips Petroleum Company, Provesta Corporation's parent company, using private capital and without government financial support, Phillips-Provesta have developed advanced propriety technologies for highly efficient manufacture of SCP. Commercialization of these technologies would be well suited to the situations of many countries, and especially so in the environments of Arab and other nations having large hydrocarbon energy resources. The processes involved employ various proprietary organisms and various "substrates" or sources of energy for growth of the SCP. The optimum ones employ alcohols such as derived from hydrocarbon gases, preferably methanol.

This paper reviews the nature of SCP and the technologies of Phillips-Provesta for SCP manufacture.

#####

Protein — an Overview

Millions of words have been written and thousands of speeches made on the world protein shortage, present and future, its dimensions, nutritional effects, and societal and political implications. Words have little caloric value and, except for creating greater awareness, have thus far had little effect on programming adequate future increase in world protein supply. This paper will not attempt to review the many and varying statistics, predictions and recommendations that have been made on the subject. Briefly and broadly they condense to these:

– Many people in many countries get inadequate protein in their daily diets for good nutrition. (Figure 1) The degree of inadequacy correlates roughly, as one might expect, with average annual per capita income.

– The areas of poorest protein nutrition are often also those having the highest birth rat-es, accompanied by lowest per capita income (Figure 2). This means that regardless of how cheaply any present or new form of protein could be produced, such populations will still have great difficulty in buying it until such time as their incomes rise, or unless they receive price supports in the interim.

– Reserves of world food to meet emergencies have dropped steadily over the past two decades (Figure 3). They are now gravely inadequate to provide for even a short major discontinuity let alone a sustained one in current food production. This makes it urgent that major new sources of protein be put into manufacture soon. In the words of the Protein Advisory Group of United Nations (Attachment A):

"We are thus challenged today with an unprecedented convergence of circumstances:

"a) immediate and increasing worldwide demand for protein;

"b) immediate demand for industry as well as agriculture to produce new forms of proteins, including single cell proteins, utilizing available technologies;

"c) immediate demands for many governments to evolve objective regulations controlling the quality and safety of novel protein sources, such regulations to be capable of harmonization at the international level to the greatest possible extent; and

'cd) an almost equally immediate demand to allow unrestricted and unimpeded international export and import of such products, which will require international similarity of national regulations. "

– One of the main reasons for this critical state of affairs – other than the obvious reason that world populations are growing drastically – is that modem man still uses primitive man's circuitous and grossly inefficient path to producing protein (Figure 4). Man tends the fields, sows the seed, nurtures its growth, praying for rain and sun, fighting the ravages of insects, birds, and forces of nature. He then harvests most of what remain%

then feeds much of it to animals to nurture their growth. He then slaughters the animals, discards much of their body weight, cooks the fraction remaining, accepts its large shrinkage, and finally eats what's left.

– In recent years a major improvement has come into being, and is destined to grow dramatically, that offers a protein production "chain" of somewhat improved efficiency. This is the technology of extracting nutritious protein from oil seeds such as soybean and, circumventing the feeding of animals, bringing the concentrated protein directly into human diet. While this is a significant improvement in the efficiency of the "chain" it is still weak and complex, having many of the same uncertainties and limitations of the crop-to-animals-to- humans chain.

– In comparison, the "chain" for certain more recent ways of producing protein is far simpler and more efficient. One is single cell protein, called "SCP", the subject of this paper. As seen in Figure 4 it compresses the other "chains" to an almost irreducible minimum.

Quality and "True Price" of SCP
Compared to Conventional Proteins

As seen in Table I among all current known sources of protein that can conceivably be used as food, SCP's rank highest in total or "crude" protein content. Milk contains roughly only about 4 per cent crude protein, chicken, beef and other meats about 19, eggs 13 and beans 22. In contrast, SCP's can contain from about 55% (yeast) to 80% (bacteria).

However, as also shown in Table 1, crude protein is not the final measure of protein quality. Only part of such crude protein is nutritively digestible. This "utilizable" percentage varies greatly between proteins from different sources. In this respect, SCP ranks well with meat, poultry, cheese, and ranks above most grains, nuts and legumes.

To the consumer, however, "utilizable" protein is still not the final "value" criterion. For him, one must, as in Table II, divide the cost per pound of the product purchased (whole egg, meat, etc.) by the percentage of utilizable protein therein. This gives the "true cost" of the protein to the consumer. On this basis SCP's rank best among all proteins. If, for example, chicken is being sold to consumers at 68¢/lb it "truly" costs about $4.68 per pound when corrected for amount of utilizable protein present. Beef at $1.50 per pound has a "true" cost of $7.50 per pound. In comparison, SCP's would be less than $1.00.

One of the main aspects of proteins that affect their nutritive quality is amino acid content. Here, as will be shown later, SCP ranks high against soymeal and fishmeal and favorably against the "standards" (FAO and egg) used by nutritionists to measure human food quality.

SCP Productivity

The productivity potential for SCP is so great compared to conventional protein that it staggers the imagination. One SCP plant making 100,000 tons per year can produce about as much protein as that which could be extracted from 120,000 hectares (300,000 acres) of soybeans, or as much beef (cattle) as could be grown on 2 million hectares (5 million acres) of grazing land having substantial grass or other forage such as in the U.S.

TABLE 1

"CRUDE" VS. "UTILIZABLE" PROTEIN

CRUDE		UTILIZABLE	
SCP – BACTERIAL	80%	EGGS	94%
SCP – YEAST	55	MILK	82
SOY FLOUR	42	FISH	80
MEAT, FISH, CHEESE	20– 35	SCP, CHEESE	70
GRAINS	8 – 14	MEAT	65
EGGS	13	SOY FLOUR	62
MILK	4	GRAINS	50-70

TABLE 11

"TRUE COST" OF UTILIZABLE PROTEIN
(U.S. Prices at Time of Comparison)

FRANKFURTERS	$10.00
MEAT	7,50
CHICKEN, FISH, EGGS	4.75
CHEESE, RICE	4.25
MILK	2.60
SCP, SOYMEAL, FISHMEAL	<1.00

Let us assume that all of the gas presently "flared" and thereby wasted in one Middle East country became the basic energy source for making alcohol, which could then act as a feedstock for growing SCP. Certainly, this is a hypothetical case because the country involved is fully aware of the value of the gas and has plans for its use in future petrochemical production. Nevertheless, and simply for illustration, if all of this flared gas were to be used for making SCP, it could produce 12,000,000 tons/year SCP or about as much protein as might. be extracted from about 14.4 million hectares (36 million acres) of soybeans, or 240 million hectares (600 million acres) of good-forage cattle grazing land. At such time as SCP may become approved for direct human consumption this output could theoretically bring the daily diets, 365 days a year, of over 500 million people to an acceptable level for good protein nutrition,

# # # # #

The Nature of SCP and processes for Making It

SCP (single cell protein) refers to many microorganisms rich in protein that can be bred rapidly when "fed" various nutritive energy (substrates). Some prefer one substrate, others another, SCP as discussed herein refers to those that prefer hydrocarbon and/or hydrocarbon-derived feedstocks such as alcohols, e.g., methanol. Many bacteria and yeasts (SCP) have been discovered by us that use alcohols for growth, Those used commercially would depend on plant design factors, locale and target markets. The final SCP products are whole or extracted parts of the cells. The SCP's also contain other valuable nutrients – fats, carbohydrates, vitamins, minerals, growth factors — all important in a balanced diet.

There are various processes for making such products. The preferred Phillips-Provesta ones, developed after years of research, employ alcohols such as methanol. The processes are highly productive and obviate the possibility of carcinogens or other undesirable components (such as other substrates might pose). They are relatively independent of location, require little land, are independent of drought, insects and other natural hazards, and are not subject to the wide fluctuations in quality, availability and price that characterize protein from crops or animals.

Proteins are made up of about 20 amino acids of which eight are essential for human life. These eight cannot be synthesized by the body and must be ingested. The body can only use these to the extent of the one that is there in the lowest amount. It is like a chain in which the chain is only as strong as its weakest link. All proteins are rated by comparison to a standard and are given a protein score which reflects the concentration of the limiting amino acid. The protein is only as good as this limiting amino acid, Some SCP's have an initial high protein score usually limited by the sulfur-containing amino acids.* Individual strains may rate even higher in particular amino acids such as lysine which is usually limited in cereals. Different cultures have different amino acid compositions.

Thus while the composition of animal, poultry, fish, milk, egg and other tissues or cells cannot be easily altered, the range and opportunity to select different enriched SCP's is unlimited.

*It is in ● sense fortuitous that the sulfur aminos are limiting because these particular aminos are commercially available and, where desired, can be introduced as supplements in the SCP to increase further ita ● lready high "protein score".

This means that one can grow the best SCP for a particular amino acid requirement and, if any one SCP cannot supply all the amino acids in the desired proportions, then two or more complementary cultures can be blended together to achieve the *most* favored mixture.

How SCP Is Made

SCP is made by continuous fermentations in which a select microorganism feeds on a substrate (e.g., methanol) and trace nutrients. The rate of growth (multiplication) of this protein is far higher than that of animals and plants. The cells split, doubling their weight, in as little as about two hours. In contrast, chickens, cattle, etc. take from weeks to months to double their weight and can maintain this rate only briefly during their life cycles.

Fermentation processes somewhat like those for making SCP, albeit far less efficient, have *been* practiced for generations (using other substrates) for making brewers yeast, citric acid, etc. It is only recently that it has become feasible to ferment using hydrocarbon and derivative substrates, thereby converting a non-food raw material into a food.

In the case of SCP the ingestible product can consist of the entire cells, in contrast to animals, much of whose mass is lost in slaughter. The advantages of this and rapid growth become compounded in achieving high end productivity. In addition, such microorganisms have unusually high total protein content, bacteria up to 80% and yeasts near or above 60%. Since such processes require no lend for agricultural or animal farming and are independent of the latter's natural growth hazards, they are not subject to the wide fluctuations in price and quality encountered in protein derived from agricultural crops and animals.

The feedstock can vary and the type chosen governs to a large degree the selection of the microorganism used, its growth condition% and the type of fermentation employed. There are four main processes. These employ either:

— normal paraffins
- mixed hydrocarbons
— methane
or – hydrocarbon derivatives (alcohols)

The yeasts, bacteria or molds employed break down the alcohols or hydrocarbons to carbon "fragments" and then synthesize and convert them into their own cellular structure. The same type catabolic and anabolic processes that occur with sources of energy such as sugars occur also in these metabolisms, while the enzymes and intermediates are different. Some organisms long marketed for human consumption (yeast) by growth on sugars can be adapted to accept hydrocarbon derivatives.

The choice of organism (SCP) for growth is influenced by many factors involved in the structure of the particular substrate. In the case of hydrocarbon substrata, organisms normally "select" the straight chain alkanes therein es their primary source of *carbon for* metabolism. If mixtures of normal paraffins and non-normal (branched) paraffins are present, the organisms will first select and consume the normals, leaving behind or consuming much more slowly the branched hydrocarbon& [This has the effect of concentrating the latter undesirable hydrocarbon compounds in the media and around and in the organism.] Aromatic hydrocarbon structures and substituted chain and ring hydrocarbons are normally more resistant to "attack" by the organisms and non-utilizable at fermentation rates that yield optimum growth.

In all current SCP processes preference is being given to yeasts or bacteria rather than molds due to the former's ease of cultivation and quality of end product. Choice between the many classes of yeast and bacteria depends on the substrate, recovery system yield (weight of cells per weight of hydrocarbon), incubation temperature, nutrient requirements for growth, amino acid balance of end product, and many other factors. Yeasts are more easily recovered than bacteria due to their larger size (bacteria about 1 micron diameter, yeasts about 5). Growth rates and yields of bacteria are usually higher than yeasts. Such relative features must be con-s&red in judging which to grow with a given substrate.

The cells of rapidly growing cultures of yeast and bacteria have high nucleic acids content, for which the tolerance of animals is much greater than that of humans. The safety and value of various SCP's (with certain substrates) used as animal feed have been established. However, the limitation on intake of nucleic acids by man appears to call for the development of techniques for their reduction below the levels normally found in rapidly grown SCP or that tolerated by animals. There are processes for lowering the nucleic acid content of SCP through choice of culture, control of fermentation variables, physical or chemical means, or purification by enzymatic techniques employing ribonucleases. The optimum procedure depends on the particular process and organism employed, and may be a combination of several methods.

In addition to choosing between broad classes of bacteria and yeasts there is the further choice of which specific type and strain within such classes would be best. It is possible deliberately to mutate strains, thus refining selection even more. This flexibility in selection is of great advantage since specific "tailormade" cultures can be employed that will offer operator and consumer the SCP most suited to the desired market.

Since a wide variety of SCP organisms is available, one seeks that SCP, substrate and fermentation procedure that in combination will give optimum SCP reproduction and recovery. Fermentation takes place in vessels which are aerated, agitated or stirred, and cooled to dissipate heat generated by oxidative "attack" by the organism on the substrate. Figure 5 is a generalised diagram of a process using methanol substrate. The SCP organism is inoculated into a sterile vessel containing a sterile nutrient medium containing all factors required for optimum growth of that organism. The minimum requirements for growth are sources of nitrogen (usually ammonia or ammonium salts), minerals such as potassium phosphate, sodium chloride, magnesium sulfate, etc., trace elements such as manganese, iron, etc., and the carbon source (hydrocarbons or hydrocarbon derivatives). Other nutrients such as vitamins, peptones, etc., may be required by more fastidious organisms. The organisms reproduce on these nutrients as long as the temperature remains within their growth range and oxygen is supplied. All SCP fermentations are highly aerobic and large amounts of air or oxygen must be constantly supplied for cellular metabolism to be maintained. With these requirements, the reproduction rate is maintained until one of these factors becomes "limiting", causing slowdown and finally cessation of growth. The small amount of SCP "seeding" or starting inoculum doubles by division in each reproductive cycle of bacteria and by budding and division in yeasts. In each such time interval (generation time) the number of cells doubles.

All fermentation routes proposed for efficient low-cost commercial production of SCP are continuous processes in which new nutrients are continually being added at a rate equal to their utilisation by the reproducing cells. An equal volume of nutrients and cells is constantly being removed so that at each time interval the fermenter volume remains constant as does the ceil density. After the initial "seeding" with SCP, the system continues to operate indefinitely at a steady state with no further addition of cells. The reactor effluent is continually collected and further processed by centrifugation, washing and drying. The four main fermentation routes, as determined by the hydrocarbon or derivative employed, are these:

Normal Paraffin Process

If a source of sufficiently pure normal paraffins is available and if its economics are favorable, then normal paraffins can be used as feedstock to produce protein. However, even the most extensive solvent extraction cannot "guarantee" complete absence of hydrocarbon residuals trapped on or in the cell. Moreover, solvent extraction can be detrimental to the nutritional quality of the product because of removal by extraction of the fat-soluble constituents of the cell. The temperature of fermentation is usually about 30-40°C for yeasts and 35-45°C for bacteria. To maintain the dissolved oxygen level required to support cell "density" of 15-25 gms dry weight of cells per liter of medium, high speed agitation and aeration is required. The high heat load of the exothermic fermentation requires extensive cooling equipment.

The fermentation effluent consists of SCP, spent medium, and traces of the hydrocarbon(s). Purification steps remove small amounts of normal paraffins carried over, plus any non-normal paraffins concentrated in the effluent. It is preferable (albeit expensive) to remove non-normal paraffins prior to the fermentation, rather than later from the effluent and cells (where small levels would be concentrated and removal would involve more complicated purification procedures). If adequate washing by water and/or detergent or solvent is carried out the SCP product will appear as a thick paste after centrifugation, drying to a white powder.

Simultaneous Dewaxing and SCP Production Process Using Mixed Hydrocarbons

This process starts with an impure feedstock usually of high content of long chain normal paraffins, or a feedstock enriched by chemical fractionation to contain a higher than normal percentage of normal paraffins.

Since the particular organisms used in this process can utilize only the normal paraffins (waxes) present in the hydrocarbon fractions or distillate, feed rates must be higher, i.e., the organisms must "search" through the larger volume of hydrocarbons for their desired n-paraffin carbon source. The fermenters thus must handle a larger volume of liquids, and emulsions are encountered. Yeast is the preferred organism here because it is more selective in choice of n-paraffin carbon structure and does not "see" the other branched hydrocarbons. Essentially the same mineral medium is fed as in the normal paraffin process and the same continuous type fermentation is used. However, in this case the fermenter effluent consists of three phases – the unused hydrocarbon, the spent medium and the cells in an oil-water emulsion. To isolate the cells, the purification procedure must be more elaborate and involves a separation of the three phases followed by purification of the cells.

Spent medium is discarded or a portion recycled. The remaining hydrocarbons phase, still present but now depleted of most of the normal paraffins (waxes) originally present, is re-recovered, then channeled into refinery operations. The SCP will at this state be coated with oil and must be exhaustively washed to attempt to remove all traces of hydrocarbons (especially aromatics). Procedures for this include hexane and detergent washes. These can help free the SCP of contaminating oil with the number of washes determining the final degree of purity. The final SCP is in theory about the same as that produced from normal paraffins. While this process starts with a cheaper feedstock, part of the economic advantage is lost because of the expense of the purification steps.

Methane Process

The methane process for producing SCP involves fermentation of gaseous hydrocarbon. Some organisms obtain their energy from such oxidations but at present at least, the process is limited to bacterial fermentations. Of all the natural gases, methane is preferred due to its abundance and favorable cost. An advantage of using gas as feedstock is that there are no separation or residual oil contamination problems involved in isolating the SCP. The disadvantages hinder commercialization. Besides the possible hazard of operating in an oxygen-methane environment there are problems created by the need to adjust gas flows to prevent too great a venting of unused methane while maintaining adequate oxygen level. Also, SCP concentrations in the reactor and SCP yields are low. Reasonable rates of production appear to require very large fermenters or very slow flow rates. The methane route appears to require significant technological advances before it is as attractive as other SCP processes.

Process Using Feedstocks
Derived from Hydrocarbons

SCP fermentations that employ select derivatives of hydrocarbons (namely, alcohols and especially methanol), rather than hydrocarbons themselves, avoid significant processing complexities inherent to the latter. Additionally they do not pose certain critical quality and consumer acceptance questions that confront proteins from hydrocarbon substrates. Processes using such derivatives are inherently simpler from a plant design standpoint than those using hydrocarbon Even though the process involved is essentially the same for gases, the use therewith of derivatives such as alcohols is far preferable in respect to such factors as equipment productivity, sizes of fermenters employed and avoidance of explosive hazards of gases. Simultaneously, growth rates are attained that are at times significantly superior to other systems.

On the basis of extensive background, familiarity with all the processes described above, and knowledge of the state of competitive art, it appears that among all such processes those employing alcohol substrates such as methanol are outstanding. There are many reasons for this statement, explained below. However, all methanol-based processes are not alike. They differ greatly in their efficiency and productivity. Moreover, some can employ only bacteria, in contrast to others (such as Phillips-Provesta) that can use methanol with either yeasts or bacteria at high efficiencies. Moat significantly, some operate at relatively lower fermentation temperatures than others. As explained elsewhere, the ability to ferment at high temperatures, as in the case of certain Phillip-Provesta types, can greatly reduce plant investment and operating costs.

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Feature of SCP processes Using Methanol

There are many advantages to those processes for making SCP that employ alcohols such as "methanol fuel" as their energy source. Such proprietary processes have been developed by Provesta-Phillips. Some of their features are these:

– It is certain, rather than speculative as with other substrates, that the proteins so pro. duced cannot be contaminated by residual hydrocarbons trapped within or on the surfaces of the protein cells because no hydrocarbons are present in the process. The possibility of various questionable components in the final products is thus eliminated.

- There is no need for expensive solvent extraction stages such as required by hydrocarbon substrates. Because alcohols are water soluble, a simple water wash will suffice, solely to eliminate excess trace minerals.

- The fermentation phase is continuous and single-stage, giving simplicity, reliability and reduced capital investment.

– Recycle of spent fermenter medium (effluent) is feasible. In contrast, in the case of hydrocarbon substrates recycling of spent medium can cause build-up of those hydrocarbons other than normal paraffins that may be present, inasmuch as the former are not utilized by the microorganisms during fermentation.

– The alcohol substrate provides a self-sterilizing effect in the fermentation state and in the input feedstock (to the fermenter) sterilizes the mineral medium portion of the feedstock.

– The process allows, if desired, the complete integration in production plant complexes of all components needed for making the protein. This is because both the main feedstock components — alcohol and ammonia - call for common feedstocks for their own manufacture — i.e., methane, air and water. The production capacity of such "component" plants in a complex can be designed to match the protein production. Moreover, any excess methanol and ammonia produced would not pose marketing problems. Both could be sold into animal feed, fertilizer and chemical markets.

– It is easier and cheaper to oxidize methane to methanol by chemical means, in a separate chemical plant designed for this purpose, than to oxidize it from hydrocarbon to methanol by biological means (fermentation). Moreover, fermentations using alcohol (e.g., methanol) require less oxygen than them using the related hydrocarbon (e.g., methane). This in turn means lower cooling costs.

– Productivity measured in terms of lbs SCP/unit fermenter volume/hr is much greater for the alcohol than for the gas process. This allows smaller equipment and attendant Savings.

– The rate of SCP production during fermentation can be continuously controlled or varied. This means inherent process control, easily maintained.

– Either bacterial or yeast (SCP) cultures can be used in the same plant, giving important commercial flexibility.

– Both yeast and bacterial fermentations can, through proprietary technology, operate at temperatures of 40°C (104°F) and above without harming the organisms or their rates of growth. This reduces heat exchange coats and allows fermentation at high input cooling water temperatures such as exist in some parts of the world.

- Absence of a solvent wash permits lipid-type constituents to be included in the protein product if desired.

– Availability of special hydrocarbons such es n-paraffins could at times be limited, or depend on the balance of other stocks available in refining operations. Alcohol substrate processes are not subject to such dependency and limitations.

– The use of a water-soluble substrate significantly reduces or eliminates problems inherent to two-phase (hydrocarbon-water) systems. Better contact is obtained between organism and feedstock (alcohol) during fermentation.

– Basically the same plant equipment can be used with either methanol or ethanol substrates.

# # # # #

Research and Development of Technologies

Our research in *microorganisms* that use hydrocarbons or hydrocarbon derivatives as sources of energy for growth began over 20 years ago when we discovered that some microorganisms could help to find oil reserves. We then later developed and patented processes that use organisms that employ alcohols as energy (carbon) for growth. Some of these were found suitable for rapid and efficient production for their protein content.

These discoveries were compared in terms of fermentation parameters, product quality, and economics, to organisms that use hydrocarbon feedstocks (gas oil, n-paraffins, methane, etc.). After thorough investigation the alcohol route, preferably methanol, was selected as optimum.* Paralleling studies developed organisms that could employ ethanol in the same equipment, thus giving greater process flexibility.

In still other studies technologies were developed and patented that allow efficient use of “crude” methanol containing levels of aldehydes that, absent such technologies, would normally be inhibitory to cell growth. This further increased the versatility of the processes. Over 800 cultures were studied and/or discovered through thousands of varying trial fermentations to find and to stimulate maximum growth rates and yields, It has generally been assumed in

*The many reasons for this choice ● re reviewed elsewhere herein.

the past that single types of organisms would be preferable for making SCP. In addition to developing technologies with these, we have discovered proprietary, stable and highly productive mixtures of certain organisms. The variety of all these options is too great to describe herein. It can be stated, however, that normally when starting a study with a new culture fermentation temperatures are initially set at some arbitrary value such as *40°C, to* isolate organisms able to use methanol as substrate, in the absence of accessory growth factors and in the presence of some particular minimal medium.

Bacterial Fermentations

From the large number of cultures found to accept methanol, those showing exceptional growth or other unique properties were chosen for further development. Throughout, selections and assessments were made using specific media devised for each culture, further to enhance growth. A few examples of isolates are:

Pseudomonas methanica	NNRL B-3449
Arthobacter parafficum	NNRL B-3453
Pseudomonas fluorescent	NNRL B-3452
Methanomonas methanooxidans	NNRL B-3451
Methanomonas methanica	NNRL B-3450
Corynebacterium simplex	NNRL B-3454

In all cases continuous rather than batch fermentations were employed because of the former's greater productivities and yields. The following data present one example of a continuous fermentation taken from earlier studies, employing methanol:

A fermenter arranged for effective mixing and continuous fermentation and temperature controlled at 40°C ± 1°C was charged with a base medium containing phosphoric acid, potassium chloride, magnesium sulfate, calcium chloride, sodium chloride, and a trace mineral solution. The fermenter was inoculated with Pseudomonas methanica B-3449 and methanol added incrementally to bring the culture to the desired cell density. Medium was then char&d continually to the reactor and the effluent removed, maintaining the culture at steady state operation. Methanol was fed continually to the reactor at 8.5% (V/V) concentration in the mineral medium feed. Supplemental alcohol* was added to maintain the system at a high cell density. No accessory growth factors were required. The pH was maintained at 6.3 with ammonium hydroxide, which also served as the nitrogen source. Air was supplied at a level of 2 V/V/rein with stirrer agitation at 1000 rpm. Additional pure oxygen was often required to maintain a dissolved oxygen level not inhibitory to maximum cell growth. Cells were recovered, washed and dried. Under steady state conditions the fermentation characteristics were:

Dilution rate (hr^{-1})	0.492
Retention time (hr)	2.03
Cell concentration (dry wt)	31.85 gm
Productivity (g/1/hr)	15.81
Crude protein content (%) (N x 6.25) no moisture	60.6

● One of the unusual features of the proprietary processes employed is thet methanol is virtually non-existent in the final SCP products, ● t a level many time. less than that of conventional foods ● nd beverages long established ● nd used in direct human consumption as permitted by the regulatory agencies of the U.S. (FDA) ● nd other countries.

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The amino acid content of this particular culture is as follows:

Amino Acid Content of a Typical Methanol-Utilizing Bacterium Grown at 40°C

Essential Amino Acids	Grams/100 grams Product basis	Protein Basis
Leucine	6.16	8.01
Isoleucine	4.01	5.21
Lysine	4.67	6.07
Methionine	1.33	1.73
Cystine	—	—
Threonine	3.53	4.59
Phenylalanine	3.25	4.23
Tyrosine	2.67	3.47
Tryptophan	0.51	0.66
Valine	4.42	5.75
Non-essential Amino Acids		
Alanine	5.50	7.15
Arginine	3.48	4.53
Aspartic Acid	7.34	9.54
Glycine	4.02	5.23
Glutamic Acid	8.44	10.98
Histidine	1.89	2.46
Proline	2.79	3.62
Serine	2.62	3.41

Larger quantities of cells were prepared in fermenters of up to 20,000 gallons in volume, for use in extensive animal feeding teats. These have given excellent results, reported elsewhere herein. Evaluation at high cell densities and minimum generation times verified the greet dependency of plant operating costs on fermentation temperatures. Fermentations maintained at about 40°C, for example, can generally employ cooling water whereas at lower temperatures they may require more expensive refrigeration.

Thermophiles

Since cooling is a major cost factor in the economics of SCP, both in respect to plant investment and operating costs, the use of thermophilic (high temperature) organisms is certainly desirable.

We have discovered and developed proprietary, thermophilic cultures that give excellent results comparable to those mentioned elsewhere herein for 40°C bacterial cultures.

Yeast Fermentations

Although bacteria have certain advantages for SCP production from methanol it was also held to be desirable to be able, alternately, to produce yeast SCP in the same future commercial

mercial plants with the same substrate, methanol. The large capital investments of commercial plants would thereby not be dependent on the gratuitous assumption that one or the other, bacteria or yeasts, would always prove optimum in every marketplace.

After extensive research we succeeded in achieving this dual capability goal,in the course of which a number of proprietary cultures were developed. The same basic screening criteria were followed with the yeasts as with the bacteria, i.e., rapid growth at high cell densities at a temperature such as 40°C on a defined minimal medium requiring only certain vitamins. As example, one of the cultures was a particular strain of Hansenula polymorpha that grew rapidly at 40°C in continuous fermentation in a mixed phase type fermenter. A 10% methanol mineral medium containing, for example, phosphoric acid, potassium chloride, magnesium sulfate, calcium chloride, a trace mineral solution and biotin and thiamine was fed continuously. The pH was maintained at 3.5 with NH_3 which also served as the nitrogen source. Aeration was at the level of 2 V/V/rein. The fermentation was alcohol-limited so the methanol content of the effluent was essentially zero. An example of the fermenter characteristics under steady state conditions is:

Dilution rate (hr^{-1})	0.14
Retention time (hr)	7.2
Cell density (dry wt)	26 gins*
Productivity (g/1/hr)	3.6
Cell yield (baaed on methanol consumed)	32.9
Crude protein content (%) (N x 6,25) no moisture	54

The amino acid content of this methanol-utilizing yeast, grown at 40°C., was as follows:

Essential Amino Acids	Grams/100 grams Product basis	Protein basis
Leucine	4.07	8.56
Isoleucine	3.20	6.73
Lysine	3.22	6.77
Methionine	0.84	1.77
Cystine	0.27	0.57
Threonine	2.04	4.29
Phenylalanine	2.56	5.38
Tyrosine	2.29	4.82
Tryptophan	0.52	1.09
Valine	3.51	7.38
Non-Essential Amino Acids		
Alanine	3.37	7.09
Arginine	2.00	4.21
Aspartic Acid	5.42	11.40
Glycine	2.96	6.23
Glutamic Acid	6.46	13.59
Histidine	1.12	2.36
Proline	2.30	4.84
Serine	1.39	2.92

● In other proprietary Phillips-Provesta technologies cell densities have been achieved that are much greater then the above value.

The fatty acid content of the dried yeast sample was examined by gas chromatography. No odd-numbered carbon fatty acids were identified by GC-mass analysis. Multiple animal tests, some of which are reported elsewhere herein, were concluded with this yeast that showed excellent nutritional qualities.

Chemical "Scores"

The chemical "score" ratings of the above described bacterium and yeast, compared to reference standards (FAO; egg) used in human diet, are shown below in Table III.

TABLE III

Standard	Yeast (% of the Standard Shown)		Bacterium (% of the Standard Shown)	
	FAO	Egg	FAO	Egg
Amino Acid				
Leucine	170	91	146	79
Isoleucine	124	80	110	70
Lysine	174	103	156	93
Methionine) Cystine)	50	40"	61	49*
Threonine	184	129	149	104
Phenylalanine) Tyrosine)	181	126	114	80
Tryptophan	143	100	100	71
Valine	148	95	125	80

" Economical fortification of either SCP with 0.89 gm of methionine per 100 grams of product increases the "score" of the SCP compared to egg) to the next limiting amino acid (isoleucine).

NOTE: Values shown are for only two of a number of proprietary Provesta-Phillips SCP's of differing (higher and lower) values.

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Animal Feeding Tests

Background

To satisfy their protein deficiencies, especially for use in animal feeds, many countries depend heavily on U.S. and Brazil imports of soy protein, and on fish protein from Peru and elsewhere. Serious shortages of these proteins and accompanyingly high prices have occurred from time to time, the most recent being those of 1972 and 1973. SCP holds the great promise of eventually relieving such supply problems because of its potential for extremely large production. As explained, its greatest initial market penetration is expected to be in animal feeds and later in direct human consumption products.

Extensive taste indicate that SCP's such as produced by proprietary Phillips-Provesta technologies can replace soymeal and fishmeal in animal feeding rations. To assure competent and unbiased conduct and evaluation of such teats they were performed, under contract with Phillips-Provesta, by the animal science department of a leading U.S. university over a four-year period (1972-1975). The test species included ruminants (cattle and sheep), swine, poultry, and laboratory clinical-study animals such as rats. The SCP's were compared to conventional high-quality protein products generally accepted by industry as standards for such studies. Quality measurements included apparent biological value (ABV), protein efficiency ratios (PER), and average daily weight gains (ADG) of the teat animals. The studies were conducted with sufficient numbers and types of animals to yield data adequate for statistical analyses. This provided a high degree of *confidence in* the validity and reproducibility of results.

The studies demonstrated the nutritive value and safety of these SCP's at percentages of the total mixed feeds that are commercially significant. Such tests are continuing on still other types of our SCP's. Some of the results obtained to date are reported herein.

Utilization of Protein by Animals

Poultry are known to be more efficient than other animals in converting protein to meat, thereby providing quicker end more economical gains from supplementary proteins added to their diets. In addition, poultry are more easily managed than other animals in "battery-type", i.e., multiple, production units. For these reasons, the production of chickens and other poultry is expected to increase faster, with the availability of new supplementary proteins such as SCP, than other meat animals in those areas of the world where there are deficits of protein accompanied by deficits of feed grains. The approximate gross conversion efficiency of crude protein for poultry versus other animals is illustrated below:

GROSS CONVERSION EFFICIENCY OF CRUDE PROTEIN BY VARIOUS ANIMALS: AVERAGE OF ALL PHASES OF PRODUCTION

spades	Per cent of the crude protein present in the feed that is effectively utilized
Broilers (young chickens)	23
Turkeys	22
Laying hens (for eggs)	26
Dairy cows (for milk)	25
Swine	14
Beef	4
Lambs	4

(Conventionally, poultry and swine consume grains as the main part of their diets, while ruminants consume mainly forage.)

Poultry

In the poultry studies, substantial increases in body weight and feed efficiency were obtained at SCP levels up to 15% of the total ration, when yeast SCP in a special "granulated" form was used to replace soybean meal as the source of supplementary protein in the rations. Smaller increases were obtained (at levels up to 6% SCP in the total ration) when the SCP employed was in a powdered "mash" rather than a granulated form. The "granulated" form, having much larger particle size than the powder, clearly improves the palatability and acceptability of SCP to poultry. The addition of small amounts of supplementary methionine to the total rations still further improved weight gains and feed efficiencies, to a greater extent in the SCP-containing rations than in the zero-SCP basal "control" ration containing soy protein. At a 10% level of substitution of SCP in the total ration, the weight of chicks (young poultry) increased 14% and feed conversion efficiency increased 12% (over the control ration containing soy protein). Weight gain and feed conversion efficiency are shown in the table below:

TABLE IV

EFFECT OF SCP SUBSTITUTED FOR SOYMEAL IN "BROILER" CHICKEN RATIONS

Amount of Supplementary Protein in Total Ration, %		Improvement in Weight Gain, %	Improvement in Feed Conversion Efficiency, %
SCP	SOYMEAL		
0	32.4	----------Control	Ration---------
5	27.4	2.4	0.6
10	22.4	14.1	11.9

NOTES: 1. SCP was a yeast type in these tests.

2. "'Broilers" are young chickens, starting at 7 days and ending at 28 days age.

Ruminants

Conventionally, beef is the preferred meat of a number of countries and is expected to remain a major part of their diets. Lamb is, in turn, the preferred meat of other countries. Thus, growth and weight gains of both ruminants are of much interest. One advantage of ruminants is that they can convert very low cost and low quality forage into meat. However, their weight gains and efficiencies of conversion of their feeds are impeded because of lack of adequate supplementary protein in such forage-type feeds. Accordingly, for improved gains, ruminants are grazed on forages during their growing period and then, where possible, they are fed grains and protein concentrate in their final growth stage to produce more and choicer meet, When this is done the ruminants' protein conversion efficiency is greatly improved.

Phillips-Provesta, having among its proprietary SCP's both yeast and bacteria types grown on methanol, conducted studies to demonstrate how the bacterial SCP could, for one, improve such rations. A number of studies have been made with both cattle (beef) and lambs.

Beef – In many parts of the world where supplementary proteins are unavailable or uneconomical, cattle and other animals must subsist on protein-deficient forage or other rations that greatly inhibit their weight gains and other growth characteristics. At times even seemingly small increases in the protein content of such rations – and, of equal or greater importance, in their protein quality — can substantially improve growth characteristics, This is illustrated by the following teats using conventional protein supplements:

- Two groups of dairy-beef calves (8 weeks old) feeding mainly on corn grain were given ration protein supplements. One was given a ration containing the level of protein recommended by the National Research Council*. The other was given a ration containing 2 percentage points more total protein, The average daily weight gain of the latter (higher protein) group was 11% greater, this being accompanied by a 10% improvement in feed conversion efficiency.

- Another series of tests was conducted with three groups of pregnant beef cows fed low-quality crop residue rations. Group A (control) received a ration containing 6.5% total ration protein, which met National Research Council requirements. Group B received the same "control" ration plus 3.5 percentage units of conventional protein, bringing the total ration protein to 10% level. Group C received the "control" ration supplemental with urea (a source of nitrogen). All tests were conducted during the last 100 days of gestation of the cows. The results were that Group B gained 173% (33 kilograms) more weight and, after calving, gave 22% *more* milk than Group A. Subsequently, the calves from Group B gained 19% more weight than Group A by the time the calves were 14 weeks old, this reflecting the greater milk production of their mothers. In contrast, Group C showed no benefits over control Group A, in any of the parameters, from the added urea in its ration. These results, in effect comparing two different sources of nitrogen for ruminants, demonstrate the importance of protein quality m animal response.

Other tests, made to compare the performance of SCP with that of the conventional protein supplements reported upon above, have shown that SCP gives comparable responses.

In another study the substitutional value of SCP was compared to urea in "feeder calf"** rations. It was found that when SCP replaced 5% of the urea in the control ration the average daily weight gains and total weight gains of the calves were significantly higher than with the control ration, all rations being isonitrogenous.

Lambs – Lambs, the second ruminant tested, also respond positively to rations which relieve protein deficiencies. In *one* series of tests the total protein content of a basically *corn grain* ration was increased, using SCP, from an 8.5% level (the control ration) to a 12% level. The average daily weight gain increased about 19%, this being similar to the results obtained in paralleling tests with soymeal and/or urea. The main effect, however, was a significant increase (24 to 28%) in wool growth when using the SCP-containing ration, versus only an 11% increase with the urea-supplemented ration, both values being in reference to the control ration.

* A division of the National Acedemy of Sciences, Washington, D. C.
** Young beef immediately after weaning.

These findings again demonstrate the importance of protein quality in supplementary ruminant rations. The more favorable performance of the SCP was also indicated by the blood urea levels of lambs fed higher percentages of SCP. These levels were lower with SCP after 4 hours than those of lambs fed urea or soymeal supplements, indicating better nitrogen utilization with the SCP.

Other Animals – Other studies have assessed the digestability and effective utilization of yeast SCP when fed to swine. In one series of tests with baby pigs it was found that, concurrently, the feed:gain ratio improved, the apparent biological value increased, and the plasma urea nitrogen reduced, all to a significant extent, when the SCP was substituted for conventional supplementary protein. Other studies have demonstrated SCP's value when fed to older "grower" pigs, again comparing the SCP to conventional proteins. Although ADG's were unchanged, feed:gain ratios were significantly improved and the average daily feed intake (consumption) was significantly reduced when using SCP-containing ration.

Summary

Studies have demonstrated the nutritive value and safety of the SCP's tested, when used partially or wholly as the source of supplementary protein in animal rations. The results have often been superior to those obtained with conventional supplementary proteins, at percentages of the SCP in the total mixed feeds that are commercially significant.

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Economics

Assessment

Frequently, when new products are evolved that appear suited to markets in which the supply of competing products is short, "demand" seemingly great, sources of potential feedstocks large, prices "good", there is an inclination to assume that the new products are ready forthwith for the marketplace. Such euphoria developed soon after it was learned some years ago that SCP could be made rapidly in massive amounts using hydrocarbon substrates. As time passed there grew better appreciation of the many factors that would influence commercial viability. Concurrently, the world entered into a period of severe monetary inflation and escalations in plant construction costs. At the same time it became apparent that the first-generation technologies around which some had planned early ventures might be rendered prematurely obsolescent by second and third generation technologies such as mentioned herein. In support of these statements one need only recall the many announcements made during the past five years of "imminent" commercial SCP projects, then compare these to the number that has actually reached fruition. This is not to imply that SCP may not have a major role in filling future world protein needs since it is certain to have one. It says only that the assessment of commercial projects has become more knowledgeable, selective, and in the process more conservative.

Markets

The markets for SCP fall into two broad classes, 1) supplements in animal feeds – animals that would later be slaughtered and fed to humans – and 2) products that would be ingested directly by humans rather than through the animal route (Figure 6).

Looking at the animal route, SCP could be used in mixed dry feeds, mixed liquid feeds, as substitutes for milk extenders (casein, whey, etc.) and perhaps in special forms of higher potency. As SCP enters such markets an important and valuable "domino" effect will result: The SCP will displace (from animal feeds) vast amounts of protein-containing agricultural products such as soybeans. The latter would then become available, through the use of known and established technologies for concentrating or "isolating" oil-seed proteins, for direct human consumption. This could bring massive amounts (albeit by an indirect route) of "new" protein into direct human consumption much earlier than when SCP might itself make a large, direct entry into this market.

Where so approved by regulatory agencies, SCP's will to a smaller degree concurrently penetrate direct human product markets. It appears, however, that until such time as nucleic acids contents can be reduced, the maximum amounts of SCP in daily, direct human consumption will be low and markets small compared to SCP in animal feeds. Opinion among nutritionists varies as to what maximum amounts can be ingested daily by humans at SCP's "natural" levels of nucleic acids. This will depend in part upon whether the SCP is a yeast or a bacterium because the nucleic acids levels of the two differ, yeast being significantly lower.

Looking at present and future markets, SCP appears in its least "upgraded" form as whole, dried cells for use in animal feeds. The next step "up" would be whole, dried cells using select SCP's and feedstocks* that could, subject to regulatory approvals, be introduced into foods for direct human consumption.**

The next upgrading, to allow greater direct SCP intake by humans, would involve products from which some of the nucleic acids have been removed. The next after this would be where the protein in the SCP would be extracted** and "isolated", possibly accompanied by further nucleic acids reduction, leading to still greater daily ingestion by humans. Finally, some years in the future one might see the advent of isolated SCP proteins that would also be "structured", textured and flavored in sundry ways to create "analogs"** of conventional animal tissue products.

As the forms of SCP progress in this manner from the least processed to the most sophisticated, and as the markets that these forms enter compete with progressively higher-priced conventional proteins, the economic viability of SCP manufacturing enterprises will correspondingly improve. This is normal, of course, wherever basic raw materials (in this case, SCP

*In the caae of some of the more advanced technologies the eeme select SCP end feedstock could be uaed for both ● nimal feeds and direct human consumption. Such commonality gives theee technologies important advantages over earlier firet-generetion technologies that were aimed primarily at animal feeds, whose acceptability for direct human consumption may be questionable.

**Presently being done commercially to increasing extent with oil-seed proteins.

cells) are upgraded into higher-priced end products. However, the effects are far greater in the case of SCP economics because of the unusually great "spread" in the prices of the corresponding proteins against which SCP would compete. This "spread" – going from low-priced animal feed protein supplement such as soymeal to high-priced proteins for direct human ingestion (meat, poultry, etc.) – u today over 1,500% in some countries. The spread is destined to become even greater in future years because the prices of human-ingested proteins are rising faster than those of agricultural crops such as soybeans.

This great spread in potential SCP selling prices makes it impossible to generalize on the economics of SCP manufacturing enterprises unless one first postulates the specific product or products "mix" that the enterprise would enter, at the same time keeping in mind that during the life of the plant the SCP types made, markets reached, and "mix" will undergo transition. Such considerations emphasize the value of creating enterprises that are built around advanced SCP technologies that will produce a variety of products of sufficiently high quality to allow change from one type and market to another without major revisions in plant equipment, feedstocks, or operations.

Locale

The feasibility and timing of commercial SCP enterprises also depends upon their sites and the markets they serve. In the United States SCP will for some time have difficulty in competing with soymeal as a supplementary protein in animal feeds, simply because soybean supply is large and its prices are low. This situation does not prevail, at least not at present, in any other country of the world except Brazil. All others lack significant soybean production yet many wish to grow animals to feed burgeoning populations that prefer meat and can afford to buy it.

"Intrinsic" Versus "Effective" Demand

While there is great "intrinsic" need or "demand" for more protein in human diet the "effective" demand, the ability to buy, is low or non-existent in those countries that have greatest need because of low per capita income. From this one might conclude that the first major markets* for SCP will be in countries of higher per capita incomes, where, however, protein need is generally less. This appears inevitable unless, because of the growing severity of protein shortages and their many possible effects, governments are stimulated to create early, meaningful economic mechanisms (financing of plants, price supports and other incentives) that will allow protein to reach the very poor at the extremely low prices they might be able to afford.

Key Process Variables Affecting SCP Economics

Many other variables also affect SCP economics whose nature and significance differ between candidate enterprises. Common to all, however, are certain key process, plant design and operational parameters that, by virtue of their commonality, provide guidelines in planning such enterprises and the conduct of research, development and design to optimize their performance.

● Thb statement applies only to markets, not to feasible locations of plants. The plants could of course be in countries having low domestic consumption but large energy reserves.

Phillips-Provesta has made parametric studies of a variety of possible project situations, using computer and other techniques. For the purpose of this paper these studies are reduced to a few examples that illustrate the influence of some of the more significant variables. The examples are expressed in “dimensionless” units so as not to make the results speciously applicable, in time or place, to any single situation. To arrive at values that would be in proper ratio to each other, investment and operating costs are arbitrarily based on an assumed U.S. Gulf Coast plant completed in 1980. [This assumption will not accurately reflect the differences that exist worldwide in such costs. For accuracy, each specific case requires special study. Nevertheless, the relationships shown are reasonably indicate of the relative sensitivity of the variables represented.] The measure of “economic value” was assumed to be an SCP plant selling price that, while variable and dependent on other factors, would in all cases yield exactly the same return on investment capital, thus eliminating R.O.I. as a variable. The R.O.I. arbitrarily chosen was a moderate one such as might reasonably be obtained with investment capital in other lines of business producing more conventional products. Manufacturing costs were calculated by methods used by Stanford Research Institute in various studies.

Figure 7 illustrates what are perhaps the two most important process variables affecting SCP selling price at constant R.O.I. These are the temperatures of the cooling water used in the fermentation stage and the temperature of the contents of the fermenter during fermentation. Three assumed values of average cooling water temperature (average of inlet and outlet) are shown. The process was arbitrarily assumed to be one in which some chosen SCP organism would give an SCP product yield of approximately 0.5 pound per pound of total methanol fed to the fermentation.* * The cell concentration within the fermenter was arbitrarily set at approximately 40 grams per liter of total fermenter vessel volume and the “residence time” of the organism within the fermenter was set at two hours.

The solid line portions of the graph show those operating regimes in which some fermenter design could conceivably be devised and employed within the framework of the premised conditions. The dashed lines represent those regimes where departure from the set operating conditions would have to occur. The simplest way to illustrate this transition (solid to dashed) is to visualize that point at which the fermenter is completely filled internally with heat exchange surfaces and yet still cannot remove the total heat generated by the fermentation. [The illustrated relationships therefore would not apply to fermenter designs in which some or all of the heat exchange surfaces are external to the inside of the fermenter vessel. However, in such designs the SCP productivity of the total fermentation cycle would probably be reduced, causing an attendant shift (increase) in the SCP selling price needed to achieve the assumed constant R.O.I.]

An alternative to cooling water (for fermentation cooling) is refrigeration. Figure 7 illustrates its effect at a refrigerant-to-fermenter temperature difference of 8.5°C when the average cooling water temperature is 36°C. Thus, while one were to be limited to about 45°C fermenter temperature with an average cooling water temperature of 36°C, one could through refrigeration operate with lower fermenter temperatures if the attendant 20 to 30% increase in selling price required to achieve the assumed constant R.O.I. would be commercially viable.

**“Total methanol employed” is not necessarily the same as “total methanol utilized” in ● fermentation. The tatter, used ● t times by others, may not include “unutilized” methanol that is in effect lost.

One can appreciate from Figure 7 the tremendous incentive that exists for the development of organisms that can operate at higher fermenter temperatures, such as those discovered by Phillips-Provesta, especially in those areas of the world where available cooling water is at relatively high temperatures.

Figure 8 shows the effect of basic feedstock energy cost on SCP selling price. The assumptions are the same as those in Figure 7. To eliminate fermenter and cooling water temperatures as variables, however, in Figure 8 the temperature difference was arbitrarily assumed to be 19°C (34° Fahrenheit). This allows the effects of basic energy (gas) cost on methanol, utility and ammonia costs to be assessed. The values shown for ammonia and methanol assume the existence of separate, large-scale plants for the production of these components. The effect of energy cost on utility costs was derived in a similar manner and reflects the fact that the utility costs are mostly energy.

Figure 9 shows the relationship of gas and methanol prices (dimensionless) to size of plant used for manufacturing methanol at constant, reasonable R.O.I. The figure embraces smaller, leas efficient methanol (MeOH) plants, sized only to the needs of methanol as feedstock for SCP production, as well as larger plants to produce “methanol fuel”. As seen, a smaller MeOH plant sized to a 100,000 tons/year SCP plant requires a methanol charge-in price (at constant R.O.I.) almost twice that of a larger MeOH plant, whose excess output could go into non-SCP markets.

Recent major rises in the costs of hydrocarbons and derivatives such as alcohols, coupled with uncertainty as to where, when and at what level such prices will stabilize, or what trend lines they will follow, has aggravated this sensitivity of economics to feedstock price. Sensitivity is made even greater if one postulates that the upward price trend of such feedstocks will be steeper than that of grains, legumes, and fishmeal, against which SCP must compete in the animal feed market. The implications of such increasing relative price “spread” are of course much leas in the case of SCP made for direct human consumption, competing against proteins such as meat, poultry, etc.

Figure 10 shows how each of the major stages of an SCP plant influences the SCP price needed for constant R.O.I. Two basic plants are premised: The first uses cooling water of any temperature, provided the SCP organism employed can operate with as little es 19°C temperature difference between the average cooling water and the content of the fermenter; the second requires a 24°C refrigeration system, assuming average cooling water temperature of 36°C and fermenter of 32.5°C. Other premises are the same as in Figure 7. Each major stage includes an allocated portion of total off-plot expenses (steam, electricity, cooling, etc.) pIus their related capital costs and capital recovery. Such allocations to each stage were made on the basis of relative usage by each. The raw materials and feed preparation stage includes the effects of the costs of raw materials, operation, capital employed and R.O.I.

Figure 10 again shows the substantial effect of the fermentation stage (refrigeration vs. no refrigeration) on overall economics, and the penalty incurred with organisms that must be employed at lower temperatures.

Proprietary technologies have been developed by Phillips-Provesta that achieve very high efficiencies through the use of organisms (thermophiles) that function well at high temperatures, thereby obviating the need of refrigeration, and that have high oxygen utilization capacity during fermentation, thereby reducing air compressor loads and improving fermenter efficiency.

Figure 11 shows the effects of methanol price and SCP plant investment upon R.O.I. at any assumed constant SCP selling price. Conversely, at any assumed constant R.O. I., it shows the SCP selling price needed to achieve such R.O.I. at varying SCP plant investments and methanol prices. Figure 11 also takes account, through methanol price, of the effects of methanol plant size (Figure 9) on the other parameters.

Some of the foregoing factors may not have high leverage in the commercialization of food products that are not capital intensive. However, SCP is significantly more capital intensive than other proteins. Aggravating this investment-induced sensitivity are the extreme monetary inflations and cost escalations of recent years, uncertainty as to when and how such increases will stabilize into reasonably predictive trend lines, and growing competition for sources of capital. [The estimated cost of construction of large SCP plants has, to illustrate, more than doubled in less than three years.]

The effects of some of these factors on SCP economics are reduced by second and third generation technologies such as referred to herein,

Effects of Governmental Regulations

Significant though they may be, many of the foregoing factors could be overshadowed in their effects on SCP economics by government regulations that control its manufacture, sale and usage. Regulatory bodies of various nations seek to insure, properly so, that “new” proteins such as SCP will not have deleterious effects on the health of their peoples. In this effort some may be tempted to place more stringent demands and restrictions upon the new proteins than those heretofore placed on conventional proteins and food products, not because of the intrinsic characteristics of SCP’s, but because of their novelty. The effects of any such regulatory bias on economics, SCP availability and industry’s motivation to build expensive SCP plants with private capital could be minor and reasonable, or they could prove severe deterrents to commercialization.

Aware of this danger, yet also mindful of the need for SCP quality criteria that safeguard the public’s interests, in a manner and to a degree commensurate with regulations governing conventional proteins and foods, the Protein Advisory Group of United Nations evolved and issued a series of advisory “Guidelines” for use by regulatory bodies in the latter’s issuance of their own national criteria. Another objective of these Guidelines is as stated in Attachment A to create, to the greatest degree possible, a commonality between the regulations of countries, thereby to allow unimpeded international SCP export-import trade between them. Such commonality would also provide planners of commercial SCP enterprises with firm, consistent points of reference, If, however, nations individually deviate significantly from the Guidelines, it will create inconsistencies that could greatly affect SCP prices, availability and commercial timing.

The foregoing statements apply to the need of commonality in SCP quality regulations between nations. They do not imply that the regulations should also assume a non-existent commonality between all SCP's regardless of the feedstock (substrate), organism or process employed. All SCP's are not the same nutritionally nor from a safety (toxicology) stand. point*. Care must be taken by regulatory agencies to write regulations that recognize such differences and distinguish between SCP's, and to avoid the temptation to set the criteria for all SCP's, regardless of their intrinsic quality, at the level of their lowest common denominator, i.e., the "suspect" types. If the latter were done, it would greatly penalize those producers who through years of effort and at great expense have arrived at organisms, processes and substrates that can efficiently and consistently produce SCP's of high quality and safety. If such superior types are arbitrarily burdened with the same stringent testing and quality controls needed for the suspect types, the effects on the superior types will certainly be negative in the form of higher manufacturing costs, higher prices, and possibly reduced availability.

● As example, SCP's made using hydrocarbon derivatives, e.g., alcohols, avoid some of the questions posed by SCP's made using hydrocarbons themselves.

\# # # # #

Conclusions

– The methods that mankind has used in the past to make protein are inadequate to relieve its severe and growing shortage. New technologies that "breed" single cell protein (SCP) efficiently and rapidly using hydrocarbon derivatives can do so with a small fraction of world petroleum reserves.

– The magnitude and timing of SCP's impact on world protein supply - at first mainly in animal feeds, later increasingly in human foods – cannot be accurately predicted because of many influencing factors, Governments, working together, could elect to create economic incentives that would stimulate early, large commercialization. Failing to do so, they may passively allow commercialization to evolve more slowly despite the world's pressing need for more protein,

– All SCP technologies are not alike from the standpoint of efficiency and the products made from them vary in both quality and safety. Many & not use methanol feedstock and thus do not enjoy its advantages. Science is now yielding advanced technologies such as the Phillips-Provesta types outlined herein that could render earlier, less efficient "first-generation" technologies obsolescent and non-competitive with attendantly poor returns (or losses) on investments.

– Categorical assessments cannot be made a priori as to the viability of SCP enterprises. sensitive to many variables, the economics of each will differ and each must be studied as a special case.

– SCP is not a panacea that by virtue of its greater efficiency will displace conventional agricultural and animal sources of protein. The methods of the past will continue to be needed, despite their relative inefficiencies, because of their great infrastructural value in society. Improvement of the old ways and adoption of the new will go hand in hand, complementing each other, thereby better serving mankind in its urgent quest for protein,

– Nations in the Middle East and elsewhere that possess large gas and oil reserves that may not already be fully committed to other endeavors appear to be in the best strategic and economic position to make and sell SCP in world trade. The advanced technologies that use "methanol fuel" as feedstock and operate efficiently at high temperatures, such as those described herein, are ideally suited to such countries.

# # # # #

Attachment A

PROTEIN ADVISORY GROUP OF THE UNITED NATIONS SYSTEM
GROUPE CONSULTATIF SUR LES PROTEINES DU SYSTEME DES NATIONS UNIES
GRUPO ASESOR SOBRE PROTEINAS DEL SYSTEMA DE LAS NACIONES UNIDAS

9 September 1974

The need for urgent action to expand the world supply of protein for human food and animal feed has been well documented. Present and projected critical shortages of protein, in affluent as well as less affluent nations, have stimulated agricultural and industrial research and development in many countries aimed at meeting this need. Novel technologies for massive and economic production of single cell proteins (SCP) from fermentation processes employing various substrates have led to construction of large production plants built by companies in several countries; more are certain to be built in the near future. These developments have several implications. For one, they imply that a revolution in animal and human feeding will take place over a relatively short period; millions of people will consume meat, milk and eggs from animals receiving new forms of protein in their feeding rations. Before very long, humans will receive such protein foods as direct components of their diet. They also imply that private industry will be encouraged by governments, as well as international and bilateral agencies seeking to stimulate development, to make huge investments in plants to produce such forms of protein. Yet another implication is that in anticipation of the introduction of novel proteins into the diets of their populations, the governmental agencies of many nations will seek guidance in the establishment of regulations consistent with those governing more conventional feedstuffs. These will reflect the need to insure that the new proteins will have a beneficial effect on the nutrition and health of their peoples.

We are thus challenged today with an unprecedented convergence of circumstances:

a) immediate and increasing worldwide demand for protein;

b) immediate demand for industry as well as agriculture to produce new forms of proteins, including single cell proteins, utilizing available technologies;

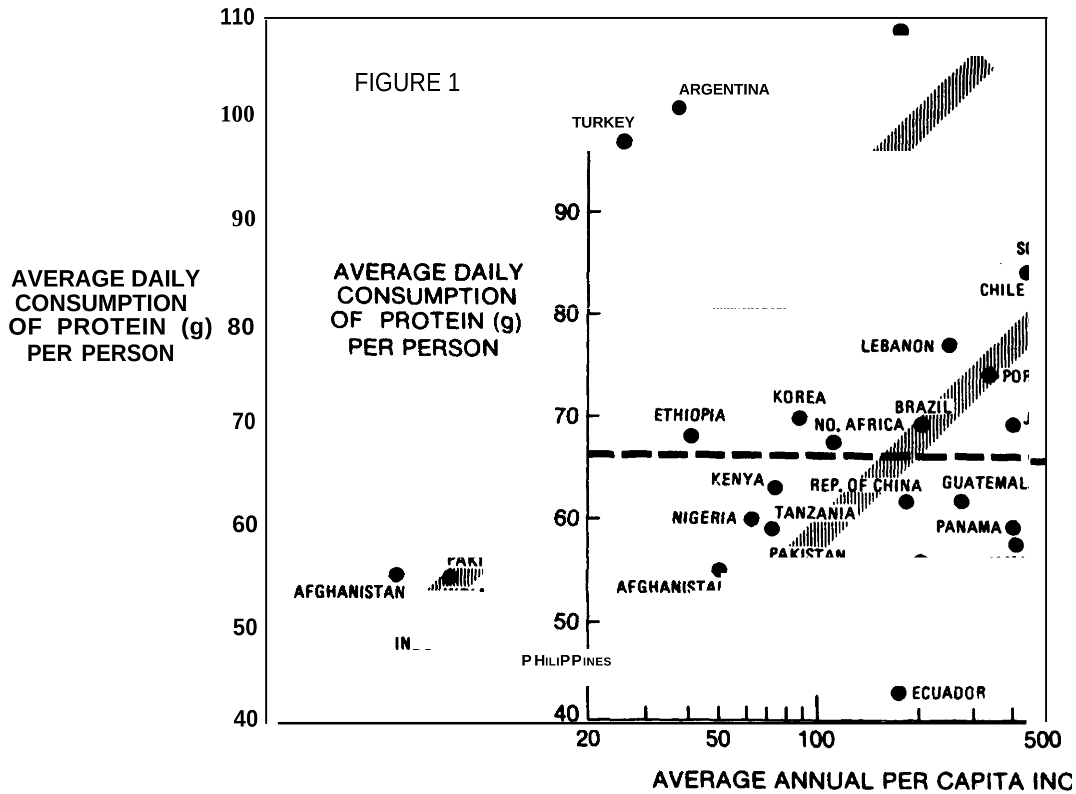
c) immediate demands for many governments to evolve objective regulations controlling the quality and safety of novel protein sources, such regulations to be capable of harmonization at the international level to the greatest possible extent; and

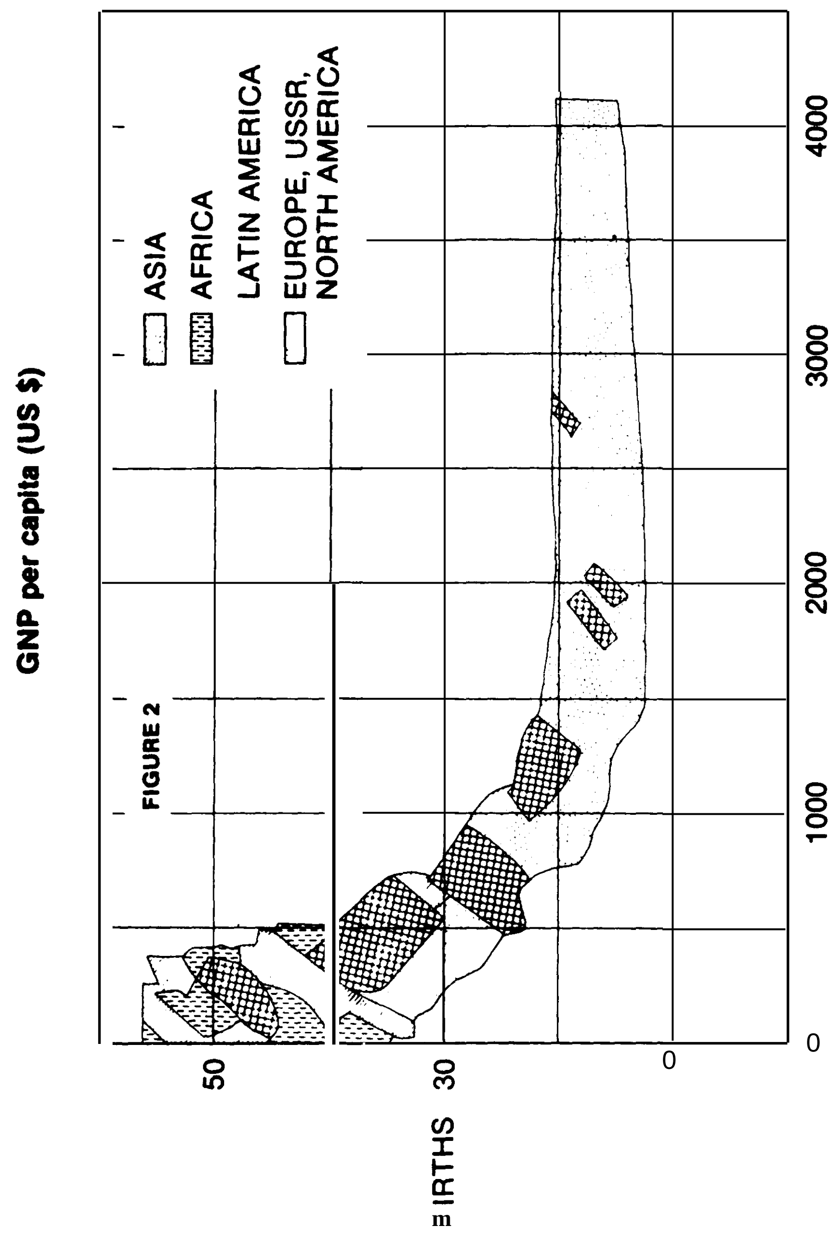
d) an almost equally immediate demand to allow unrestricted and unimpeded international export and import of such products, which will require international similarity of national regulations.

Members of the Drafting Committee

Dr. K. L. Blaxter
Dr. K. Aibara
Dr. A. F. Langlykke
Mr. Emil A. Malick
Professor J. C. Senez
Dr. B. L. Oser, Chairman

WORLD PROTEIN REQUIREMENTS





GNP per capita (US $)
FIGURE 2
ASIA
AFRICA
LATIN AMERICA
EUROPE, USSR, NORTH AMERICA
0
1000
2000
3000
4000
50
30
0
IRTHS
m

WORLD FOOD RESERVES AS DAYS OF CONSUMPTION

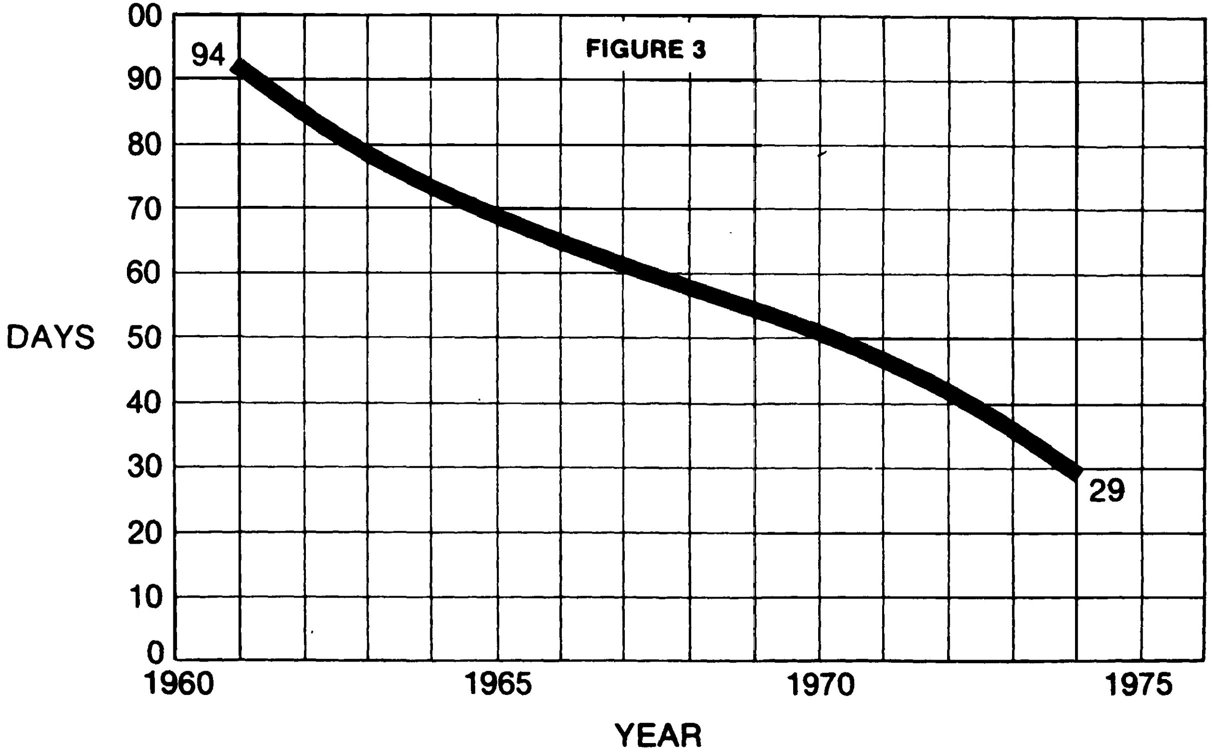
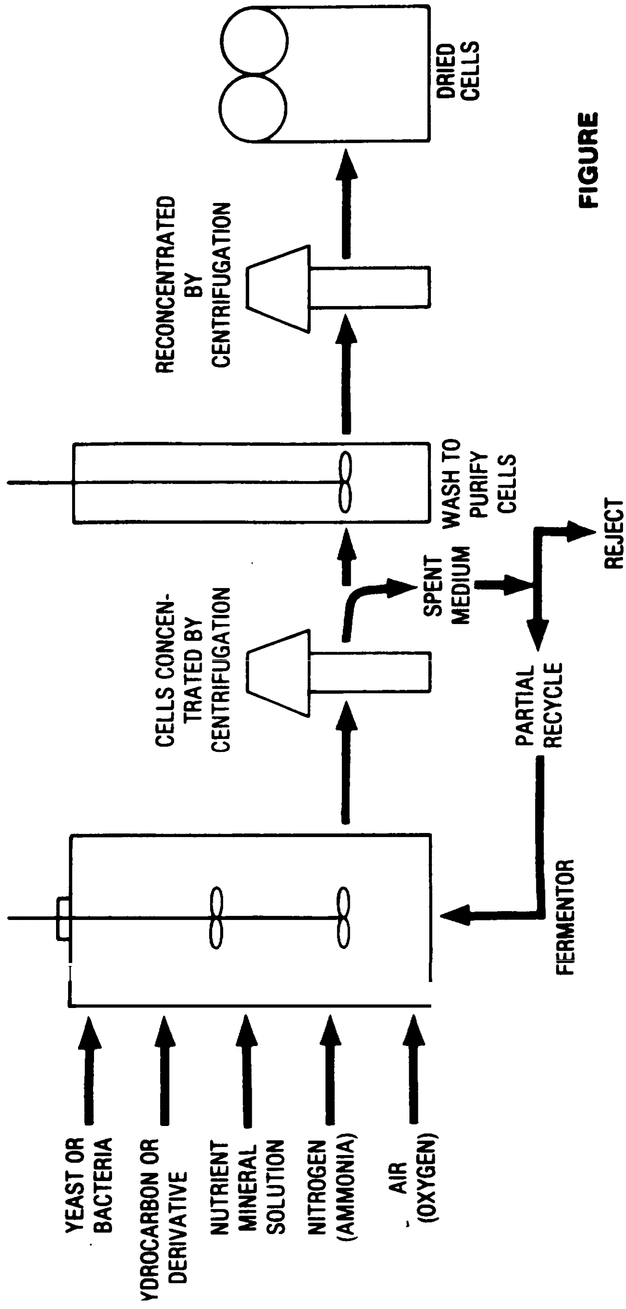


FIGURE 3

PROTEIN PRODUCTION "CHAIN"

CONVENTIONAL	SOYA	SCP
PLANT SEED	PLANT	FERMENT
↓	↓	↓
GROW, NOURISH	**GROW**	HARVEST
↓	↓	↓
HARVEST	**HARVEST**	UTILIZE
↓	↓	
FEED TO ANIMALS	EXTRACT OIL, ETC	
↓	↓	
GROW ANIMALS	ISOLATE PROTEIN	
↓	↓	
SLAUGHTER	UTILIZE	
↓		
COOK, SHRINK		
↓		
UTILIZE		

FIGURE 4


YEAST OR BACTERIA
YDROCARBON OR DERIVATIVE
NUTRIENT MINERAL SOLUTION
NITROGEN (AMMONIA)
AIR (OXYGEN)
FERMENTOR
CELLS CONCEN-TRATED BY CENTRIFUGATION
SPENT MEDIUM
PARTIAL RECYCLE
REJECT
WASH TO PURIFY CELLS
RECONCENTRATED BY CENTRIFUGATION
DRIED CELLS

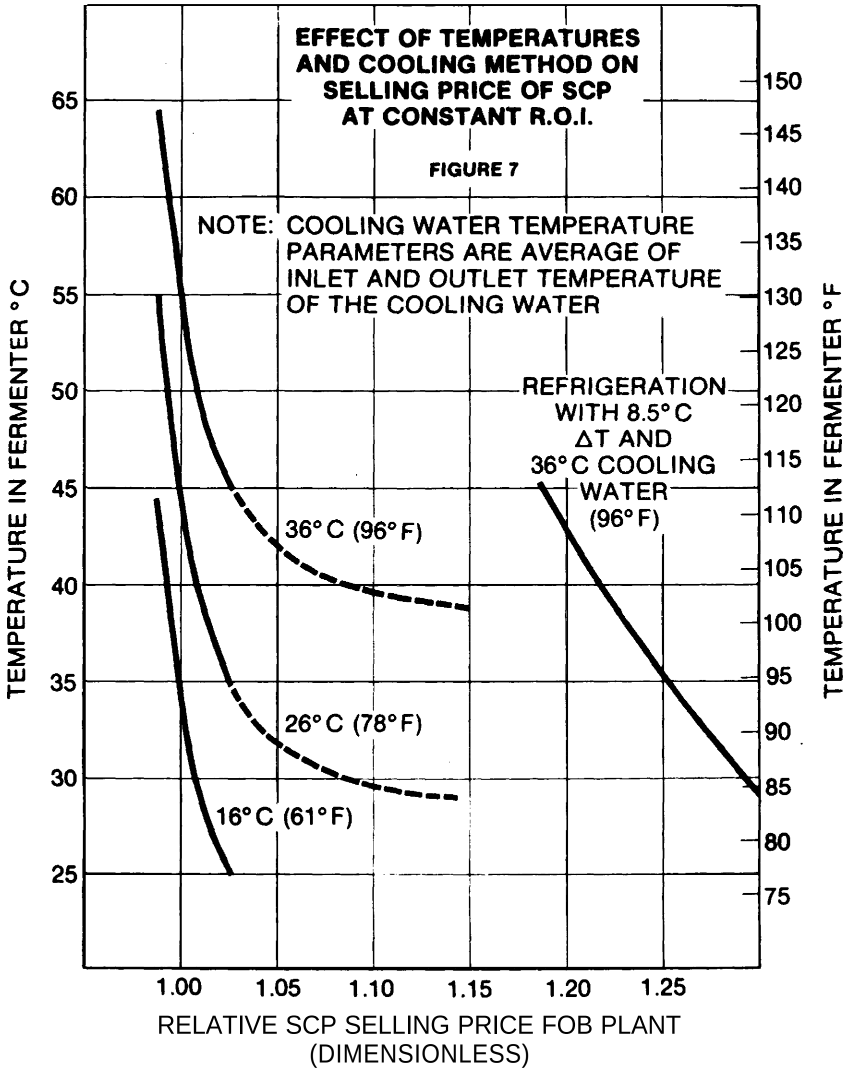
FIGURE

COMMERCIALIZATION

SCP MARKETS

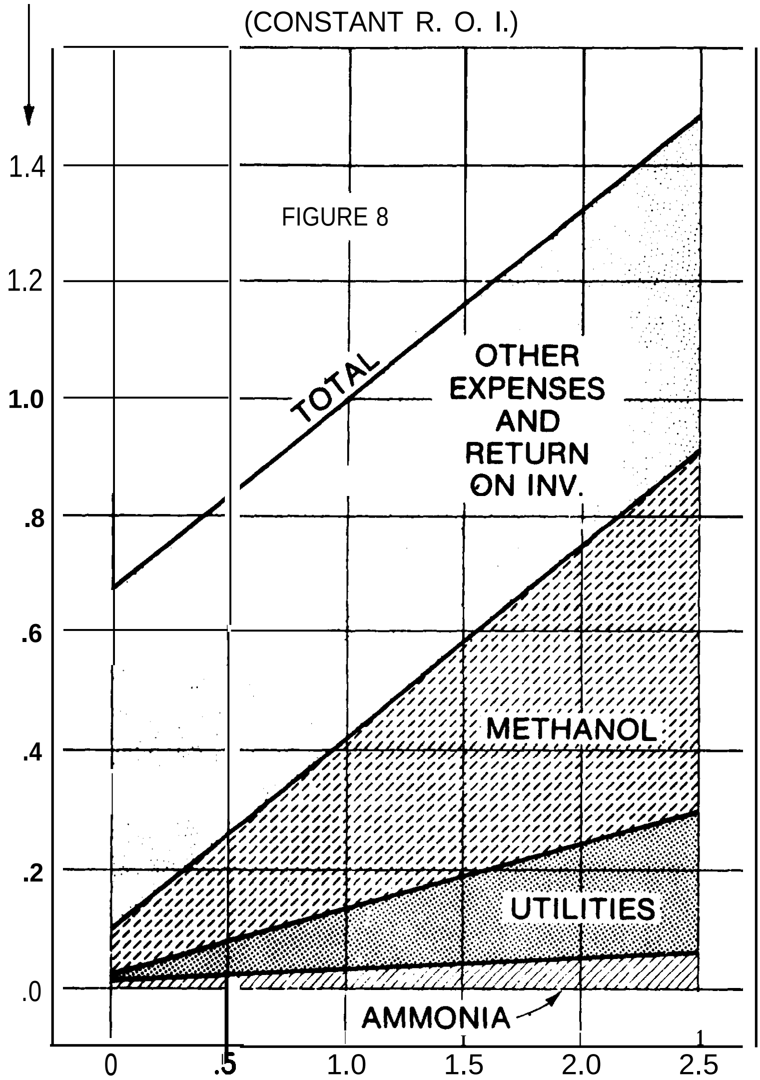
FIGURE 6

- **ANIMAL**
  - IN MIXED DRY FEEDS
  - IN MIXED LIQUID FEEDS
  - AS MILK EXTENDERS
  - "DOMINO" EFFECT
- **HUMAN**
  - WHOLE CELLS
  - ISOLATED PROTEIN
  - "STRUCTURED" ANALOGS
- **LOCALES**
- **INTRINSIC VS. EFFECTIVE DEMAND**


EFFECT OF TEMPERATURES
AND COOLING METHOD ON
SELLING PRICE OF SCP
AT CONSTANT R.O.I.
FIGURE 7
NOTE: COOLING WATER TEMPERATURE
PARAMETERS ARE AVERAGE OF
INLET AND OUTLET TEMPERATURE
OF THE COOLING WATER
REFRIGERATION
WITH 8.5° C
ΔT AND
36° C COOLING
WATER
(96° F)
36° C (96° F)
26° C (78° F)
16° C (61° F)
TEMPERATURE IN FERMENTER °C
TEMPERATURE IN FERMENTER °F
65
60
55
50
45
40
35
30
25
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
1.00
1.05
1.10
1.15
1.20
1.25
RELATIVE SCP SELLING PRICE FOB PLANT
(DIMENSIONLESS)

EFFECT OF ENERGY COSTS ON SELLING PRICE OF SINGLE CELL PROTEIN AT CONSTANT R.O.I.
(DIMENSIONLESS UNITS)

RELATIVE SCP SELLING PRICE FOB PLANT
(CONSTANT R. O. I.)



RELATIVE ENERGY COSTS

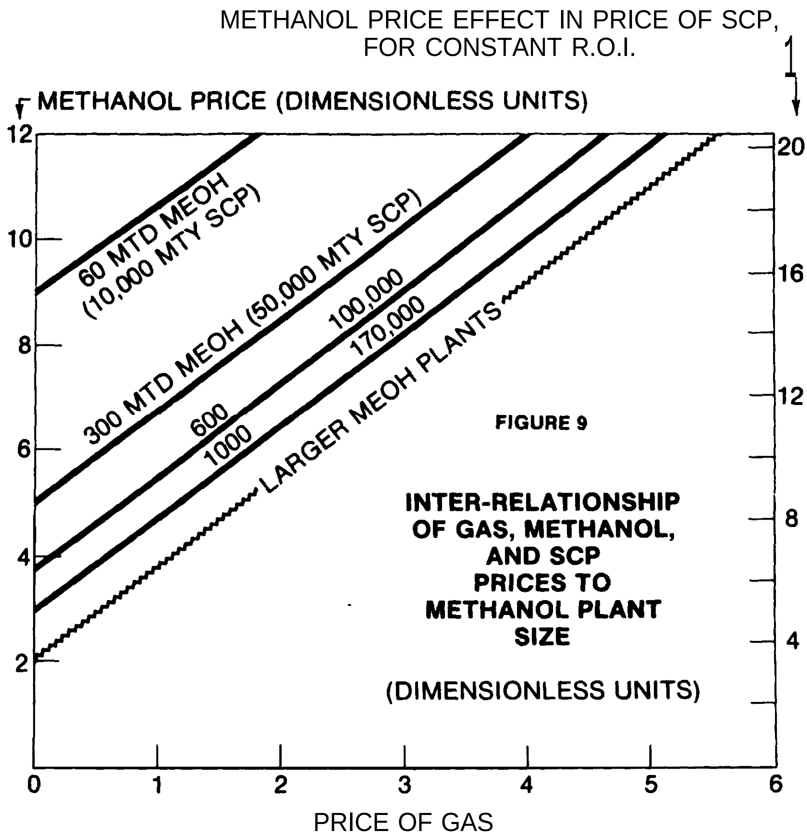
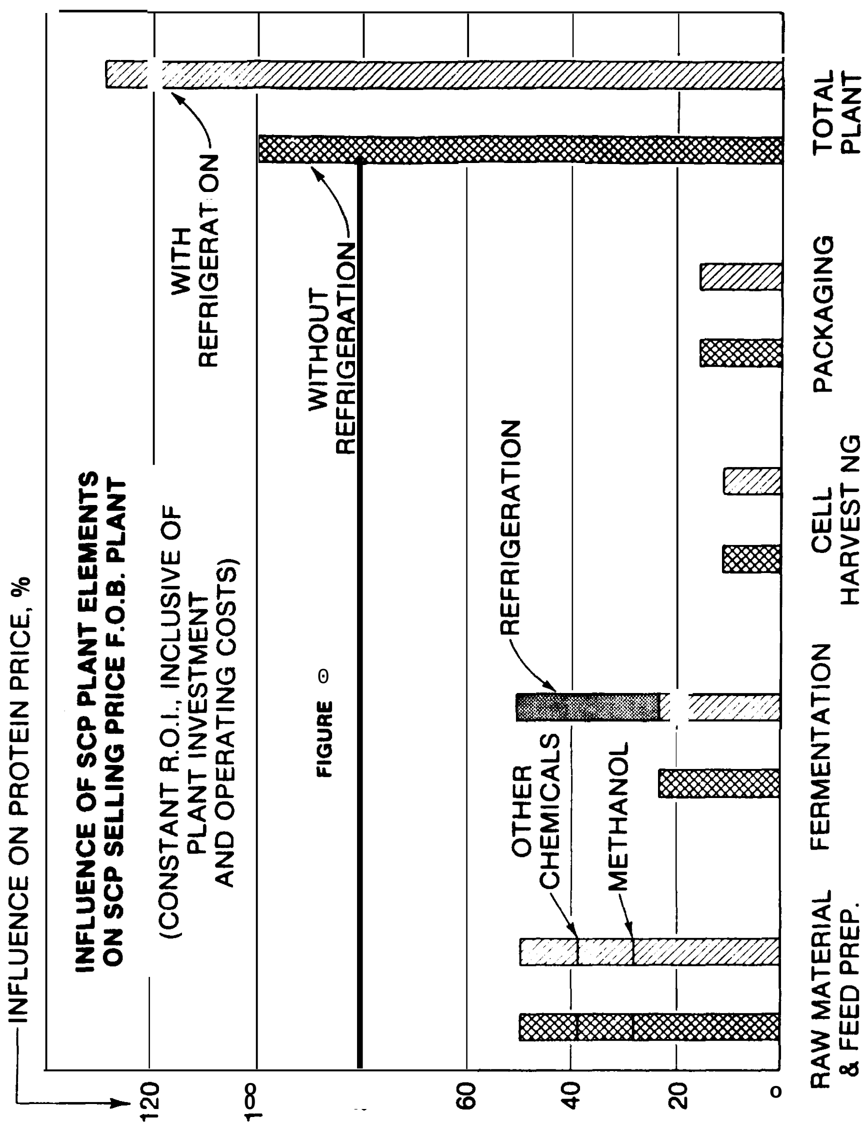


FIGURE 9

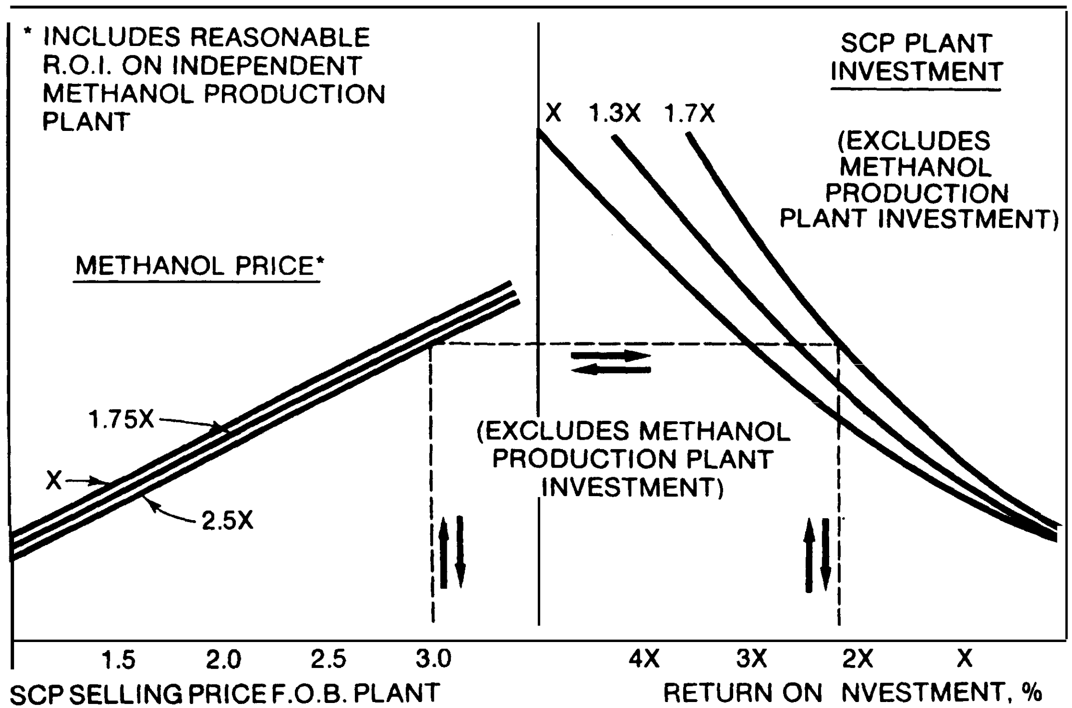
INTER-RELATIONSHIP OF GAS, METHANOL, AND SCP PRICES TO METHANOL PLANT SIZE

(DIMENSIONLESS UNITS)


INFLUENCE ON PROTEIN PRICE, %
INFLUENCE OF SCP PLANT ELEMENTS ON SCP SELLING PRICE F.O.B. PLANT
(CONSTANT R.O.I., INCLUSIVE OF PLANT INVESTMENT AND OPERATING COSTS)
FIGURE
WITH REFRIGERATION
WITHOUT REFRIGERATION
REFRIGERATION
OTHER CHEMICALS
METHANOL
120
100
60
40
20
0
RAW MATERIAL & FEED PREP.
FERMENTATION
CELL HARVESTING
PACKAGING
TOTAL PLANT

SINGLE CELL PROTEIN PLANT
100,000 TM/YR CAPACITY
MIDDLE EAST LOCATION
(DIMENSIONLESS UNITS)

FIGURE 11



APPENDIX B--EXHIBIT 2

[Excerpt from the Journal of Commerce, Aug. 27, 1973]

WORSENING FOOD SHORTAGES CALL FOR GLOBAL PLANNING

(By Emil A. Malick)

For decades international experts have warned of the need for massive, globally-integrated actions to relieve growing world food shortage. Yet the overall trend still goes from bad to worse, with protein most critical.

Paradoxically, in the face of shortages, science, agriculture and industry today have the latent ability to close the food gap to a greater extent than ever before in man's history.

New and improved technologies could, if the world works in concert, provide the foundation for orderly long-range relief of malnutrition-malnutrition that reveals itself not only as severe starvation but also, in its more insidious forms, as retarded mental and physical development of children and reduced intelligence and physical capacity for productive work in adults.

Like Gulliver straining at his bonds, industry is held back from making such inputs because of many unnecessary impediments to effective execution of new projects in many parts of the world.

Only government can cut the bonds . . . (by legislative actions that would) . . . transform high-risk, high-sensitivity ventures into ones that meet the minimum criteria under which private enterprise must work if it is to stay solvent.

In the past it was held that food demand would pivot on population growth, and that short-term upsets in grain production, which makes up 52 percent of man's food worldwide, could be covered by surplus reserves.

Now two new factors, both negative, have crept into the food equation.

One, rivaling population growth in its effect, is the rising affluence of many nations reflected by a desire for more meat. The other is the recent depletion of surplus agri-product stockpiles.

The yellow caution lights of the past have now turned red, clear to all except the color-blind. On a global scale the gap between supply and demand grows greater and world prices will hit unprecedented highs, hard to cope with by the affluent, impossible by the poor.

The half-hearted, disjointed efforts of the past have done little to curb population growth and world population will still probably double by the next generation, meaning three billion more mouths to feed.

If the present trend holds, fully 80 per cent of this growth will be in poorer nations where per capita income, often a scant $50 to $100 a year, cannot buy enough food to avoid malnutrition and starvation even at today's prices let alone those of the future.

The effect of rising affluence on greater meat demand may trend along U.S. lines, where per capita beef consumption rose from 55 pounds per year in 1940 to 117 pounds in 1972, roughly 900 per cent more per person than in Asia, and it is still rising.

Coupled with 60 per cent increase in U.S. population, U.S. consumption tripled in the same period and despite increased domestic production made the U.S. the world's leading importer of beef.

The feeding of animals for growth of meat protein requires great amounts of grain and legumes. Yet some of these same agri-products make up almost the entire directly-consumed diets of many people of the world.

Of today's three billion people one-third uses roughly as much grain to feed animals as the other two-thirds uses directly as food. In many poorer countries people eat on the average 400 pounds of grains a year, whereas in some more affluent countries per capita average runs nearly 2,000 pounds a year, of which only 150 pounds is consumed directly, the rest being fed to animals.

As a result agri-resources to support the average North American are seen to be some five times greater than those needed to support peoples elsewhere.

Feeding more grain to animals to meet rising meat demand will thus to some degree take grain out of the mouths of the people of poorer nations unless the latter, aided by massive domestic agri-programs, produce far more than in the past.

There is a way to break this "domino" effect. It calls for making better human use of the nutritious protein contained in oilseed crops, especially soybeans. Such protein can be extracted and "isolated" from oilseeds by means of currently available processes. The "isolates" can then be used for direct human consumption, either as bland supplements in other foods or, in more sophisticated forms, as tasty, nutritious high-protein "analogs" that resemble meat, poultry and fish.

By such means people would utilize "natural" agri-crop proteins at about 70 per cent "efficiency." In contrast, feeding soybeans, for example, to animals to cause them to grow protein for human use results in only 7 per cent "efficiency" of utilization of such "natural" proteins. The new technologies, now in limited production, thus permit man to make far better use of his agricultural resources.

Using oilseeds in this manner would, however, mean less of them for use as feeds for growth of animals. This could force lower per capita meat consumption, unless man creates new, less critical feeds to make up the deficit.

Here, the most exciting candidate is single cell protein (SCP) made by breeding, at rapid and efficient rates, select species of micro-organisms high in protein content. The "fermentation" processes employed use various substrates—hydrocarbons, hydrocarbon derivatives, others—as sources of energy to grow the SCP.

As yet such products have not been fully proven in the marketplace but their promise is great and massive in scale. Commercial plants are now being built abroad and may soon in the U.S. In time, with more development, some types of SCP may also become usable in human diet, adding still more needed protein to man's supply.

At best, however, neither the U.S. nor other nations can expect the U.S. to continue as the world's "breadbasket" for grains and feeds. Other nations must in time stand on their own feet in such respects.

Today the U.S. produces, for example, roughly 75 per cent of the world soybean crop. Of this an astonishing 90 per cent enters the world market. The U.S. has upped soybean output 400 per cent in the last 20 years, but mainly by planting more acres.

Now, roughly one out of seven acres in the U.S. is in soybeans and we are running out of suitable land and water for further increase, at least to the degree needed to meet growing world demand.

The new technologies are not just sophisticated "space age" types but also "grass roots" agricultural know-how that could open the way in less developed areas to tremendous increases in output of arable land and utilization of water. Rice yields per acre in India, for example, today average around one-third of Japan's and yield of corn in Brazil is aid to be one-third of U.S. acreage. There is much room for improvement, given the means-technology, financial support, incentives.

Acting in concert, world governments can use as a springboard for their efforts the extraordinarily thorough "Indicative World Plan (IWP)" of U.N.'s Food and Agriculture organization. Despite its detail (700 pages) the "IWP" is incomplete in many important aspects, as FAO itself points out, dealing as it does mainly with the developing countries but saying little about the developed nations which must interact with the others in any truly meaningful global plan. Still, the "IWP" can serve government and industry as a cornerstone. If governments continue to drag their heels and shortages get worse there will inevitably be the temptation to hit the panic button and to institute "crash", spot-remedy programs that will be far more costly and far less effective than orderly, well-integrated global planning. Awareness of this pitfall is growing.

All efforts, well-planned or not, will be futile in the long run unless the more developed countries demand that those that they would help, the nations today responsible for 80 per cent of the world's population growth, concurrently take forceful measures to check such growth. For unless the world simultaneously attends to both variables--population growth and food supply—the entire rationale fails to pieces and we can't get there from here.

And even under ideal conditions it is extremely unlikely that shortages, malnutrition and starvation can truly be "eliminated" in the foreseeable future. Maybe in distant years new sciences will achieve this utopian goal. Meanwhile, all we can do is to strive much harder to alleviate the problem.

APPENDIX B—EXHIBIT 8

[Excerpts of Statement by E. A. Malick* in the *Congressional Record* of Apr. 1, 1969]

WORLD FOOD DEVELOPMENT--ITS CHALLENGES AND OPPORTUNITIES

There are two words which characterize the present world food picture--*contradictions and confusion.* We read and hear that, on the one hand, there is a world food crisis that may bring civilization down to its knees and, on the other hand, that the crisis is not really a crisis, even though it looks like one to some, because better agriculture and other new technologies can cope with the crisis in time to avert worldwide disaster.

It is true. The specter does loom close. And it may exact its toll, not just in the form of starvation, but through many other side effects that starvation creates. These include social instability and greater susceptibility by the hungry to manipulation by those who would use hunger as a political weapon. Of concern to industry is also the prospect of potentially irreparable disorder and setback that mass hunger and attendant intellectual decline could create for future worldwide industrial growth.

The greatest tragedy, however, is none of this. It is that there is no *reason for the world to lack food. The* tragedy is not that industry lacks the ability to create vastly greater supplies of food, and with startling speed. It is that we are still *floundering on how to get the job done.* The greatest tragedy is the current lack of a hardhitting, single-minded, systems-oriented programming of effort to eradicate the food shortages in all corners of the earth. Working together, industry and government could without question assure an ample world food supply that can keep up with any presently projected growth in world population.

What the world is also starved for is innovative management and pragmatic programming of food development on a global scale. I use the word "management" to include both government and industry, each operating in its own sphere and planning broadly rather than piecemeal.

The chasm can be bridged only by an industry that is ready to apply bold new management insights that will result in programs as yet unconceived—programs that reflect integrated short and long-range considerations. And these must be built on the rock of economically viable enterprises rather than the sands of short-range problem solving and subsidies that in the long run weaken the recipients and dissipate the strength of the providers.

In such new programs industry will not be able to get by with conventional market development thinking regardless of how effective such patterns have been in the past in developed marketplaces. World food development is far more complex and is not susceptible to a same-song-second-verse approach. Of course, many of the variables are the same-financing, operations, promotion, marketing, distribution and the like. But these take on new forms in the case of world food development. Superimposed upon them in the case of food are new variables as well, the weighting of which may differ from program to program. Penetration of developed markets with products and services is one thing. Penetration of new food markets with new technologies, particularly in underdeveloped areas, is a horse of another color.

Each situation must be searched out and developed for itself, not by rote--and we, *rather than the customer,* must adjust to fit. We cannot equate the market with one or another (new) product or technology. Each is useful, Each has its place. But somewhere, not *everywhere.* Each is only a tool, and to insure successful application of these particular tools *innovative thinking* is essential. Lack of such innovative programs, custom fitted to each job, is what has made this market appear to many to be like punching a rubber bag.

In addition, programming has been badly fragmented. There are too many overlapping groups involved, each with a small piece of the action and each with a

* President of Provesta Corporation, a wholly-owned subsidiary of Phillips Petroleum Company.

different angle-political, social or economic. Governments everywhere must remodel their thinking to produce effective broad-spectrum programs, adopting viable economic patterns conceived by industry, rather than trying to have industry adapt itself to the varied, shifting and at times disoriented policies of momentary expediencies.

The potential sources of supply of new food are great. Altogether, such (new and improved) technologies could, according to some, support a world population of 50 billion people compared to the world's present 3½ billion or so. Here again, the accuracy of the projection is not important. What is important is that a great cleat more *can be done, even with today's know-how.*

These technological advances can be brought into highly developed countries as well as underdeveloped ones in a smooth, evolutionary manner, although the time scales and phasing for the two types of markets will differ. New sources of agricultural protein do not displace farming. They augment it. Protein from the sea and from microorganisms does not displace livestock and poultry. It adds to it, providing new sources of feed to more animals as well as directly to humans in time. Farming, animal growing and new technologies therefore phase together harmoniously.

There are many critical questions such markets pose: Corporate restraints on doing business; price controls; restrictions on choice of raw materials; poorly developed marketing and distributing; low per capita income; lack of domestic investment capital ; body english by government groups, and others.

But the job can be done if business management takes the initiative, devises the modus operandi, and government helps to clear the path. Both industry and government must accept these complementary roles (and) do the job in a manner that will create economically *sound industrial development.*

So far, governments have in the main part failed to adopt this (cooperative, cofunctioning) posture and industry has not been too clear on its own posture. But there are now encouraging signs that both see the light. Industry must bear the child. Government, as the sire, can benefit from the counsel the U.S. Navy used to give expectant fathers when they asked for leave to attend the birth of their offspring: The father is necessary only at the laying of the keel-not at the launching.

Actually, government and industry have very similar fiduciary responsibilities. Government must always, in principle at least, use the money of its stockholders, the taxpayers, to obtain good social and economic returns of investment of funds. Business works the same way. Each segment has the responsibility to its own stockholders to use its money to get a good return.

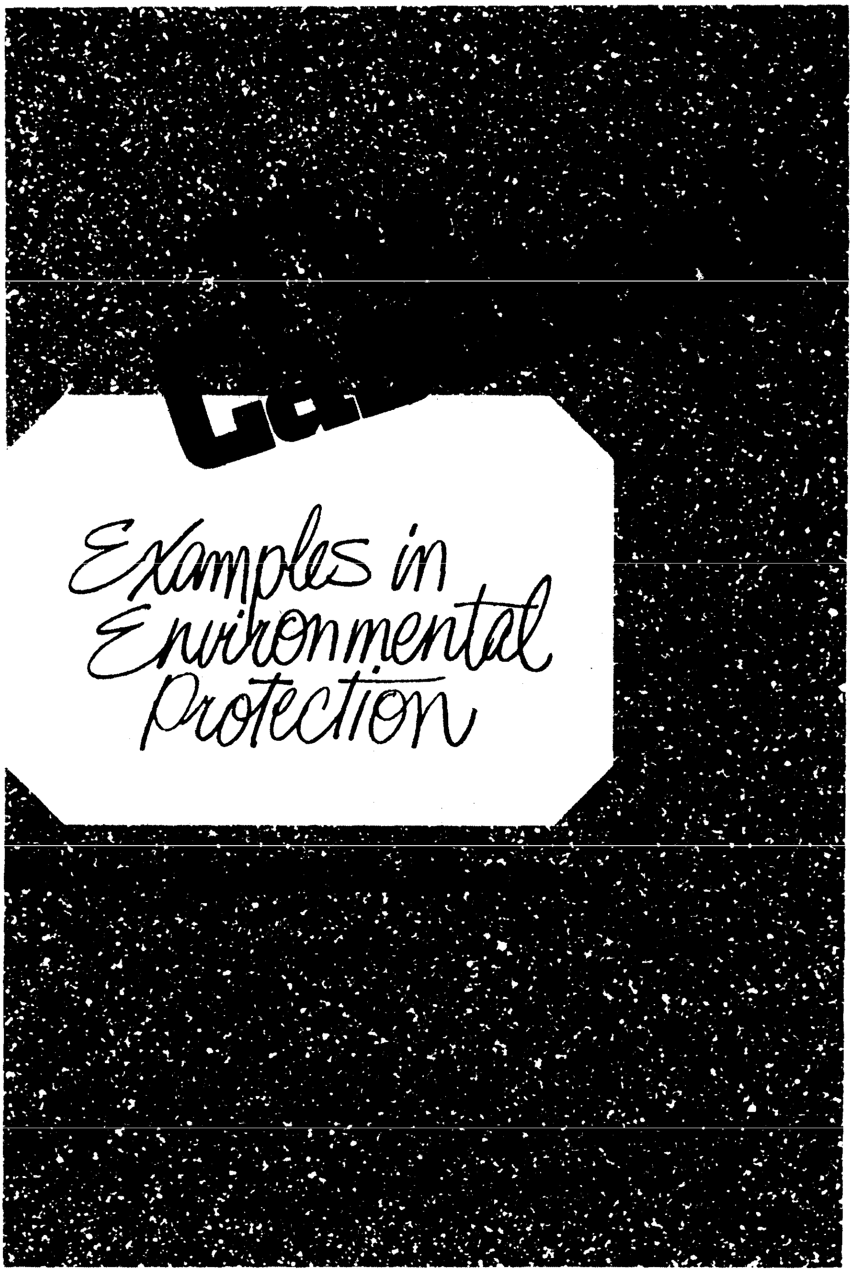
Government must relate to business. Business must relate to government. And both have to bend. Both have to help architect new vehicles to get the job done. In dealing with the food crisis, however, broad and concrete end-objectives have not yet been set, integrated timetables are non-existent, organization is not pinpointed, and lines of responsibility are not clearly delineated and not delegated—at least not to the degree needed.

There is growing awareness of this "organizational gap." But *there are as yet no strong signs that such a globally-planned effort (in food) will be put into being on the scale needed in time to avoid severe* social and *human disorder.*

Industry must apply all its skills of persuasion and capability for efficient performance to the task if for no reason other than to assure its own continued health and growth. It cannot flourish. without a healthy, alert, energetic and intelligent humanity. In nutrition, as in no other field, we now know that unless humans receive adequate and balanced diets early in life, actually starting prenatally, they will suffer to one degree or another irreparable damage to their brain cells. If the diet is grossly deficient at early stages, as it now is for large and growing numbers throughout the world, the net result will be people who throughout their lives will be underproductive in society.

Neither industry nor government could support *or* thrive under the burden of such an incapacitated mankind.

APPENDIX B.—EXHIBIT 4



To obtain the complete copy of this booklet, write: Public Relations Division, 4 D4, Phillips Petroleum Company, Bartlesville, Oklahoma 74004.

APPENDIX C-EXHIBIT 1

ENVIRONMENTAL IMPACTS OF COCA-COLA BEVERAGE CONTAINERS

(By Arsen Darnay and Gary Nuss)

PREFACE

The report examines and compares the total environmental impact associated with the manufacture, filling, and disposal of various beverage containers. Total environmental effects were evaluated and compared for eight different beverage container material systems. The study concept was conceived by Harry Teasley of Coca-Cola USA and articulated and executed by Midwest Research Institute.

Volume I is a summary of the study results. It describes in brief the research methodology and the study assumptions. Volume I contains comparisons of the eight container systems in each of the major environmental categories and includes the study team's speculations and judgments on the research findings.

Volume II is a detailed presentation of the rationale and calculations involved in arriving at estimates and measurements of the effects of each container system on the environment. Volume 11 contains individual chapters on each material system. These chapters include details on rationale, calculations, and data sources.

Principal researchers for MRI were Mr. Arsen Darnay and Mr. Gary Nuss. Additional contributions and research support and assistance were provided by Dr. Edward Lawless, Mr. Paul McNergney, Mr. Donald Heiman, Dr. Eugene Vandegrift, Mr. William Park, Mr. James Cross, and Miss Linda Crosswhite.

The authors wish also to acknowledge the aid and assistance of the beverage container manufacturers who provided data and perspective for the research effort--Chattanooga Glass Company, Owens-Illinois, Alcoa, Reynolds Aluminum, Monsanto Company, B. F. Goodrich Company, American Can Company, and Continental Can Company.

Approved for: Midwest Research Institute.

JOHN MCKELVEY,
Vice President,
Economics and Management Science.

INTRODUCTION

In the spring of 1970, Coca-Cola USA asked Midwest Research Institute to study the total environmental impacts caused by the production, use, and discard of beverage containers used by the company.

This assignment was the result of a staff study conducted by Coca-Cola USA headed by Mr. Harry E. Teasley, Jr., Product Manager, Packaging. The staff study was an exploration of the ways in which Coca-Cola's containers affected the environment. One conclusion of this study was that the interactions between the company's container systems and the environment represented a complicated set of material and energy transfers. The handling of beverage packages as components of solid waste was only one of many such transfers and possibly the least important one.

The Coca-Cola study team also concluded that information sufficient to inventory all major materials and energy transfers necessary to produce, fill, deliver, and dispose of beverage containers was not readily available but could probably be obtained.

Finally, the team concluded that an effort to create this body of information would be useful and enlightening and would create a better understanding of the total environmental impacts caused by beverage production and consumption.

Midwest Research Institute was asked to meet two objectives in its environmental study of beverage packaging and distribution:

1. To establish the total environmental impacts created by the use of each of several selected container systems available to Coca-Cola USA; and

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2. To compare the impacts of various types of containers under the assumption that each container type is used exclusively for Coca-Cola packaging.

The report presents MRI's conclusions. The study is a "first" in environmental research. In it, we attempt to give a "total" environmental profile of several products, showing all major material and energy transfers that can reasonably be identified. To the best of our knowledge, such profiles have not yet been developed for any other group of products, although the concept presented here and the method followed will, we believe, be widely used in the future to introduce environmental considerations as a new element in commercial and industrial planning.

RATIONALE AND APPROACH

The why's of environmental analysis

Pollution control in the conventional sense--the treatment of industrial effluents before discharge-is already a major new cost item in industrial practice. The national drive toward environmental cleanup, however, is now beginning to expand into novel directions. For one thing, the so-called "third pollution," solid waste generation, has been discovered, and proposed solutions to the waste problem include the recovery of wastes for industrial use, the reduction of waste generation at the source, and the raising of (revenues for waste disposal by imposition of disposal taxes on manufactured goods. For another, the fundamental connection between consumption and pollution is now common knowledge, and the curbing of consumption is viewed—rightly-as a simple way to arrest environmental deterioration.

These "new directions," if followed, mean a restriction of corporate freedom to act and higher operating as well as administrative costs. Industry, as a whole, appears willing to accept a reasonable limitation of its sphere of activity for environmental reasons-with emphasis on ***reasonable.*** But industry representatives are understandably anxious that in the sound and fury of our rush to clean up air, water, and land, reason will be the first casualty; and when the dust settles, industry will find itself fettered-while the environmental problems will still be with us.

At this point in time, the "good life" provided by industrial civilization conflicts with the ideal of a clean environment at many points. Pollution arises from fossil and nuclear fuels whose conversion in machines and use in production, transportation, communications, lighting, and heating is the foundation of the good life. Dispassionately considered, the environmental issue is an invitation to find a new balance between two "goods"—the good life and the good earth. A clean environment under medieval working conditions would be unacceptable to most. On the other hand, the good life is disappointing if it must be lived on a blighted globe.

A reasonable approach to the environmental issue must balance the various, and often conflicting, values we wish to increase. An indispensable prerequisite for such an approach is knowledge-knowledge of the environmental impacts created by our activities and the values we must give up in order to minimize those impacts.

Industry's best insurance against hasty legislation and intolerable strictures on its activities is to create understanding of its role in delivering values to the public—as well as the environmental insults that accompany such delivery. To do this is a tall order: it requires a high degree of objectivity and institutional maturity. Self-analysis, if honest, always runs the risk of finding fault. But ultimately, it is to industry's benefit to participate in the environmental debate in an objective manner. Only such participation can guarantee that a reasonable balance between our various needs can be established.

This study is an exercise in self-analysis. It is an answer to the question posed by one company : "What is our contribution to environmental pollution ?"

Study approach

This study concerns itself with the use of containers in Coca-Cola product distribution. Beverage production is one of the cleanest industrial operations. Few pollutants and little waste reach the environment from the filling plant. But beverage production requires large quantities of containers whose manufacture generates pollution, and the containers are ultimately disposed of as solid waste after a single or multiple use.

Coca-Cola USA wanted to know not only the environmental impacts caused in the beverage packaging and distribution phase of its operations but also the nature and magnitude of impacts caused on its behalf by others. Two specific aspects of Coca-Cola operations—the raising and harvesting of products that become beverage components and the production of syrup-were excluded from the analysis.

The approach adopted was that of tracing a beverage container "back" through the various fabrication, processing, and mining/extraction steps necessary for its manufacture and delivery to the filling plant, to study its behavior in the filling plant itself, and then to trace it "forward" into consumption, discard, and disposal operations. Analysis of returnable containers also required a look at the "return loop" whereby these bottles are brought back to the filling plant for repeated use. A return loop was also studied in analyzing the environmental impact of aluminum cans under various assumed rates of recycling of obsolete aluminum cans.

We selected the measure of 1 million beverage units (fillings) delivered to market as the analytical base. Next, we traced eight container systems (five proven and three experimental) through nine operations, and within each operation we looked for eight specific environmental impacts. The study approach is depicted conceptually in Figure 1.

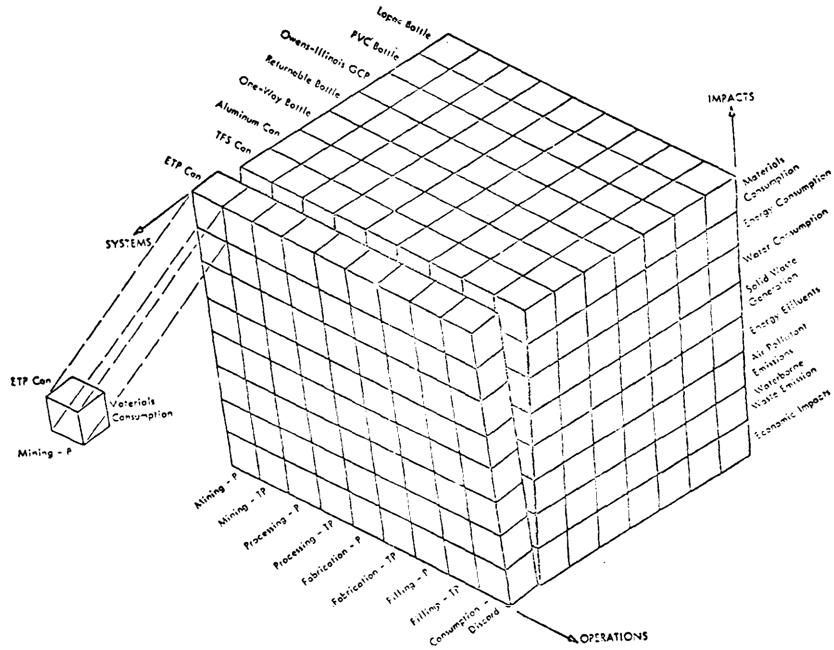

Figure 1 - Research Concept

Container systems.—Three metal containers, two glass containers, a combination glass-plastic package, and two plastic containers were selected for analysis: the electrolytic tin plate steel can (ETP can), the tin free steel can (TFS can), the aluminum can, the one-way glass bottle (OWB), the returnable glass bottle (RB), the Owens Illinois GCP container, a polyvinyl chloride (PVC) bottle, and the Monsanto Lopac plastic bottle.

Because data from Coca-Cola on filling and distribution operations were available only for 12-fluid-ounce-capacity cans and lo-fluid-ounce-capacity glass bottles-which in fact compete for market shares on an equivalent basis—these sizes only were studied and compared. Filing and distribution data on the GCP, PVC and Lopac containers were not available; these are experimental systems; in our calculations, we assumed that they would behave in the same way as one-way glass bottles.

Impacts measured.--The basic thrust of the research was to measure impacts on atmospheric quality, water quality, and on land (in the **form of solid** waste generation). Two additional measures, however, were also introduced: impact

on natural resources, measured in terms of materials and energy consumed, and impacts on foreign trade, measured in terms of import levels required for a given container system.

Following our research and analysis, we found that data could be presented, more or less accurately, in the following eight impact areas:

1. Materials consumption, including all materials needed for making the product but excluding water and fuels.

2. Energy consumption, broken down by type of fuel and by point of use (i.e., mining, processing, fabrication, filling, and in transportation associated with these activities, and with disposal). Energy consumption is uniformly shown in million British thermal units (Btu).

8. Water use, by point of use, given in 1,000 gallons.

4. Solid waste generation, including mining wastes; processing, fabrication, and filling wastes; and discarded containers as waste.

5. Energy effluents, including airborne particulate matter, nitrogen oxides, hydrocarbons, sulfur oxides, carbon monoxide, aldehydes, and other organics, and lead.

6. Air pollutants emitted in processing and fabrication, excluding pollutants generated by combustion of fuels.

7. Waterborne wastes generated, excluding such wastes as are generated in mining operations, which are included with mine tailings.

S. Economic impacts that result from waste management and the purchase of materials from foreign countries.

Operations analyzed.—The **initial study design called for the analysis of seven specific operations which together represent the total beverage container production-use-disposal system: mining/extraction, processing, fabrication, filling, retail distribution, consumption, disposal, and transportation steps between operations.**

In the metal and plastic container sectors, processing is a multistage operation which could be broken down into a number of processing steps. In the glass sector, processing and fabrication are combined into a single operation. In spite of these differences, we retained the original operation breakdowns for mining, processing, fabrication, and filling. But we found it more practical in dealing with environmental impacts to combine all operations after filling into a single "consumption-disposal" category. Finally, we treated transportation between operations as a special operational step throughout. Thus, in this report, impacts are measured in the following operations: Mining-Process, Mining-Transport, Processing-P, Processing-T, Fabrication-P, Fabrication-T, Filling-P, Filling-T, and Consumption/Discard-T.

The study results are quantitative, Impacts caused by the delivery to market of 1 million fillings in various containers are shown in measurements appropriate to the impact. We were not asked and made no attempt to establish what damages or hazards are caused by various pollutants emitted; we only recorded the quantities produced in such a manner that the container systems can be compared to each other.

Methodology

The methodology used is discussed in detail in the Appendices where detailed data are presented. Discussion of methodology in general terms is impractical because of the multiplicity of actions that have to be explained—which is best accomplished with direct reference to the data used. However, some comments on procedure can be generalized.

Analysis began with a determination of the physical components of each container and closure, by weight, and the gross quantity of each required as input into the container manufacturing plant for a given unit of container output. This information was provided by container manufacturers.

Next, the number of containers required to deliver 1 million fillings of beverage was determined from data provided by Coca-Cola.

These two sets of data were then combined to establish the total processed materials required as inputs to the container fabrication operation.

Analysis of the materials processing operations resulted in information on the types and quantities of raw materials needed at each processing stage per unit of output, and processing input requirements represented quantities of raw materials that had to be mined or extracted in mining operations.

Consumption of energy per unit of output in the various operations was determined either from census data or from industrial sources. **Data were obtained** by type of fuel or energy consumed; these data were expressed uniformly in million Btu using published conversion factors. Energy consumption data per operation output unit were multiplied by the number of units needed for 1 million fillings to yield total energy requirements.

Water consumption data were obtained in the same way as energy data.

By using national transportation statistical sources (Interstate Commerce Commission data for rail and truck movements and U.S. Corps of Engineers data for barge traffic), the average distance that various commodities are moved by transportation mode and the percentage of tonnage moved represented by each mode were established. Data on movement of containers to filling plants, from filling plants to retail outlets, and the movement of empty containers to disposal sites were determined from company sources and from other published reports.

Next, total ton-miles of movement by transportation mode and total fuel consumption, by type of fuel, per ton mile were established from national statistics, so that average energy consumption values in transportation could be used.

Data on transportation energy consumption between various operations were calculated by multiplying tons of materials required for 1 million fillings by average distance moved by mode and by average energy consumption per ton-mile. In addition to commodity and product movements, of courses, the weight of packing also had to be taken into consideration to obtain realistic values.

Using federally sponsored research reports on air pollution generation, energy effluent factors were established by unit of fuel combusted in various stationary and mobile conversion/combustion units. These factors, multiplied by energy consumption in the various operations and transportation steps, resulted in the measures of energy effluent generation.

Assembly of data on (1) mining, processing, fabrication, and filling waste production; (2) waterborne waste generation; and (3) airborne waste generation (other than energy effluents) depended on a large number of data sources, some of them corporate, some federal research reports, some statistical sources such as the Bureau of Mines annual reports. In some cases, waste generation was estimated based on analysis of materials balances in the processes involved.

Where a container and its closure consisted of more than one material, separate studies of each material had to be undertaken and combined to yield a total for the container system.

Study Limitations

To establish the total environmental profile of products is a new departure in product analysis. Such studies, until the present, would have served no valid commercial purpose. Not surprisingly, therefore, few if any companies have the reporting systems that can deliver information to make environmental judgments about their products.

This state of affairs required MRI to seek information from many different sources, published at different times, using different bases. Many information elements needed were not available in published form and had to be gathered by personal visits to companies. Much of the effort was devoted to the assembly of necessary data and information and to the reconciliation of conflicting information and information referring to different time periods. Some of our data came from industry surveys, some from conservation with two or three companies. Some corporations, because of the nature of their industry, could not reveal information on their operations, and we were forced to estimate impacts by analogy with other industries or by selecting an impact level from a wide range of reported impacts.

For these reasons, the data presented here should be viewed as good approximations of the truth but subject to revision as better information becomes available.

Information on the experimental container systems is understandably more sketchy than on the established packages. Among established packages, data on aluminum containers were taken almost entirely from published sources since industry representatives could not reveal operating data; such data are considered proprietary.

Study Assumptions

Research of the type conducted here, where problems of data accuracy, absence of information, and other analytical difficulties have to be dealt with, must necessarily make use of assumptions to allow completion of the work. We consider

the assumptions used extremely important in qualifying the findings and so wish to make them explicit at the outset.

Geographical scope.—Since the **environment by definition includes all of inner and to some extent outer space, this study could not have been completed unless geographical boundaries had been set for impact measurement. Thus, we assumed that only those environmental impacts would be measured which occur within the boundaries of the Continental United States. Thus, for instance, mining wastes generated and energy consumed in mining iron ore or bauxite in a foreign country for import to the U.S. are not reflected in impact measurements.**

Operations measured.-In addition to a geographical boundary, we also set an operational boundary, assuming that only those impacts are measured which **occur in** *direct* connection with an operation involved in the production, use, and disposal of containers. Thus, energy consumption, pollution and waste generation, and water use are measured for mining iron ore, fluxing limestone, and coking coal necessary for pig iron production. But the same impacts are not measured for the mining of coal burned to generate electricity which is, in turn, used in mining and processing of raw materials and the fabrication and filling of cans. Impacts related to the production and delivery of fuels are considered *indirect* impacts and are not reflected in the analysis.

Materials exclusions.--Our work would have been unmanageable if we had been required to trace the impacts of all materials necessary for the production. delivery. and use of beverage containers. Materials used in small quantities such as tin in ETP cans; chromium in TFS cans; feldspar and other minor materials in glass manufacturing: plastic gaskets in closures: inks, lacquers. and sealents in can production : and packing materials of all kinds were simply added to the total weight that had to be handled: they were not traced back to their origins.

Transportation assumptions.—Several assumptions were made concerning transportation, as follows:

1. Rail.—Whi1e electrical power is reportedly used to power some rail movements, we made the simplifying assumption that all rail movements were diesel **powered.**

2. *Truck.—We* assumed that all truck transport, except that used in filling and disposal, would be provided by both diesel and gasoline powered vehicles in proportions as experienced nationally for both inter- and intracity movements.

3. *Filling transport.—Data* **provided by Coca-Cola were assumed to be representative** for each type of container. It was assumed that cans are transported to warehouses by diesel truck and from warehouses to retail establishments by gasoline truck. We assumed that experimental containers on which data in filling transport were unavailable, would move in the same way as the traditional container they most resembled--this Lopac and PVC like the one-way bottle, the GCP like the cans.

4. *Retail to point of consumption.--We* did not attempt to measure transportation requirements from point-of-purchase to point-of-consumption nor, where applicable, the transportation required for returning empty, returnable containers to retail outlets by consumers.

5. Disposal movement.—Based on surveys conducted by Combustion Engineering Company, we assumed that all solid wastes moved 6.5 miles and that this movement was by gasoline powered truck.

Electrical energy.—As a simplifying step, we assumed that all electrical energy used in any part of the beverage system comes from coal, oil, natural gas, and hydroelectric facilities in proportions as experienced nationally. Also, in measuring electrical energy consumption, we used as ameasure 10,600 Btu per kilowatt-hour [1]—the fuel energy required to generate this unit of energy on a national basis—rather than the theoretical equivalent value of a kilowatt-hour, 3,413 Btu.

Since aluminum production consumes proportionately more hydroelectric prover than all consumers of electricity, our assumption may seem to overstate, slightly. the quantities of fuel consumed in aluminum production and the quantities of pollutants emitted as a consequence of fuel combustion for electrical generation. This point is discussed further below.

Size equivalency.--Since data from Coca-Cola on filling and transport operations were given to us for 12-ounce cans and 10-ounce bottles and. furthermore, because these two types of containers compete on an equivalent basis in the marketplace, we assumed that they are equivalent for purposes of environmental comparison, in spite of the fact that on a unit-by-unit basis more liquid is delivered in cans than bottles in this case. The data presented. of course, can be used

[1] Derivation of this value is presented in Appendix A, volume II, of this report.

to express equivalency between quantities of liquid delivered, in which case fewer-cans are used and the environmental impacts of the can systems would be proportionately lower—approximately ten-twelfths or 17.7 percent.

Trippage.--Based on Coca-Cola's experience at the time of initiation of this work, we assumed that returnable bottles make an average of 15 trips before either breaking or being rejected as no longer serviceable. Consequently, one returnable container is equivalent to 15 nonreturnable containers in the impact analysis.

Plastic containers.—In the cases of beverage containers made of conventional materials--steel, glass, aluminum-processing steps and material requirements are defined largely by the particular material used. This situation does not exist with plastic containers. A particular plastic material may be derived from several different raw materials and by several different processes.

Ethylene is a starting material for both the GCP polyethylene cup and the PVC bottle. In the U.S. most ethylene is derived from liquid hydro-carbons--ethane or propane-extracted from natural gas; moreover, most plants to be built in the future will probably also be based on ethane-propane given current conditions.[2] Since the study team obtained direct manufacturer's data and experience on ethylene produced from propane feedstock, our analysis of ethylene production is based on propane as a feedstock.

Lopac is a proprietary polymer developed by Monsanto Company; and due to its newness and the company's proprietary interests, data on specific Lopac processes and requirements were not made available to MRI. Our analysis, therefore, is based on analogous processes and materials.

Monsanto recommended that Lopac monomer production be based on acrylonitrile production and that Lopac polymer production be based on PVC polymerization processes. These suggestions were incorporated into our analysis.

Acrylonitrile is produced from a propylene feedstock, and propylene may be derived either as a by-product of gasoline manufacturing operations or from ethylene production from propane feedstock. Although most propylene is obtained from gasoline operations, our study assumes the propylene required is a by-product of ethylene produced from propane. This assumption places Lopac on the same basis for material requirements and mining-extraction impacts as the other plastic or plastic-containing systems.

To obtain the propane feedstock for conversion to plastic raw materials requires two processing steps which are classed as mining-extraction operations for this analysis. The first step is recovery of natural gas from the gas field ; the second step is extraction of propane from the natural gas at a natural gas plant. In the latter operation various airborne effluents are generated and emitted from the process; although these effluents are the same types as the effluents from energy consumption, they are classified as mining wastes since they are process wastes occurring in the mining-extraction operation.

One drawback to the use of PVC—in any type of packaging--is the formation of hydrogen chloride (HCI) when PVC is incinerated. Because of this particularly noxious effluent and the difficulties it creates in incinerators, the study team concluded HCI should be included in the energy effluents total for PVC. Since roughly 14 percent of the nation's solid waste is incinerated, 14 percent of the waste PVC going to disposal was considered to be incinerated. This ratio was used to estimate total HCI emissions from the incineration of PVC wastes generated by the manufacture and use of 1.01 million containers. These effluents were included as "energy effluents" in disposal operations rather than as "process wastes" because it was felt that the HCI emissions should carry a weight of 0.4 instead of 0.1.

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[2] Of the two materials, propane has had an economic advantage over ethane because of by-product credits. In addition, propane is more easily transported than ethane, although an ethane feedstock gives a greater yield of ethylene.

APPENDIX C—EXHIBIT 2

AUTOMOBILE POWER SYSTEMS EVALUATION STUDY

STATEMENT OF OBJECTIVES

As part of its continuing efforts to assure that the best possible automotive power systems are made available on an appropriate time schedule, Ford Motor Company is awarding a study grant to support independent research studies and technical appraisals of potentially promising alternatives to the internal combustion engine.

The overall objective of these evacuations is to provide independent, objective guidelines for achieving and maintaining optimum vehicle characteristics with respect to national needs and desires for clean air, conservation of non-renewable natural resources, improved safety and general betterment of mobility and quality of life within an affordable economic framework.

A concomitant general objective of the evaluations is the proper timing of actions relating to power system changes—the research and development lead-times for various propulsion alternatives, time-phasing of logistical support and infrastructure development, feasible rate schedules for large-scale conversion to alternative systems, etc. In other words, the overriding questions relate not to *what can be done,* but to *what should be done and when* in **order to gain significant advantages over today's internal combustion engine and its logical and likely evolutionary derivatives. It is expected then that comparisons of all alternatives will be made against a moving baseline of timely improvements and extensions of present engine technology. For all comparisons, the time-frame of greatest interest is the decade 1980-1990,** but study attention must extend well beyond this period to comprehend such things as resource availabilities including potential for different fuels; full-conversion evaluations and economic implications.

Specific objectives with respect to each admissible alternative course of action would include the following:

A. An engineering appraisal, including identification of operational characteristics and parameters, of major unresolved technical considerations, including time and cost estimates for their probable resolution.

B. A determination of the earliest feasible and practicable large-scale conversion of vehicles to the system, with an estimate of the most reasonable conversion rate.

C. An assessment of the probable total aggregate economics, natural resource, environmental and societal impacts Of the conversion, including production, logistic and energy support requirements. Here, explicit attention should be directed to forecasting and bounding future motor vehicle use, taking into account changed land use policies, new life styles and the probable increased availability of public transportation.

D. An overall comparative evaluation in relation to forecasted internal combustion engine technology, including the engine improvement information that has been provided to the National Academy of Sciences.

E. Explicit development of manufacturing costs for major system components, treating them parametrically where costing uncertainties so dictate. Here, extensive use of sensitivity testing would be indicated to define cost targets critical to decision choices.

F. Categorization of research and development requirements into tasks that logically call for either government funding or industry funding, depending on the size of commitment time for payback, recipient of the benefits, probability of success, etc.

During the course of this effort, Ford will make available information on present internal combustion engine technology to the extent that such information would not be prejudicial to any patent or proprietary interest. Ford will also make available alternate engine information such as that already provided to the Environmental Protection **Agency and the National Academy of Sciences.**

Our parallel efforts to forecast technology and socioeconomic and environmental factors will not be made available in order to avoid introducing an appearance of bias or lack of objectivity in the study.

Finally, it is our desire that the results of the study be made available to the public in published form without prior editing or approval by Ford Motor Company. The product is the sole responsibility of Cal Tech JPL.

APPENDIX C-EXHIBIT 3

1975 GENERAL MOTORS REPORT ON PROGRAMS OF PUBLIC INTEREST

[To obtain a copy of the full report, write to: General Motors Corp., Detroit, Mich. 48202.]

APPENDIX C-EXHIBIT 4

TECHNOLOGY ASSESSMENT IN BELL CANADA[1]

(By Lawrence H. Day, Assistant Director—Business Planning, Bell Canada)

INTRODUCTION

The information in this report outlines the process and activities associated with technology assessment (TA) in Bell Canada. This material is presented to the Technology Assessment Board of the U.S. Congress in the belief that the sharing of these experiences will contribute to the continuing dialogue on the value of TA. The following views should be considered as the author's opinion of how TA is conducted in Bell Canada, and not considered as a formal statement of corporate policy.

The report begins with a brief introduction to Bell Canada. The function of the author's organization in Bell Canada, the Business Planning Group, is elaborated in some detail since this is the Group that has conducted or sponsored the major TA activities in Bell Canada. The document continues with a review of some of these activities, with special emphasis placed upon our work in the substitution of telecommunications for travel, and its resultant impacts. The next section deals with a current review of the social impacts of a new electronic polling service that the corporation is currently considering. The last part of the paper will review some of the lessons we have learned in the past four years, and the author's opinions of where TA will fit in the future in both Bell Canada and the corporate environment in general.

BELL CANADA AND THE PLANNING GROUP

BELL CANADA

Bell Canada is Canada's largest provider of telecommunications services. It operates as a corporate entity in the Provinces of Ontario and Quebec. Other key organizations in Canadian telecommunications are described below. Bell Canada operates in association with the Trans-Canada Telephone System (TCTS) for the provision of nationwide telecommunications services. The TCTS is composed of eight organizations (Bell Canada, three Bell owned or controlled, three owned by Provincial governments, and one a subsidiary of a U.S. corporation, General Telephone). The TCTS competes nationwide with CN-CP Telecommunications in the voice, data, and visual telecommunications businesses. Other organizations include TeleGlobe Canada, the Federal Government owned carrier for overseas telecommunications, and Telesat Canada which is a joint public-private corporation for the provision of satellite telecommunications within Canada.

Bell Canada is Canadian owned and controlled and is not associated with the American Telephone and Telegraph Corporation. Bell Canada owns its own manufacturing organization. Northern Telecom. Northern Telcom. is not a captive supplier in the traditional sense, Bell owns 62 percent of the shares but only buys slightly more than 50 percent of Northern's output. The rest is sold to other Canadian and foreign firms. including over $100 million in sales in the U.S. Bell Canada and Northern jointly own Bell-Northern Research which is Canada's largest industrial research organization. Another key subsidiary is Tele Direct which handles Directory (Yellow Pages) sales and publication in Canada. Consolidated operating and sales revenues for Bell Canada in 1975 were approximately $3 billion.

[1] Much of the material in this document has been published in previous Business Planning reports and papers. The publications list in Appendix 3 is provided to keep references to internal documents to a minimum.

THE BUSINESS PLANNING GROUP (BPG)

BACKGROUND

Forecasting has been an established function at Bell Canada and the telecommunications industry for many decades. In the past however, forecasting has been oriented toward identifying both customer demand patterns and technological change. The BPG was created in the mid-1960s to conduct new forms of research and planning, not to duplicate or consolidate any existing planning or forecasting function in Bell. Within the context of a rapidly changing environment, it is the BPG's objective to position itself through research, information collection, and analyses to be capable at all times of advising decision-makers on possible future business opportunities, threats, and their impacts on the corporate environment. The opportunities and impacts that concern the Business Planners are those that might arise through technological, economic, social, or market developments in the intermediate (5 to 15 years) and longer term future.

The Group's mission and approach to its research may be delineated further through a brief examination of some of the project areas and techniques used to conduct these various analyses. One area of research is a multifaceted examination of the potential of future trade-offs between travel and communications. This research examines the technological, economic, behavioral, energy, environmental, and government policy issues associated with the substitution question. Another project reviews a similar range of issues associated with potential social impacts of "wired city" services. Both of the above two areas will be examined in more detail in the review of Bell Canada TA activities. Other areas of concern involve evaluation and testing of various approaches to computer conferencing and future '{paperless offices" (described briefly below). All of these projects, and others not discussed here, have involved the use of a variety of techniques and support capabilities that are important in the BPG's research. Several are described below.

TECHNIQUES AND RESEARCH AREAS

TREND EXTRAPOLATION

Perhaps the most basic form of futures research in many business planning efforts involve the use bath of regression analysis and judgmental trend projections. Sample areas explored include expected changes in the Canadian gross national product (GNP) to the year 2000, corporate revenue and expense components, Canadian energy trends, and computer market trends. One project involved using the concepts of "S" curve forecasting for products and services in the early and rapid stage of growth. This overall concept utilized the idea of diffusion growth of services or products throughout an industry from an initial pace-setter.

THE DELPHI APPROACH

Six major Delphi studies have been conducted by the BPG. Over 215 panelists explored the future of education, medicine, business information systems, and future communications systems in the home. The main thrust of these studies was to identify emerging trends and changes that would have an impact on needs for visual and computer communications. The studies were market-oriented and forecasted the adoption of various services at defined threshold levels. Market adoption and not technological breakthroughs was the prime criterion used. Each of the forecasts was presented in a social framework developed by the Delphi panelists. Various structural and social changes expected in the relevant professions considered were also forecasted.

SPRITE (SEQUENTIAL POLLING AND REVIEW OF INTERACTING TEAMS OF EXPERTS)

This is a new methodology developed by the BPG that modifies the Delphi process as originally defined by the RAND Corporation. SPRITE utilizes the concept of controlled debate and feedback to uncover impacts resulting from the uses of technology. Here consensus is not a goal as it is in Delphi studies. The panelists offer assessments that are presented from the point of view of an interest group. These views are not summarized in overall study averages but remain independent for counter analysis by other interest groups. Hence, SPRITE is a valuable tool for TA studies. The methodology was applied to two studies of future communications into the home. The services examined included Shopping from the

Home, Checkless Banking, Programmed Education, Home Security Services, and ten forms of information retrieval service that could be used in the home.

SURVEY RESEARCH

The BPG has used survey research in a number of its projects. For example, a large scale survey of business travelers was conducted to provide behavioral data for a project on the potential of long term trade-offs between travel and communications services.

CROSS IMPACT ANALYSES

The technique of cross impact analysis has proved to be a valuable aid in explicitly stating assumptions of the interrelationships and interdependencies in the development of new forecasts. The technique is used to represent relationships of variables in a complex environment, and present the summary in a meaningful fashion. Recent experience enables us to identify four major attributes of the technique: (1) an educational process takes place in the garnering of data since people must think over complicated relationships in a structured manner; (2) a communication process takes place since answers are usually obtained by having several panelists in the same room vote and discuss their answers; (3) a summarization process takes place after the data has been gathered since many people's opinions on various topics are mirrored back to them on one matrix, thus enabling the drawing of conclusions using this one matrix as a reference; and (4) a computer-based sensitivity analysis can be run on the data to simulate the influence of sudden changes in policy. This can lead to counter-intuitive results that provide new perspectives for decision-makers.

Of course, the ultimate limitation of cross impact, and indeed any Delphi-like process, is the accuracy or inaccuracy of the raw data. However, benefits that should be expected are the possibilities for education, communication, and summarization of complex policy environments often found in interdisciplinary research. The BPG has studied the cross impact technique extensively, and has published several critical documents on its potential for futures planning. The group has also applied the technique in several of its major TAs. Cross impact analysis has also been used by the group to analyze several corporate policy issues. This involved the use of a specially prepared computer analysis package. The BPG has also assisted several Canadian government departments and corporations in the use of cross impact analysis.

The above paragraphs describe several techniques used for technological forecasting and assessment. The BPG also uses powerful computer support tools as well. The "Paperless Office" trial is an important example.

THE "PAPERLESS OFFICE" TRIAL

NLS (the On-Line System) is a concept conceived over ten years ago at the Stanford Research Institute (SRI). In 1973, the BPG became the first corporate organization to agree to subscribe to the NLS experimental system. The BPG now participates as a real-world user and has undertaken an extensive assessment of the system from the user and social point of view.

The NLS is a highly refined information retrieval, text editing, electronic mail, and teleconferencing system designed to aid the "knowledge worker" by facilitating the rapid organization and preparation of text-based information. The system's ideal, as originally conceived, is to "augment the human intellect". The system provides a means through which information can be more readily generated, processed, and retrieved. Ideas are exchanged in an ongoing mode, with a shared data base of journals, reports, and projects that are available to all NLS participants.

Members of the BPG, both the professional and support staff', have direct access to NLS through terminals located in the BPG offices. Portable terminals are also available to facilitate working from remote locations, that is, working from the home or from distant cities. In addition to using NLS for daily office functions (report writing, memo storage, message sending, etc.), the BPG is using NLS to build its internal computerized data base, which supplements the shared NLS data base of a broader scope.

THE STAFF

An examination of the formal training of the various Business Planners shows that Group members have a wide variety of educational backgrounds. This includes advanced degrees in business administration, electrical engineering, marketing, political science, public administration, arts, computer sciences, linguistics, and economics. Regardless of the educational backgrounds of the individual planners, they are all encouraged to be generalists. Hence the approach to problems is from the point of view of a generalist rather than a subject specialist. In addition, specialized skills in various technical, behavioral, and legal areas are obtained on a consulting "as required" basis rather than through permanent hiring. Past experience has shown that these specialists tend to become cut off from their parent disciplines if they become full-time planners. This is often to the disadvantage of both the Group and the individual. One slightly unusual aspect of BPG staffing is the fact that many group members have degrees in business administration. This is not common for technological forecasting and assessment or futurist groups but it has resulted in a healthy generalist atmosphere in the Group.

TECHNOLOGY ASSESSMENT IN BELL CANADA

INTRODUCTION

The TA work at Bell Canada was initiated by the BPG in 1972. At the time, this was regarded" as a logical extension of the technological forecasting activities underway in the Group. This extension was undertaken at the initiative of the Group management rather than under specific direction from senior management. This was not unusual since the vast majority of Group projects have been initiated internally rather than assigned to the BPG. The broad mandate of the organization has encouraged this approach to technological forecasting and assessment.

The definition of TA that has been used is one of the accepted ones in the TA profession. Our shorthand definition is that TA is the advance identification of the secondary impacts that often arise from the uses of technology. Our more formal definition has been the one presented by Vary Coates:

"Technology assessment is the systematic identification, analysis, and evaluation of the real and potential impacts of technology on social. economic, environmental, and political systems and processes. It is concerned particularly with the second and third order impacts of technological developments; and with the unplanned or unintended consequences, whether beneficial or detrimental, which may result from the introduction of new technologies or from changes in the utilization of existing technologies. Technology assessment seeks to identify societal options and clarify the tradeoffs which must be made; this approach is designed to provide an objective and neutral input to public decisionmaking and policy formulation with regard to science and technology." [2]

BPG has undertaken TA activities in four areas. The actual work ranges from projects that follow a rigorous TA methodology to those that are involved with exploring fundamental interactions between telecommunications and other sectors of society. These activities are:

(a) The study: A Technology Assessment of Computer-Assisted-Instruction Use in Colleges;

(b) Exploring the societal impacts of proposed wired city services;

(c) Exploring future trade-offs between travel and communications services;

(d) Sponsoring research into the impact of new telecommunications services on native Copulations of the Canadian North ;

The first three of the above studies were conducted using internal professionals with outside support where required. The final study was contracted with Queens University of Kingston, Ontario and was monitored by a BPG professional. This report will concentrate on the first and third studies. The Computer Aided Instruction (CAI) study will be referenced since it was the first TA conducted by the Group and used the most widely known methodology, the MITRE approach. The Group has been interested in trying out a variety of methodologies in its TA activities since it is clear that there is no approach that enjoys widescale approval as the "right way" amongst the professionals associated with the field. The CAI study is summarized below. The work in travel-communications substitution takes up the bulk of this descriptive section on BPG-TA activities.

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[2] Vary R. Coates, Technology and Public Policy : The Process of Technology Assessment in the Federal Government. Summary Report, Program of Policy Studies in Science and Technology, 'The George Washington University, Washington, D.C., July 1972, p 1.

TA OF COMPUTER-ASSISTED INSTRUCTION

This study represents the most formal and extensive TA conducted by the group to date. This study had two prime objectives:

To illustrate a methodology that will be of use in future TAs.

To assess potential societal impacts of CAI in post-secondary institutions.

The primary objective was undertaken to determine what methodologies were available to conduct structured TAs. The group had been involved in extensive technological forecasting activities in the educational field for several years, and through these efforts and the acquisition of data from many outside research organizations had developed a large educational data base. It was obvious that more than this action was required to conduct a TA, and that a methodology was needed to organize a TA project. The initial phase of the CAI project was concerned with a Search for a TA process. The approach outlined by Mitre Corp. in their research for the Office of Science and Technology (Executive Office of the President) was selected as one that would serve our needs.[3]

CAI was selected as a subject of study for a number of reasons. Bell Canada had financed research and trials of systems in the educational technology field. The Business Planning group had also conducted two extensive Delphi studies exploring the future of educational technology. Part of this research was conducted with McGill University in Montreal as part of a graduate thesis research program, and this choice of subjects matched their interests as well. Finally, the field is one that has been the center of many controversies and grand promises in the last decade. This study was designed to bring all of these issues into a common perspective. The steps followed in the CAI study are outlined below. Since the Mitre methodology was used here. it is useful to list the seven basic steps followed in this process:

1. Define the assessment task;
2. Describe the relevant technologies;
3. Develop the state of society assumptions;
4. Identify the impact areas;
5. Carry out a preliminary impact analysis;
6. Identify possible action options;
7. Carry out a complete impact analysis.

The MITRE approach is shown in figure 1. This figure also illustrates the forms used in the various steps of the TA, which were also adopted by the BPG. The approach used in each of the seven steps in the CAI study will now be examined.

1. ***Define the assessment task***

Definition of the scope of the study was an important first step. Initially the researcher had the entire field of educational technology as his scope of interest. Areas such as computerized library systems, information retrieval television, audio-visual terminal development, and chemical learning were excluded from the scope of the study in order to make the analysis manageable. The scope was restricted further to the use of CA I in post-secondary institutions rather than attempt to cover its us? across the various school levels, industry, and research institutions. Four groups that would be affected more than any others in society by the introduction of CAI were selected for the action and impact analysis; students; professors; colleges; and industry. The study was a future-oriented, technology initiated one. The impacts discussed were social, economic, or institutional in nature.

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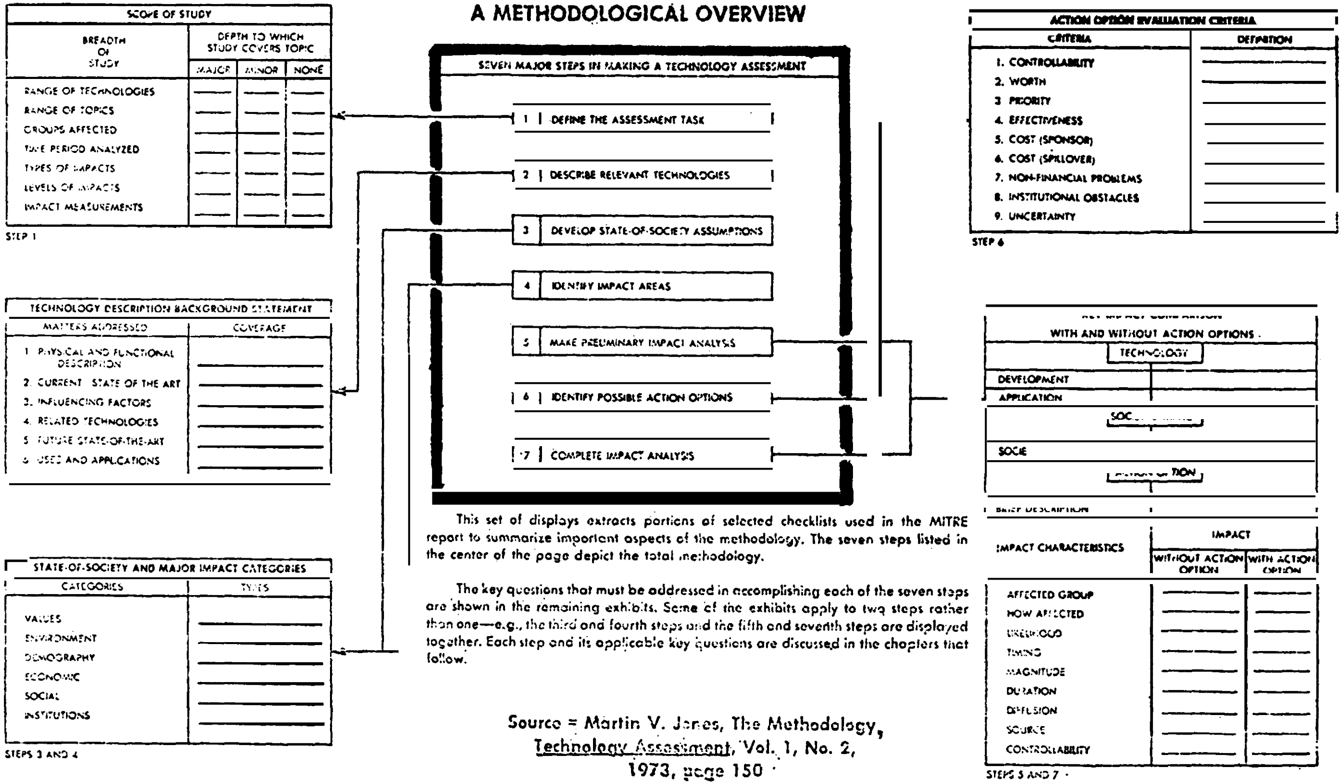
[3] Martin V. Jones. A Technology Assessment Methodology : Some Basic Propositions, Volume 1, The Mitre Corporation, Washington, 1). C., June 1971.

FIGURE 1
TECHNOLOGY ASSESSMENT: A METHODOLOGICAL OVERVIEW



This set of displays extracts portions of selected checklists used in the MITRE report to summarize important aspects of the methodology. The seven steps listed in the center of the page depict the total methodology.

The key questions that must be addressed in accomplishing each of the seven steps are shown in the remaining exhibits. Some of the exhibits apply to two steps rather than one—e.g., the third and fourth steps and the fifth and seventh steps are displayed together. Each step and its applicable key questions are discussed in the chapters that follow.

Source = Martin V. Jones, The Methodology, Technology Assessment, Vol. 1, No. 2, 1973, page 150

2. Describe the relevant technologies

This section relied on input from two sources. Firstly, the two Delphi studies on the future of educational technology conducted by the BPG were used to provide common definitions and a forecast data base. Secondly, the report produced for the U.S. Congress by the Committee on Public Engineering Policy that explored the societal impacts of CAI was used for some scenario inputs and some general technical limitations statements.[4]

The Bell Delphi studies were used to provide inputs on the cost-benefit ratios that would be required for CAI adoption at the various school levels, for descriptions of future related technologies, for forecasts of future hardware and software, and for the various potential applications of CAI.

3. ***State of Society Assumptions***

The state of society assumptions were developed from the Bell Delphi data base as well. The areas explored were future trends in Canadian value systems, the business and economic environment, the institutional environment, and the relevant social factors.

4. ***Major impact categories***

The categories selected for further evaluation were the business (economic), institutional, and social impacts of the widespread introduction of CAL The researcher concluded that the impact of CAI on future values would be difficult to determine at this time.

"In the case of CAI, though value assumptions set the stage for widespread use, it is difficult to foresee any changes in values resulting from this single technological development, at the present time."[5]

5. ***Preliminary impact analysis***

The process used was as follows:

"The primary impact is traced from its source to its ultimate effect on a certain social group. The primary impact in turn, becomes the source of the secondary impact. Because the second-order effect will occur only if the first-order event has taken place, probabilities of secondary consequences are always lower than the likelihood of corresponding primary effects.

The impacts presented are quoted substantially from a pilot TA commissioned by the Committee on Public Engineering Policy. Forecast dates of the Bell Canada Delphi's are incorporated and impact characteristics are quantified."[6]

The following sixteen impacts were selected for examination in this analysis:

—increased costs;
—improved construction;
—physical plant modification;
-closer ties between schools;
-restructuring of curriculum;
--extended day, week, and year;
—standardization and centralization;
-coping with poorly prepared students;
—impersonal education;
—individualized instruction ;
—aid for minority-group students;
—student-instructor relationship;
—modification of instructor's role;
—new copyright protection;
—industry-controlled education;
—development of industries and products.

6. Identify possible action options

Phases 6 and 7 of the MITRE methodology were completed during the second part of the CAI study. The researcher shifted his focus from secondary research to that of original data collection. His objective was to obtain an independent, Canadian evaluation of the possible impacts of the options for various actions. The study design used group judgmental data from a number of Canadian experts on the various aspects of CAI system design and use, This

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[4] Study of Technology Assessment Report of the Committee on Public Engineering Policy, National Academy of Engineering, Government Printing Office, Washington, D.C., 1969.

[5] Philip Feldman, A Technology Assessment of Computer-Assisted-Instruction, Business Planning Group, Bell Canada, Montreal, Quebec, August 1972, p. 1S.

[6] Ibid., p. 21.

was a specialized survey rather than a Delphi study since there was only one round of the questionnaire and no interaction between the respondents during the study. However, the survey was not a normal one in the statistical or market research sense since the respondents were not selected from a random sample. They were selected from earlier panelists on the business planning Delphi study on educational technology, and from a list of members of an educational technology committee of the National Research Council of Canada. The final group of respondents represented a cross-section of individuals from the teaching profession, university administration, educational research organizations, government departments, and industry. Each potential respondent was given a copy of the report outlining the preliminary analysis (steps 1 to 5) and each had received copies of the Delphi material. Hence, the respondents were working from a common data base and were well-aware of the use of their inputs.

The initial concept was to complete a sixty-ceil cross-impact analysis. However, this was too great a task through which to put any volunteer respondent. The researcher decided to choose the most important action options and impacts, and to work out a modified impact matrix. The probability of the selected impacts and actions occurring in the next ten years was evaluated first by the panel.

7. ***Final impact analysis***

This was obtained from the replies of the CAI-TA panel assembled by the researcher. As noted above a reduced matrix was constructed. This is shown with the final estimates of the societal impact of the CAI in figure 2.

The final reduced matrix was analysed by the researcher who developed the following conclusions:

"Though (figure 2) does not examine every conceivable action and impact related to CAI the data clearly indicates that few unfavorable societal consequences will result from widespread use of CAI in colleges. In fact, it appears that almost all parties will benefit from the proliferation of CAI systems. Students, whether they are at the top or bottom of their classes, will benefit because of increasing individualized instruction. Professors will benefit because they will be liberated from the mundane chores of reinforcing knowledge. Finally, industry will benefit because of new education related business opportunities. In order to maximize the favorable effects mentioned above, we will now recommend that certain action options be undertaken. Since the ultimate purpose of a TA is to delineate actions whose execution will influence projected events in a socially responsible manner, the following recommendations constitute the most important segment of this TA:

Governments should legislate new types of copyright protection.

Development of a common author language should be encouraged.

Colleges should examine the feasibility of introducing professional incentives for programmed materials.

There should be greater co-operation between colleges and industry including the institution of CAI programmer consultant services.

Professors should use CAI as a supplement rather than a substitute."[7]

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[7] Ibid., p. 03.

IF THIS ACTION OCCURS . . .

. . . THEN THIS IMPACT IS MORE (+)* OR LESS (−) LIKELY TO OCCUR:

		PROBABILITIES	ACTIONS OF GOVERNMENT: NEW TYPES OF COPYRIGHT PROTECTION ARE LEGISLATED	ACTIONS OF GOVERNMENT: A COMMON AUTHOR LANGUAGE IS DEVELOPED	ACTIONS OF COLLEGES: DISADVANTAGED STUDENTS WITHOUT NORMAL QUALIFICATIONS ARE ADMITTED	ACTIONS OF COLLEGES: PROFESSIONAL INCENTIVES FOR PROGRAMMED MATERIALS ARE CREATED	ACTIONS OF PROFESSORS: CAI IS USED MAINLY AS A SUPPLEMENT TO INSTRUCTORS	ACTIONS OF PROFESSORS: CAI IS USED MAINLY AS A SUBSTITUTE FOR INSTRUCTORS	ACTIONS OF INDUSTRY: CAI PROGRAMMER CONSULTANT SERVICES ARE INSTITUTED	ACTIONS OF INDUSTRY: COOPERATIVE PROJECTS INVOLVING COLLEGES AND INDUSTRY ARE
			.7	.5	.7	.5	.7	.3	.7	.7
IMPACTS ON COLLEGES	THERE WILL BE A GENERAL IMPROVEMENT IN THE QUALITY OF EDUCATION	5	0	+1	0	+2	+1	−1	+1	+2
	THERE WILL BE MORE DISSEMINATION OF CAI PROGRAMS TO MANY COLLEGES	.7	+1	+2	+1	+2	+1	+1	+1	+1
	THE ACTUAL COST OF CAI SOFTWARE WILL INCREASE	5	+2	−1	0	0	0	0	+1	0
	THE ACTUAL COST PER STUDENT OF INSTRUCTION WILL INCREASE	.7	+1	−1	+1	0	+1	0	0	0
IMPACTS ON PROFESSORS	THE ABILITY TO COPE WITH POORLY – PREPARED STUDENTS WILL INCREASE	.7	0	+1	+1	+1	+1	+0	+1	+1
	THE STUDENT – INSTRUCTOR RELATIONSHIP WILL IMPROVE	5	0	0	0	+1	+1	−2	0	+1
	FACULTY WILL USE THE CAI CONCEPT MORE EFFICIENTLY	.7	0	+1	+1	+2	+1	0	+1	+1
	SEGMENTS OF PUBLISHED MATERIAL WILL BE DIRECTLY QUOTED IN CAI PROGRAMS	.1	+1	0	0	+1	0	+1	0	0
IMPACTS ON STUDENTS	GIFTED STUDENTS WILL BE ABLE TO FINISH THEIR STUDIES MORE QUICKLY	7	0	+1	0	+2	+1	+1	0	+1
	THERE WILL BE A DECREASE IN THE DROP OUT RATE OF DISADVANTAGED STUDENTS	5	0	+1	0	+1	+1	0	0	+1
	THE EDUCATION PROCESS WILL BECOME MORE IMPERSONAL	3	0	0	0	0	0	+2	0	0
	STUDENT UNREST WILL DEVELOP TO A GREATER DEGREE	3	0	0	0	0	0	0	0	−1
IMPACTS ON INDUSTRY	THE FUTURE WORK FORCE WILL BE BETTER SUITED TO INDUSTRY NEEDS	5	0	+1	+1	+1	+1	0	+1	+2
	THERE WILL BE NEW CAI EDUCATION – RELATED BUSINESS OPPORTUNITIES	7	+1	+1	.1	+1	+1	*Z	+1	+2
	THERE WILL BE A LACK OF PATENT AND COPYRIGHT PROTECTION	5	−2	0	0	0	0	0	0	0
	THERE WILL BE A CHANGE IN THE RELATIONSHIP BETWEEN SCHOOLS AND INDUSTRY	S	+1	0	.1	+1	0	+1	+1	+3

* A positive sign (+) indicates the effect of the occurrence of the development will be to increase the likelihood of occurrence of the subsequent development, and a negative sign (−) indicates the converse. The strength of the impact is indicated by the following code: 0 = No impact; 1 = Minor impact; 2 = Strong impact; and 3 = Very strong impact. (Source = Enzer)

SUMMARY OF REVISED CAI SOCIETAL IMPACTS

FIGURE 8

TECHNOLOGY ASSESSMENT OF TRAVEL-COMMUNICATIONS SUBSTITUTION

INTRODUCTION

This area is one that has captured much of the attention of the BPG in the past five years. A variety of projects have addressed issues associated with the potential of future communications services to substitute, supplement, or interact in some way with the transportation sector. In total, these activities add Up to a multi-faceted TA of the various social, political, environmental, energy, behavioral, and corporate impacts of the interaction of travel and communications. The Group has never collected all of these studies into one big report and called it a TA. However, we feel that both the spirit, techniques, and scope of the research justify its inclusion in a review of our TA activities, The work in this area has been concentrated in a number of projects. The key areas are outlined below:

.4 continuing assessment of the technologies that are the driving forces in the telecommunications fields. These will not be discussed here but are summarized briefly in Appendix 2.

A detailed behavioral evaluation of the individual traveller's perception of travel and communications and his or her attitude towards the substitution of certain types of travel with telecommunications alternatives.

An examination of the energy implications of travel-communications substitution.

A review of the policy implications of substitution across a wide spectrum of activities.

Participation with SRI's recent National Science Foundation (NSF) sponsored TA of Travel—Communications Substitution.

The BPG has never attempted to replicate or "Canadianize" related research in other relevant countries and fields. The approach has been to build on and expand from the base of available research. Hence, in the narrative that follows, references will be made to the work of others were it is important to the understanding of our TA activities in the substitution field. It should also be noted that the discussion below should only be considered a superficial introduction to a research area that is becoming one of the most popular in the telecommunications impacts field.

The focus on substitution is significant since it emphasizes one of the impacts that will develop from the uses of communications systems in both current and projected forms of social interaction. This is a shift from earlier research that examined various communications systems such as audio or visual teleconferencing and postulated that one of the uses of a particular system might be some impact on travel activities. The substitution research is not tied to any single communications system, present or projected, but is focused on the potential impacts that will develop from the uses of a wide range of communications systems. Research starting from the direction of impacts rather than particular technologies is almost certain to have more widespread applicability across various societal sectors, and in some cases, between societies themselves. The material in this paper is designed to illustrate some of the types of impacts that future travel—communications substitution may have in the next decade.

The potential of future communications-based systems to stimulate some form of substitution for "travel is a frequent subject of discussions of the future environment. Most forecasts seem to lie at each end of a spectrum of possible analyses. At one end there are broad generalized scenarios optimistically postulating many forms of substitution of local and intercity travel through the use of a host of computer-communications services. The links between today and the future are not usually detailed and we are left with considerable uncertainty as to how this future communications-based society evolved. The economic, social, and political benefits or potential negative impacts of this substitution process are also not examined in any detail. At the other extreme there are very specific studies of how specific technologies may augment the substitution process for individuals working at certain institutions with defined travel patterns. Between these two poles there is a considerable knowledge and research gap, Several projects underway at Bell Canada and in other institutions are designed to help till this knowledge gap. While many of the activities described here are Canadian or American, the author recognizes that parallel activities are also underway in Europe and Japan.

The question of substitution may be regarded as generic in the case of a macro-analysis. However, our futures research and that of others has indicated that the subject should be examined on two levels of substitution: inter-urban and intra-urban. inter-urban substitution refers to the process of replacing certain types of intercity travel with communications and computer-based services. This travel is usually that of businessmen, government, officials, or educators for defined occupational purposes. Intra-urban substitution refers to the process of replacing a wide variety of activities within an urban area with a large number of electronic services. These forecasts usually include replacing daily commuting to work with "electronic offices" in the home or in neighborhood work centers. Electronic education, security, banking, shopping, voting, and consumer information retrieval services are also envisioned within the urban area in order to reduce the need to travel for many routine nativities. Much of the research and speculation in this area is found in the "wired city" or interactive broadband systems literature.

The term, substitution, is used here as a shorthand expression that refers to very complex, mostly unknown (to date), relationships between the transportation and communications sectors of our society. This relationship is not new, of course, as these two sectors have been intertwined in a maze of relationships since the development of postal, telegraph, and telephone services. Research on the impacts of these old communications services upon personal travel has been extremely limited to date. The simultaneous rapid growth in the use of modern communications and transportations systems during the last few decades in North America has masked the development of interrelationships between these two sectors. Studies have indicated that those who travel a great deal also use communications systems frequently. Thus, existing communications and transportation systems appear to be mutually reinforcing. However, many argue that the rapid proliferation of new communications technologies when combined with the current crises, congestion, and negative side-effects of many transportations systems, will lead to a new era of substitution.

The phrase substitution processes should not be interpreted too narrowly in terms of face-to-face personal contacts. While certain existing face-to-face contacts may be replaced in the future with new technologies, *new* forms of communications systems may create the ability to undertake activities that are impossible today with face-to-face contacts or existing technologies. Thus, substitution processes may, in fact, serve latent needs that have not been served up to now.

SUBSTITUTION: WILL IT HAPPEN?

An adequate analysis of the intercity substitution question must examine the fundamental reasons why people travel. There are obvious stated occupational reasons for many travel activities, However, there are a host of unstated social and personal factors at work when travel decisions are being made. An understanding of the travel-communications substitution issue requires research into these behavioral factors that would also underlie any future decisions on substitution. The other key variable involved in determining whether or not substitution will occur in the future is the financial cost-benefit trade-offs that must be determined between the costs of travel and the proposed communications substitute. This section of the paper considers both these variables on an inter-urban and intra-urban basis.

INTER-URBAN SUBSTITUTION

BEHAVIORAL ANALYSIS

The BPG has undertaken an analysis of these issues. This survey research was concerned with business travel in Canada between the cities of Montreal, Toronto, Ottawa, and Quebec City. Business travelers between these cities utilizing air, rail, auto, or bus modes of transportation were given a questionnaire to obtain the types of information shown below:

(a) Basic trip statistics;
(b) Purpose(s) of meeting(s) ;
(c) Information carried to or acquired at meetings;
(d) Reasons for not substituting existing communications media for this trip;
(e) Indirect personal activities associated with the business trip;
(f) An assessment of the most satisfactory and unsatisfactory aspects of the current trip;

(g) The Potential of various future communications capabilities to replace the type of trip the traveller is on currently; and

(h) Organizational, personal, and statistical data on the individual respondents.

The questionnaire was given to 30,000 business travelers during October 1978. Approximately 9000 usable replies were received, These permitted detailed sub-analysis of the substitution question by mode of transportation, particular inter-city corridor, organizational characteristics of the traveller's employer, executive level, ethnic group, and potential substitute capabilities. The response to the survey was a much higher level of returns than expected. This in itself may indicate that interest in the substitution question is becoming widespread among travelers.

The data from the survey was shared with the participating common carriers and government agencies. This information will also be traded with individuals and groups who are working on similar or related issues in outside futures research groups. The survey tested a series of hypotheses that were grouped into five categories: the communications situation; trip characteristics; idiosyncratic variables; role of the traveller: and telecommunications capabilities of the alternatives. The hypotheses were developed after an extensive search of the literature and research into communications behavior patterns. In many cases, the hypothesis were developed by other researchers after smaller surveys of sub-groups of travelers or through laboratory experiments with various test groups, The questionnaire was designed with the assistance of a consulting behavioral scientist in order to assure that the responses would help the BPG obtain useful data on the various hypotheses.

TEE HYPOTHESES WERE:

COMMUNICATIONS SITUATION

(u) There are situational and behavioral variables associated with the particular form of communication that is to take place which predispose individuals to meet fact-to-face by traveling rather than to communicate over or through an artificial medium.

(b) As the complexity of the communication task increases, the greater Is the perceived felt need for travel. Such predispositions occur at a significant level in bargaining, conflict resolution, and authority relation situations.

(c) Personal familiarity is negatively related to the propensity to substitute in situations that require (or are perceived by the actors to require) building or maintaining friendly relations, persuasion, assessments of others' reactions. or security.

(d) Routinized interaction activities have a lower trip threshold and a greater propensity for substitution than more complex non-routine interactions.

(e) The propensity to substitute varies according to the purpose of the trip.

(f) The propensity to substitute telecommunications for travel increases after a certain threshold of trip making is reached: the threshold varies depending upon the purpose of the interaction.

TRAVEL

(a) Trips that involve the personal transportation of materials, or for having material or equipment serviced or handled are negatively associated with the propensity to substitute.

(b) There is a positive relationship between the duration or number of activities engaged in on the business trip and the propensity to substitute.

(c) There is a negative relationship between the number of non-business activities associated with the business trip and the propensity to substitute,

IDIOSYNCRATIC

(a) There is a negative relationship between how business travelers feel about their general travel activities and the propensity to substitute.

BOLE

(a) There is a negative relationship between an individual's position in the business hierarchy and the propensity to substitute.

Telecommunications CAPABILITIES

(a) There is a positive relationship between the traveller's perception of the utility of telecommunication alternatives to business travel, and the propensity to substitute.

An overview analysis of the survey results indicate several interesting findings. Presentation of these comments should be prefaced with the reminder that these questionnaires were distributed before the Arab-Israeli war and its subsequent impact on energy supplies, travel convenience, and public consciousness regarding the negative societal implications of transportation systems. The overall results of the sample indicated that 20% of the business travelers would have substituted the existing trip they were on, if appropriate communications substitutes had been available. This finding is not offered at this time as an indicator of the overall average potential for substitution but it appears to be a representative look at the short trip, commuter travel often experienced on the travel corridors studied.

Factors that do not appear to influence the substitution decision include:

- The travel corridor;
- The mode of travel;
- Whether going out on a trip or returning from one;
- The number of associates with whom the businessman is traveling; and
- The number of positive aspects perceived in the current trip.

The factors that do influence the substitution decision significantly include:

- Those having shorter trips want to substitute more;
- Those having fewer activities per trip want to substitute more;
- Those who perceive more negative aspects of travel want to substitute more; and
- Those engaging in more non-business activities per trip want to substitute less.

While the survey results revealed the above trends or tendencies, the correlations were generally much weaker than would have been expected, considering the fact that the original hypotheses were based mainly on earlier research. The strongest correlation was found with the telecommunications variables. Those respondents who perceived electronic alternatives favorably were more inclined to want to substitute future travel than those who felt that electronic telecommunications was too impersonal. The survey results also indicated that individuals from different types of organizations do differ in their propensity to substitute. Representatives from educational institutions were the most likely to substitute while representatives of non-technical manufacturing, finance, and insurance-related industries were the least likely to substitute. However, all of these results were representatives of tendencies rather than clearly defined profiles of non-substituters versus substitutes.

An overview of some of the results of the Bell survey took these factors into account when it concluded: "While 20 percent of the travelers surveyed indicated that they would substitute their current trip, the present study offers little support for hypotheses concerning replacement of travel by telecommunications. For the most part, the directions of the relationships postulated stand up but the weakness of the correlation coefficients indicate that the variables are of little consequence in distinguishing explanatory differences between those who would and those who would not replace their present trip. The lack of explanatory results suggests that the decision to substitute may be an idiosyncratic one which the variables included in this study did not tap." [8]

Thus, we have determined that there is a significant proportion of the business traveling public that would like to substitute certain travel activities with telecommunications but we have not identified a homogeneous model of the "typical" substitute.

COST-BENEFIT ANALYSIS

This form of behavioral research helps determine if people are willing to substitute in a "free-decision" environment. Often this is not a relevant factor in governmental, business, and educational institutions. Telecommunications systems that meet cost-benefit criteria definitely are most easily acceptable to

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[8] James H. Kollen and John Garwood, "The Replacement of Travel By Telecommunications". 18th International Congress of Applied Psychology, Montreal, Quebec, July 30, 1974, pp. 26-7.

managers. Various studies have shown that audio and augmented audio teleconferencing systems usually turn out to be cheaper than travel for defined trip patterns. The reverse is almost always true for video based systems. All of these calculations involve an assumption of the cost of the time of the traveller (ie. it costs "x" dollars per hour for an employee whether he is traveling or in the office; hence, travel time saved equals dollars saved). The problem with these forms of calculations is that the institution has to spend more money in telecommunications systems in order to optimize the existing expenditures in salary charges. Illogical or not, many managers would rather have employees underutilized rather than spend more money to optimize a "sunk" cost, namely salary. If this attitude can be overcome then many non-video teleconferencing systems can result in net savings for the using organization.

One operational instance of detailed cost-benefit analysis is the experience of National Aeronautics and Space Administration (NASA) during the Apollo program. A series of teleconference networks were created, ranging from audio teleconferencing through to high speed facsimile (50 kilobits per second). These networks were used to replace certain types of travel during the course of the program. A series of analyses using various assumption patterns, indicated that the use of the networks saved from $1.4 to $4.1 million per year. An examination of travel costs before and after the introduction of the teleconferencing systems indicated that the average travel cost per professional assigned to the Apollo program dropped from $860 per year to $650 per year. These latter figures ignore the costs of time spent in travel whereas the earlier calculations assume an allocated cost of salary against travel. The study also noted that the use of teleconferencing resulted in many informal contacts and faster decisionmaking than could occur if travel had been the main form of long-haul interaction between the various groups involved? No attempts have yet been made to try and quantify these types of factors in a cost-benefit analysis. However, it is interesting to note that a rigorous application of cost-benefit analysis in the major institutional environment can result in considerable substitution of travel through the use of telecommunications.

INTRA-URBAN SUBSTITUTION

BEHAVIORAL ANALYSIS

The question of intra-urban substitution involves a different group of travellers and different behavioral issues. The type of substitution that is often discussed here involves the use of various "wired city" services. The area most analogous to the material reviewed above is "telecommuting". One of most extensive examination in this field is a recent study at the University of Southern California (USC).

The USC study examined two types of telecommuting in some detail. One part of the research was an examination of the attitudes of the user populations of interactive television systems used at USC and Stanford University. These systems were designed mainly to serve working adults who are studying towards advanced degrees. The alternative to physically attending the courses is to use the interactive TV system. Briefly, these systems are as follows:

The USC IITV [Interactive Instructional Television System], established in 1972, is designed primarily to serve professionals in engineering, aerospace, and information sciences who wish to take graduate level courses. These students are generally in mid-career and usually are employed fulltime by industries located from 10 to 30 miles from campus. Before installation of the IITV systems, these students commuted to the USC campus either in the evening or on a released-time basis during the day.

The IITV system transmits live lectures to ten regional centers from the studio at USC. Eight of these centers are located at major companies in the Los Angeles metropolitan area; two sites service clusters of companies. Regular academic courses are offered, both credit and noncredit, graduate and undergraduate. Since the program started, and average of 40 courses per semester have been offered by USC over the IITV network. The system includes talkback capability provided by FM radio transmitters at the remote sites. A daily courier service delivers and picks up homework, exams and other class work.[10]

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[9] Samuel W. Fordyce, "NASA Experience in Telecommunications as a Substitute for Transportation", NASA Memo, April 1974.

[10] Jack M. Nines, Frederic R. Carlson, Paul Gray, Gerhard Hanneman, Telecommunications-Transportation Tradeoffs, University of Southern California, December 1974, pp. 111–2.

The users of these systems pay the regular course charges plus surcharges for the right to telecommute. The corporations pay for the costs of the television classrooms. The USC study team felt that these two systems represented real cases of travel-communications substitution and conducted surveys to determine the users attitudes towards the substitution. The following four conclusions were drawn from the study.

"(l) Instructional television as a telecommunications substitute for transportation, offers the IITV user a substantial savings in time and travel. The director of the IITV system at USC, Dr. Jack Munushian, estimated that in the 1974-1975 academic year, the USC IITV system would save 250,000 commuter miles.

(2) One of the major motivations for participation, is a willingness on the part of the participant to complete or expand his or her educational training; given this motivation, the convenience and ease of the IITV system play a major part in the decision to participate. A corollary to this conclusion is that IITV students tend to feel that the availability of the system resulted in their taking a more aggressive attitude toward continuing their education.

(3) Users of an IITV system show greater affinity over time, indicating that familiarity with the system can favorably affect attitudes toward the system.

(4) Over 60 percent of the participants perceived IITV as being as effective as in-classroom educations (with Standford students showing a slight decrease in this assessment over time; comparison of grades and performance ratings by the instructors indicated essentially identical academic achievement for participants in the two modes (IITV and in-classroom). This response indicated that no appreciable (or at least quantifiable) loss in effectiveness was occurring as a result of using the IITV system." [11]

COST-BENEFIT ANALYSIS

It is interesting to note that the cost-benefit equations on both the inter and intra-urban trade-offs turn on the issue of valuing travel-time, whether this is allocated salary-time for institutional travelers or valued personal time for urban commuters. This leads to the conclusion that more than personal attitudes and accrued cost-savings to individuals and institutions will be required to lead to significant new levels of substitution in the shorter term. The energy issue is one example of an external force that will very likely cause a much closer examination of the substitution question than if it was left to free-will and normal market forces,

The USC study went on to examine the telecommuting question in the business environment. The Western regional office of a major national insurance company was examined in detail as a potential candidate for decentralization through the use of remote work centers and telecommunications support systems. This company had a central downtown location in Los Angeles and was examining various forms of decentralization, mainly as a result of high labor turnover at the clerical level. The corporate goal was to tap into new labor markets in the suburbs as well as eliminate the perceived disadvantages of long commute patterns for employees in those areas. Thus, this was a case where clerical rather than management or professional workers were regarded as a target for dispersion through the use of telecommunications. The USC team felt that this was a good case example as the company was one in the "information industry" where the substitution possibilities are expected to emerge first in the future.

The USC study determined that 15 remote work-centers connected with a computer and communications network would enable the insurance company to conduct its business on a dispersed basis. It went on to conduct a detailed cost-benefit analysis for both the company and the employees. The company saved costs in staff turnover and training, through reduced staff, lower salaries for clerical employees (a premium had to be paid to attract staff in the central location), elimination of a free lunch program, and income obtained from leasing the old headquarters site. Increased costs associated from the proposed system were in new building charges in the remote work centers, computer and communications costs, administrative and travel charges, and the loss of a special tax benefit given to insurance companies with one central office. The net savings to the company based on two different system configurations

[11] Ibid.. pp. 116--7.

were $4.1–$4.2 million annually. Thus, there were distinct cost incentives for the company to adopt the electronic work-center concept.

The cost-benefit calculation for the employees is not so straightforward. They lose monetary benefits in the form of the free lunches and salary premiums paid for working downtown. The cost savings for the employee revolve around saved travel-time and saved travel-costs. The USC calculations showed that any employee commuting more than seven miles per trip would save money. Since the average employee trip is 10.7 miles per trip, the average employee will save. However, ignoring problems of the "non-average" employee, one key assumption is that the employee values his time on a monetary basis. Time saved must be equated to dollars saved or the employee would result in a net dollar loss. This is not an area of certainty, especially with clerical employees versus professional employees such as those studied in the IITV survey. Generally, we can assume that an educational task would be required to induce old employees to want to try out this system. New employees in the suburbs would not present the same problem, and in fact the insurance company has operated non-electronic suburban work-centers for some time with a lower salary for clerical staff. This is certainly an area that will only be settled through the actual electronic decentralization of an existing operation.

ENERGY AND ENVIRONMENTAL ISSUES

INTRODUCTION

There are a host of environmental and energy issues related to travel and transportation systems. These have become increasingly important in public and private policy determination in the past decade. One forecast is that these factors may lead governments to promote or encourage communicating rather than traveling in the future. This could he through a wide variety of administrative mechanisms, including ones that may alter the economic cost-benefit ratio in favor of communications alternatives.

The environmental costs associated with transportation systems have become identified in considerable detail in the past decade. Current research is expanding information on these issues at a rapid pace. The environmental considerations associated with communications systems are virtually unknown, although recent interest has been expressed on the subject. Analysis that has been undertaken to date, leads us to believe that these costs are far lower on a per capita user basis than those for transportation systems.

Any comprehensive analysis of the environmental costs associated with travel and communications systems must go beyond an examination of operational costs of visible structures. The costs of construction of the physical plant required to provide these services should also be included. The environmental costs associated with maintaining the required infrastructures are required as well.

The phrase, environmental costs, has been used to refer to a wide variety of issues. The list be;pw is not exclusive, but it gives an indication of the types of environmental costs that are associated with the use of transportation and communications systems. These factors will have to be added to the economic and behavioral ones in order to provide an adequate analysis of the overall question of inter-urban and intra-urban substitution.

(a) Energy consumption of transportation or communications systems (increasingly important with the North American and European energy crisis).

(b) Energy consumption required to construct. operate, and maintain the manufacturing plant, and industry infrastructures for both sectors.

(c) Resource consumption for construction, operation. and maintenance of the required infrastructures.

(d) Pollution factors associated with the two industries. e.g. air, water, radiation, noise, thermal, and visual pollution.

(e) Damage to ecological systems.

ENERGY IMPACTS OF TRAVEL-COMMUNICATIONS SUBSTITUTION

As noted above, the energy implications of transportation systems are relatively well-known, The BPG analysis of the Canadian situation follows. It should be noted that a similar picture is found in the United States and much of the analysis would likely apply there as well.

The basic findings of our research indicate that the transportation sector of the economy accounts for 24 percent of the total energy consumed in Canada.

The passenger sector accounts for 60 percent of that energy consumption. Over 90 percent of all Canadian passenger-miles are accounted for by motor vehicle and air transport. Both of these forms of transportation are very energy inefficient. The importance of examining the business sector of passenger travel, as in the business planning survey, is shown by the fact that **25 percent of all passenger travel is for business purposes (60 percent of all air travel is for business reasons). The influence of the transportation sector on total national** energy consumption levels indicates the possibilities for energy conservation through reduction of some forms of travel by communications substitution.

MACRO TRADE-OFFS

The task ahead is to identify the energy impacts of communications systems use. Research interest in this area has been growing rapidly. The energy crisis has led to many comments in the general and specialized press on the potential for some form of energy conservation through travel-communications substitution. Peter Goldmark, former President of CBS (Columbia Broadcasting System) labs, recently stated that if we "eliminated commuting over 10 miles, I have calculated that we could save half our current consumption of gasoline while generating only negligible amounts of pollution. "[12] He also goes on to argue that creating a "new rural society" (use of the technologies described above to reduce business travel and commuting to work) would reduce the need for expanding large cities and would also reduce the energy required to support their centralized infrastructures-air conditioning, heating, lighting, elevators, etc. Goldmark's calculations, and those of all of the research in this field currently, are rough but they indicate the order of magnitude of the potential savings.

MICRO TRADE-OFFS

These overview calculations give a perceived perspective of the global implications of large scale travel-communications substitution. Several studies have tried to examine this from the opposite perspective; the impact of substitution for specific trips using defined technologies. Similar research has been conducted by the BPG and by the Communications Studies Group (CSG) of University College London and the London School of Economics in conjunction with their work with the U.K. post office.

The approach is to calculate the energy consumed in particular journeys using various forms of transportation. This requires estimates of the number of people traveling to a meeting which is a key variable for the transportation-energy consumption calculations. One of the difficulties in this form of estimate is that the number of people at one location for a teleconference is not a cost or energy consumption variable. The incremental cost of adding people on to an audio or video teleconference is virtually zero. Hence more people can attend a teleconference cheaper than in person. On the other hand, the length of a meeting without a reasonable period (one day) is a key variable for the energy consumption of telecommunications alternatives, and a fixed cost item for transportation systems. Another key variable in the telecommunications side of the equation is an assumption on the source of electricity for operation of the system, Electricity derived from hydro dams has a much more efficient conversion ratio (85 percent) between primary and secondary energy (the ratio of the raw energy available at the source compared to the energy actually obtained for end usage) then say coal-oil (35 percent,) or nuclear (30 percent) sources. This is particularly important in the Canadian situation since some provinces are highly dependant on coal-oil and nuclear sources (Ontario) while others have large supplies of hydro power (Quebec).

The result of these types of calculators result in trade-off curves for various city pairs using defined transportation and telecommunications systems. Figures 3 and 4 illustrate the results of the BPG and CSG work respectively. This form of micro-analysis can be built back up to national estimates of macro-savings. The two groups have found in independent studies for Canada and the U.K., that approximately 2 percent of national energy consumption could be saved through the reduction of a moderate amount of business intercity travel. This does not include infrastructure savings or the reduction of intra-urban transportation. Details of the analyses by both Groups can be found in the referenced studies,

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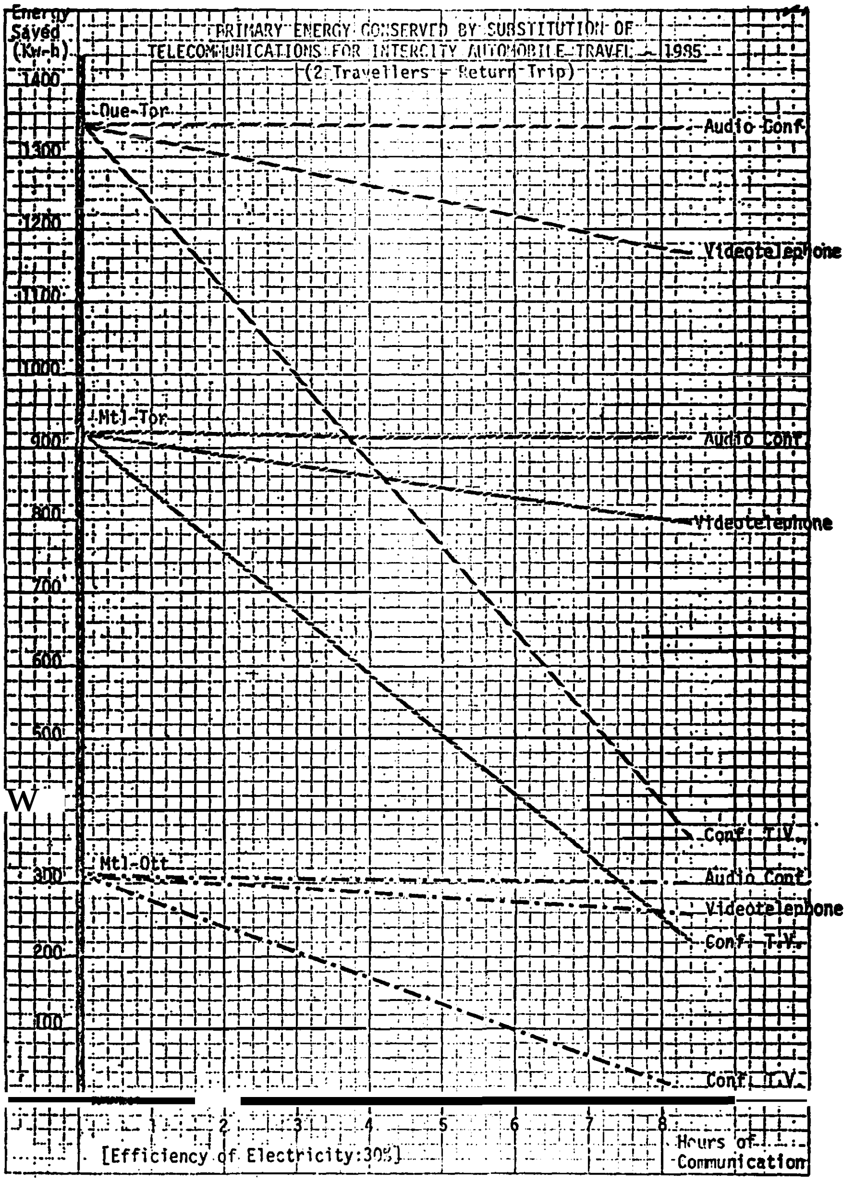
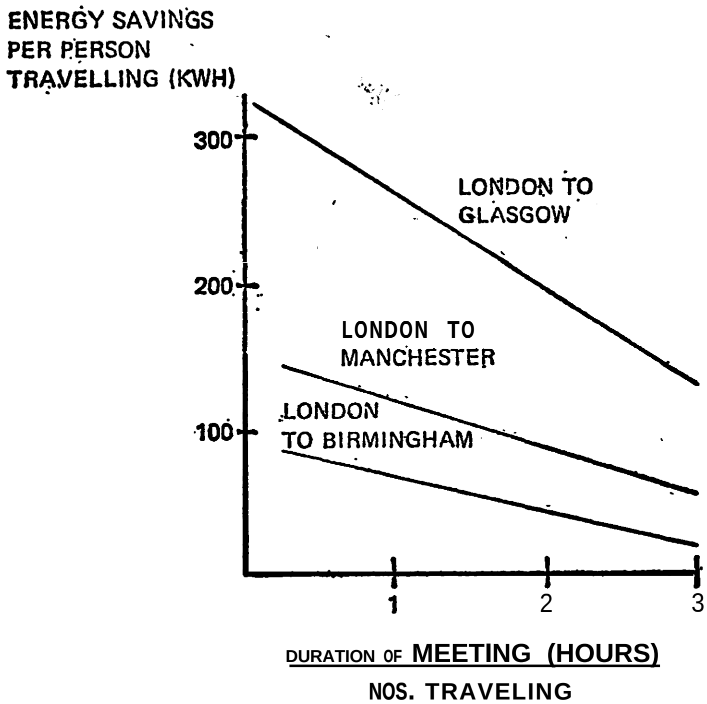
12 Peter C. Goldmark. "A Rural Approach to Saving Energy : Technology Could Help Ease Urban Congestion", New York Times, NOV. 12, 1973, p. 12.


Energy Saved (Kw-h)
PRIMARY ENERGY CONSERVED BY SUBSTITUTION OF TELECOMMUNICATIONS FOR INTERCITY AUTOMOBILE TRAVEL - 1985
(2 Travellers - Return Trip)
1400
1300
1200
1100
1000
900
800
700
600
500
300
200
100
Que-Tor
Mtl-Tor
Mtl-Ott
Audio Conf
Videotelephone
Conf. T.V.
1
2
3
4
5
6
7
8
Hours of Communication
[Efficiency of Electricity:30%]

ENERGY SAVINGS OF CONFRAVISION OVER RAIL TRAVEL (PER PERSON) FOR THREE INTER-CITY ROUTES



SOURCE: PYE, ET. AL., TRAVEL OR TELECOMMUNICATE? THE ENERGY CONSIDERATIONS. P. 9.

Similar calculations have been made by Dickerson and Bowers in their preliminary TA of the video telephone conducted at Cornell University.[13] Dickson calculated that an 8-hour meeting between Los Angeles and New York was 8 times as energy efficient as a return personal trip using a Boeing 747.

While energy issues are important, there are other environmental issues that should be considered in the travel-communications equation. Pollution is certainly one of the factors. Van Vleck points out that the transportation sector

[13] Edward M. Dickson and Raymond Bowers, The Video Telephone: A New Era in Telecommunications, Cornell University, Ithaca, N.Y., June 1973, p. 144.

produces 75 percent of the carbon monoxide. 56 percent of the hydrocarbons, and *52* percent of the nitrogen oxide pollutants.[14] These side-effects of travel must be shared by all in our society, not only those who travel.

The question of resource consumption has also become more widely understood as planners and decision makers become more aware that we have a finite stock of 'non-renewable resources and that the demand is outstripping the replacement of renewable resources. The transportation sector is an important consumer of many of these resource elements. Recycling will have to become more prevalent in the transportation industry in order to preserve material resources. Substitution is another means of conserving resource depletion, Again, we do not yet have material consumption patterns available for telecommunications, but we do have some idea of the facts for the transportation sector. The U.S. transportation industry consumes 75 percent of the nation's rubber, 53 percent of its lead, 40 percent of its zinc, 29 percent of its steel, and 19 percent of its copper.[15] Further research is required to determine the communications industry's consumption patterns and the elasticity of the material trade-offs between the transportation and telecommunications industries.

The energy, pollution, and material elements of the substitution equation are certainly incomplete at this time. We can obtain an idea of the relative impact of various trade-offs through the preparation of scenarios assuming levels of substitution. This is only one step towards a greater understanding of this issue. However, it is certainly a move away from merely assuming that these trade-offs will favor the communications half of the substitution issue.

SOCIAL AND POLICY ISSUES

The material reviewed to date has revealed that the substitution issue has many dimensions. This last brief section overviews some of the other questions and issues that will have to be examined in any comprehensive examination of travel-communications substitution.

POTENTIAL NEGATIVE IMPACTS

No development is without its negative drawbacks. Those of us examining the substitution question may tend to overlook some of these potential problems. Several of these are listed below.

PRIVACY

The adoption of substitution as a significant conscious choice in many sectors of society will bring us face-to-face with many of the privacy and security issues that have been troubling many observers for the past decade. Dependence on computer and communications services for so much of our social interaction is certain to bring about periodic lapses in personal and institutional privacy. These issues have been discussed extensively elsewhere and this paper will go no further than to indicate that they certainly have relevance to the substitution issue.

LOSS OF INTERPERSONAL INTERACTION

Many social scientists and thoughtful observers have pointed out that work activities have a very high level of social interaction content, People need to interact with people on a purely social level and work settings create the ability for this to happen. Reduction of intercity travel may cut back the range of interpersonal experiences that individuals have access to during their travel. Reduction of commuting patterns through the use of remote work-centers or home work-centers would also have a severe impact on interperson interaction. If remote work-centers were common public utilities rather than dedicated to specific institutions (a likely scenario in order to reduce the cost overhead of these institutions) then the interpersonal bonds that develop may be based upon friendships of people who happen to use the same work-centered rather than work for the same employer. This could have significant impact on job mobility patterns and employee loyalty. These social factors lead this author to forecast that remote work-centers will only be used two or three days a week with the other weekdays being used to go into the central business district for meetings and social contacts with other people in the institution.

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[14] E. M. Van Vleck, "Substituting Telecommunications for Travel : Feasible or Desirable, IEEE National Telecommunications Conference, San Diego, California, p. 5.
[15] Ibid., p. 6.

DISRUPTION OF HOME LIFE

The above forecast is strengthened when the potential disruptions of home life are considered. Having the working husband and perhaps working wife, plus children, pets, etc., in the same environment continuously would likely be more of a strain than most people could survive. Working at home occurs now with the use of portable terminals, and its popularity will climb rapidly in the next decade. However, the home life problems will limit this to being a sporadic activity rather than a regular occurrence. The remote work-center is the more likely means of reducing the tensions that would follow a permanent shift from the office to the home.

SECTOR UNEMPLOYMENT

Gradual substitution is the most likely scenario for the future. However, if significant shifts occur in institutional or individual attitudes, energy availability, environmental awareness, or the cost-bene!it trade-offs between travel and telecommunications then we could expect to see rises in the unemployment levels in the transportation sector. This is not a minor factor. The transportation unions are some of the strongest in North America and have a long history of righting (successfully) technological or policy advances that they perceive as having a negative impact on their members. The telecommunications industry is far more automated than the transportation industry, and a corresponding growth in employment in the former field would not likely follow cutbacks or reduce growth in transportation. The transportation industry also has a successful history of lobbying with the political sector of our society and we might expect to see attempts to make substitution a political issue if the industry began to see it as a significant threat to present or future business growth.

DISRUPTION POTENTIAL

Just as significant reliance on telecommunications creates a privacy problem, it also raises potential dangers of massive failure, sabotage, strike shut-downs, and breakdowns due to natural disasters. Systems will have to be designed in a fashion similar to the existing telephone network. This means considerable redundancy, distributed intelligence, human back-up and control override capabilities, and rapid recovery ability. There must also be the capability to eliminate the cascading disaster possibility that has caused major problems in the electrical industry. The potential dangers here certainly weigh heavily against a very centralized system.

ACCESS RIGHTS

The question of who will be allowed or will be able to afford access to the technology that can make substitution possible has troubled many observers. The phrase “information rich and information poor” has come to symbolize this concern. It can be argued that substitution, especially for local transportation, will only result in the creation of further ghettos. The poor will be even more cut-off from the affluent who will ***be*** able to work in electronic isolation. If the urban substitution process was carried to its ultimate conclusion, large cities would have their economic structures cut out from underneath them. The commuters would cease to be a source of tax revenue and hence cut out a significant slice of city revenues. On the other hand, many clerical and support jobs might move to the electronic work centers where the poor could not afford to commute, thus creating employment dislocations. The support industries of the city (restaurants. shops. service trades, etc.) would lose significant markets. This negative scenario postulates a drop in the revenue base of the city along with a great increase in the need for social support systems as the underprivileged see their employment opportunities shrink. The scenario is quite likely to never occur. As noted above, there are many social and other reasons to expect employees to want to go to the central offices several days a week. **In** addition, we could expect to see government and business lenders take positive actions to avoid most of the severe impacts postulated above before events got out **of** hand. Nevertheless, the question of access to substitution systems and the social-political impact that would develop from their widespread use must not be treated lightly as travel-communications research and policies are developed.

There are certainly other potential negative implications of travel-communications substitution. This short list is merely presented to indicate the range of possibilities and the agenda for future substitution research.

POLICY QUESTIONS

The whole topic of substitution also raises a series of policy questions that have only been alluded to up to this point. Several of these issues are reviewed below.

ENERGY POLICIES

Long- and short-term energy supply issues, compounded with the resource and pollution questions, may lead governments to regard substitution as a partial solution to these problems. If this occurs, governments are going to move from a passive interest in the potential of substitution in a few telecommunications oriented agencies and departments, to an active interest at the highest policy levels. One of the questions that will arise immediately is the question of relative subsidies between the industries.

SUBSIDY POLICIES

The transportation sector of the economy has traditionally been directly and indirectly (e.g. government-financed research) subsidized. Ship, rail, auto, and air transport have been heavily subsidized for capital (e.g. land grants), operating costs or losses (e.g. on non-profitable routes where it is socially desirable to maintain service), and in infrastructure investment (e.g. airports, highways, etc.). On the other hand, the telecommunications field has been less heavily subsidized and more regulated than the transportation field. This historical trend has occurred for a number of reasons:

communications deals intimately with fundamental information freedoms, the right to privacy, etc. Thus the government has restricted itself to primarily regulatory and policy-making roles in this area. Another possible reason is that electrical communications has been, for the most part, highly profitable to the private sector from the beginning, when it has not been, as in telegraphy in late years, and to some extent in UHF television, the regulatory agencies have acted strongly to support these media to the extent that regulatory actions can help." [16]

The question of travel-communications substitution raises the subsidization issue from a new perspective. If the social benefits of a substitution are strongly positive, then existing patterns of subsidy may be socially counterproductive. Either the transportation subsidies should be reduced or telecommunications alternatives to travel should be subsidized in some fashion. This whole question is a likely target for a massive study in itself. The issues are much more complex than mentioned here. However, the subsidy issue will have to be examined in both government and private industry before the substitution puzzle can be completed. These studies will probably lead to further questions on the process of regulation itself.

REGULATION

The question of regulation of the transportation and telecommunications industries flows from some of the above considerations. A substitution policy cannot be formed within a single government regulatory body. Telecommunications and transportation are regulated in Canada and the U.S. by many different agencies or branches of large regulatory agencies. A substitution policy cuts across the mandate of these various groups and frictions can be expected if substitution becomes an important policy issue. Of course, it may not become an important issue for the traditional transportation and telecommunications regulatory bodies since it may be regarded as lying in a no-man's land between them. However, a likely scenario would be for a new organization, such as an energy or an environmental agency to provide the substitution focus that would then bring about interest from all of the parties. It seems likely that we could not expect to see rapid solutions to some of the regulatory issues until this institutional process sorts itself out.

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l@ Ibid., p. 9.

INTERIM APPROACHES TO POLICY

The term, interim, is used to indicate that government actions are still possible, and probably required during the regulatory shakedown period postulated above. Policies can be refined much easier when there are more hard data and information available that demonstrate the existence of viable technological, economic, and socially acceptable patterns of travel-communications substitutions. These data will only emerge through a continuation of the type of research referred to above, only in much greater depth than to date. Research into all of the aspects of substitution discussed in this paper is certainly needed. Government agencies from both the transportation and telecommunications sectors, as well as in third party agencies (e.g. energy) should conduct and sponsor research and experimentation into substitution. The results of this research will certainly indicate whether or not the policy issues are important enough to risk the bureaucratic upheaval that some of the above policy shifts would generate.

CONTINUING RESEARCH

The material reviewed in the foregoing section on social and policy questions raised a number of important unanswered questions. In the introductory section it was noted that the substitution issue has been a subject of considerable interest for the BPG for the past 5 years. This interest continues and current activities are centered on some of the issues explored above.

The joint study with the Stanford Research Institute (SRI), the Business Planning Group (BPG), and the Communications Studies Group (CSG) of London is designed to answer many of these questions, especially those associated with the intra-urban area. This study, which is approximately 80 percent complete at this date, is an extensive examination of about 60 areas and their policy implications associated with intra-urban substitution under a variety of substitution scenarios. The BPG has filled in some of the gaps with its research and will participate in the data sharing with other members of the study team who have pieces of the puzzle. Thus, involvement with this TA study is a part of the BPG activities associated with a long-term and continuing TA of the substitution issue.

Another activity is a current project that is attempting to evaluate the key issues associated with working from the home and other remote locations. This study is assembling all of the relevant data from a number of research areas (the SPRITE study, the SRI/BPG/CSG study, teleconferencing research, and the BPG evaluation of the paperless office trial in the perspective Of working from home. This study will identify the key positive and negative issues associated with this aspect of substitution and will lead to corporate recommendations and, perhaps, further research into important unanswered questions.

Finally, the extensive evaluation of the Paperless Office trial referred to above in several places, is in itself a TA. The evaluation is being conducted with the cooperation of over a dozen U.S. government agencies and business firms and their users of NLS. This evaluation will result in the first detailed look at the widescale experimental use of a multi-organizational computer system that permits working at home, electronic mail, joint authorship of documents from remote locations, office management tasks, data base construction, and text editing-word processing.

A key part of this evaluation is the data being received from a detailed 28-page questionnaire that has been filled out by representatives from all the user groups (with the exception of the U.S. National Security Agency for obvious reasons). While sections of this questionnaire are oriented towards regular systems evaluation and human factors issues, significant data is being obtained which would be expected in a TA activity, Some of the impacts explored in this area are:

On the flexibility of working hours;
On the need to adapt to the system rather than vice-versa;
On accessibility of work to others;
On privacy;
On individual's professional images;
On face-to-face communications versus computer-mediated interaction;
On work styles;
On the use of normal mail systems;
On communications patterns with subordinates, peers, and superiors;

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On remote and working from the home; and
On managerial styles.

All of these continuing activities are a part of the longer term pattern of an on-going evaluation of the various primary and secondary impacts associated with the substitution issue. This process will be referenced in the final section of the report in which the impacts of TA for Bell Canada and industry and government in general will be discussed.

IMPACTS ON BELL CANADA

INTRODUCTION : THE GENERAL IMPACT

This report has been oriented to this point to projects, past experiences, and specific studies. In this section, a more subjective evaluation of the impact of TA on Bell Canada will be undertaken. This evaluation should be placed in the context of our own evaluation of TA and its future.

TA has been an activity that, to date, has been associated with the conduct of specific studies that were of interest to various funding organizations. Most studies have been funded by neutral agencies such as the U.S.-NSF that do not have decisionmaking roles. Most government and business firms which have funded or conducted TAs, have not touched upon especially controversial or key areas of concern to the parties concerned. The studies have also not been directed toward helping resolve thorny decision questions of agencies-or firms. Many organizations have regarded their TAs as learning experiences with the process of assessment. These experiences have often been oriented toward learning about the methodologies that can be used to conduct assessments and what their various strengths and weaknesses are. TAs have also been directed toward broad question areas rather than very specific issues. All of the above statements are generalizations, of course, but they do serve as a very shorthand history of TA to date. As the studies in the previous section indicate, these comments also summarize the Bell Canada experience.

The above statement is not intended to minimize the importance or honest effort that has been placed in the studies of Bell Canada and the other organizations. Bell Canada is committed as an organization to understanding the social impacts of its decisionmaking process. In February 1975, Bell Canada, in association with Datacap Ltd. organized a conference on Technology Assessment and The Limits to Growth. This conference was formally sponsored by the Ministry of State for Science and Technology and the International Society for Technology Assessment. Over 300 individuals from business, government and academia attended this Ottawa conference titled: Technology and Growth. J. C. Thackray, now President of Bell Canada, stated in his welcoming address to the conferees:

"There may be some of you who wonder why Bell Canada is so deeply involved in a conference of this nature. We're the supplier of the communications services that many of you use every day. Maybe at one time in the past that may have meant simply providing equipment. But not any more. For many years, we have been concerned with the effects that our business can have on the total environment, Not just the immediate and obvious effects, but the long term consequences, How do telecommunications affect the evolution of society?

It is our firm belief that technology must be the people's servant, not their master. In our research, our planning, and our on-going study of environmental affairs, our objective is to ensure that our services meet the needs of the public and that the side-effects of our actions are in the public interest." [17]

This understanding of the importance of TA is a clear indication of the impact that the Bell Canada experience with TA has had. To a significant extent, the Bell Canada experience with TA has been an educational one. At the senior management level, a significant measure of understanding the futurity and social impact of technology-based decisions has been gained. At the professional level, the business planners have gained a healthy understanding of the strengths and weakness of TA and the methodologies associated with the process.

A significant part of! this understanding is that it is the process itself, not the particular study that really counts. Important areas cannot be given the effort they require in a single, normally short timeframe study, that attempts to answer the important questions associated with the topic. The Bell Canada experience with travel communications substitutability, research indicates that a continuing research program into expanding areas of concern can identify a broad

[17] J.C. Thackray, Introduction to 'Conference, Technology and Growth proceedings, Business Planing Group, Bell Canada, June 1976.

range of impacts in considerable detail. The process of monitoring a field over a period of time helps identify the key impact areas. These can be given an in-depth examination rather than cursory treatment, in a study that tries to identify all possible impacts in a time- and resource-limited environment. Too many **TAs end up becoming catalogs of impacts rather than the definitive documents that their sponsors and assessors would like to see.**

The above comments reflect an assumption on the process of decisionmaking in many business and governmental organizations. Decisionmaking is often an incremental process. This can he, of course, very negative if environmental decisions are made that are regarded as minor but have long-term cumulative and harmful impacts. However, if TA processes parallel these incremental decision-making activities, combined with a good monitoring system, there is the potential for a very powerful form of TA. The process of incremental TA in a business or government mission agency can lead to a more serious understanding of the secondary impacts of various decision streams than "single shot" studies that attempt to do too much and end up accomplishing too little as a result of their over comprehensiveness, and the normal difficulties of accurate long term forecasting of any type, especially serially-ofiented forecasting. Thus, one of the important lessons learned in Bell Canada. is that an incremental approach to TA may be more important in business-oriented TA activities than large single effort studies that are oriented towards the relatively rare, one-time, major, irreversible decision. This is quite different from the type of decisions that are made in the political environment leading to bills being passed that may have a long-term impact and where the legislature may not revisit the field with new legislation for some time.

Another lesson learned with our TA and technological forecasting activities is that experience, even of a limited nature. with the developments in question can be of considerable value when compared to large amounts of paper speculation, no matter how sophisticated the methodology or how knowledgeable or prestigious the individuals who input to the process. Thus, an incremental **TA process can include the concept of field trials that generate experience with the technologies in question. This type of experience is social impact-oriented as opposed to merely gathering market or technical trial data.**

This experience and the concept of incremental TA with feedback from trials and ongoing monitoring activities is being applied in a current case. This is also a case of considerable importance to Bell Canada and is not an item of mere academic concern. The new service-technology is called "incasting" and it is an ideal target for the type of treatment described above.

INCASTING : APPLYING THE EXPERIENCE

"Incasting" is a form of instantaneous electronic polling that can be conducted using the regular telephone network without any interruption to the normal flow of telephone traffic. The prime motivation for this development has been the desire of the Canadian Broadcasting industry to have a form of interactive broadcasting with convenient and rapid feedback from the audience. With "incasting," home respondents would have a small two-function voting device called a Votaphone. There are two types of Votaphones that would be available. The first would be universally avaiIable to any home requesting one. The second would be used in **homes that are a part of a statistically-controlled random sampling of homes that could be used for scientific inferencing and extrapolation. The "incasting" operation has been described as follows:**

"During the proposed 10-second period of an interactive broadcast. the home audience is able to vote or respond by means of a specifically installed item of residential equipment called a Votaphone. The Votaphone itself is an extremely simple keyboard unit containing only two pushbuttons.

By voting in carefully prescribed sections of the lo-second response period, it is possible to vote in more than a simple binary yes-no format. For example, if the two pushbuttons are labelled + and —, they can he interpreted as meaning yes and no respectively in the interval 1 to 5 seconds, but be interpreted as, "Do not know," and "Do not like the question," 'if depressed in the interval **6 to** 10 seconds. Human factors studies show that the minimum sub-interval that should he considered useful is 2.5 seconds. **This permits choice of up to 8 ways of casting the single vote during a 10-second voting period, since the vote can be either positive or negative in one of four time-slots. "** [18]

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[18] Peter Parkinson, "Incasting," proceedings of the Second Subscriber Loops and Services Symposium, London. U.K., May 1976 ,p. 97.

The clients who would use “incasting” would probably be in the broadcasting field. They would purchase “incasting” time slots and integrate the questions into their broadcasts. The answers to the questions from the audiences (the universal or statistically inferential ones) would be delivered to the broadcasters in a matter of seconds. The users might fall into a number of categories. Public affairs broadcasting would take on a new dimension with instantaneous audience feedback. Advertising could change in the same way. Government, public interest groups, politicians et cetera, might use it to gauge public interest on various topics. The possibilities become wide indeed once the concept is grasped.

The concept of electronic polling (as opposed to voting in the political sense) has been discussed in the “wired city” and interactive cable television literature for some time. However, it has been regarded by many as mainly a theoretical possibility in the distant future when new communications infrastructures have developed. The essential difference with “incasting” is that it could be developed today, using the existing telecommunications structure, at a relatively low cost, and operate without damaging the existing telephone traffic. A technological and conceptual breakthrough (now patented in Canada and the United States) makes this possible.

Bell Canada is studying the possibility of having an “incasting” trial. The Canadian broadcasting industry is very keen to participate. Other interested parties such as the Canadian Radio-Television and Telecommunications Commission and Statistics Canada (both Federal Government agencies) are also very interested. The internal Bell Canada decision is being pursued along a number of paths that would be expected in any significant opportunity analysis. However, the social-political issues have been some of the most prominent since the project was undertaken.

It is clear that even though this is a polling system and not a voting one, that its use could have significant social-political impact. The internal debates at the highest levels of the corporation have often concentrated on these TA issues rather than the pure business interest or technology ones, These debates have been very intense and the TA process is being brought into play. A consulting political scientist has been exposed to the concept and has provided new insights into the potential impacts, Further seminars are planned with knowledgeable experts in relevant fields in order to map out the impact possibilities. The project manager for "incasting” has personally conducted the CAI-TA referred to above, and hence is more than casually aware of the TA processes that have to be brought to bear in a case such as this one. Finally, any decision to conduct an “incasting” trial will be matched with one to track the social impact aspects of the trial.

The "incasting” project is in mid-course and it is difficult to know how it will be resolved. There is not any corporate commitment to even conduct a trial at this time. However, as the “incasting” story unfolds, the process of corporate TA will be followed. As noted in the previous section, it is the author’s conviction that the use of a TA process as a part of the on-going managerial process of decisionmaking is of far greater importance than single-shot studies. The use of a TA process throughout the “incasting” project will be far more significant than one study on the social implications of electronic polling.

Conclusions

Bell Canada and the BPG have been seriously committed to TA for the past four years. Similarly, the organization has been committed to some of the basic concepts for a much longer period of time. The experience with TA itself has been an evolutionary one. This experience has been educational at both the methodological-professional level and at the decisionmaking level. Our current view continues to support professional research activities where new information is required. However, we have come to recognise that TA is more valuable in the corporate environment when it is a normal part of the continuing decisionmaking and re-evaluation process than when it is only associated with one-time studies of particular topics. The material outlined in this document. particularly as it is related to the work in travel-communications substitution and to “incasting” is offered as concrete experience to support this philosophy.

APPENDIX I : TECHNOLOGY ASSESSMENT AND INDUSTRY

INTRODUCTION

TA has been a concern of governmental bodies for some time. The role of the industrial sector in TA has not been discussed widely beyond the obvious negative role of being a target for problem-oriented assessments. This short review will attempt to present a more positive role for the corporate sector.

industry's involvement in TA can occur as a result of several different types of pressures. These pressures for involvement can be grouped into three categories: (a) defensive reactions; (b) positive pressures; and (e) corporate social responsibility. Each of these forces will be reviewed in turn.

INDUSTRY AND ASSESSMENT

DEFENSIVE REACTIONS

Legal

The introduction and enforcement of environmental protection statutes have proved that institutions can be made legally responsible for the secondary consequences of their actions. One school of thought in technology TA feels that prior assessment of the potential secondary impacts of major business decisions will become a legal requirement. Legal issues will also arise if TA becomes part of the adversary regulatory system used in many OECD nations. Hence, some corporations are starting to conduct TAs in anticipation of more formal requirements to do so,

Potential Bias. The overwhelming interest in government-oriented TA when compared to the business contribution has led some people in industry to fear that all assessment work may have an anti-business bias. If this does not occur there is still a fear that the assessment activities will be too academic. When the legal question reviewed above is taken into account as well, business planners are led to believe that they must provide a contribution to TAs or this potential for bias could become a serious problem in the long term.

R & D Planning. TA is designed to be an anticipatory process A realistic analysis leads us to conclude that most of the introduction of new technologies in OECD countries still occur in the private sector. An understanding of the development and implementation process for technologies into society reveals that this is a complex process that begins with basic R & D planning. Inclusion of TA inputs to this system should begin at the earliest stages of technological research. It is unlikely that many businessmen would accept inputs from government assessments alone. Thus, industry's role in the R & D process is also creating pressures to conduct extensive assessments.

These initial pressures are negative in the sense that they indicate events are forcing industry to become part of the assessment movement rather than becoming contributors in a voluntary way. This is not the case, as there are positive forces at work that make TA a logical activity for corporations.

POSITIVE PRESSURES

CORPORATE LONG-TERM PLANNING

Many of the techniques that are used for TA are those used in long-term planning in business. Other useful techniques are found in market research and planning, econometric modeling, and statistical analysis. While there is a clear distinction between these forecasting techniques and a complete TA, familiarity in industry with the use of these methodologies creates fertile ground for TA in business. The main thrust in TA is to extend the vision of business planners to secondary as well as primary impacts. This is an evolutionary, not revolutionary, step for planners in many of today's large business concerns.

As noted above, the development of strict environmental control statutes in many OECD countries has led to the requirement to prepare studies showing the potential secondary impacts of introducing new technologies into the environment. The *involvement* of corporations in sponsoring or directly preparing environmental impact statements has acquainted both corporate planners and business executives with the concepts and practice of examining secondary impacts in advance of taking actions. It is not difficult to move from examining environmental secondary impacts to reviewing the broader range of considerations involved with TAs once the decision maker is familiar with environmental assessment.

COSTS

Experience in trial and actual TAs has indicated that they are often quite costly. Most of these studies have been conducted by outside groups not part of the decisionmaking agency. Outside assessments by consulting firms, universities, or government agencies appear to spend large portions of their resources in acquiring a data-base of information required to gain knowledge of the industry and technology that they are assessing. Cooperative research with industry in conducting assessments can help reduce the costs of assessments considerably, in some cases this may be an order of magnitude reduction. This scale of reduction is possible as industry often has the basic background data available in its files. The costs of reconstructing this data are often monumental, with no assurance that the reconstruction will be accurate. Preparation of assessments by industry or joint work with government, university or consulting agencies in a cooperative non-hostile environment may help make TA a more cost effective process.

CORPORATE SOCIAL RESPONSIBILITY

The discussion above has noted that there are negative or self-preservation reasons for corporate involvement in TA, and that there are also positive reasons for TA to become a natural evolution of business planning activities. There is an even stronger pressure for involvement than these factors; this is the growth of what has become termed "corporate social responsibility." While this is often regarded as mere rhetoric or good advertising fodder by non-business people, there is in fact a hard-core development here that is quite serious. This is not a universal factor across business or particular industries but it is a rapidly growing consideration in many corporations. This consideration in business makes TA a central activity of the future in corporations that are truly interested in the social impact of their decisions.

The author expects that this interest will develop first in industries that are currently under some form of government regulation. Regulated industries have experience in dealing with governments on a routine basis and are not quite as caught up in the standard government vs. business rhetoric that occurs elsewhere. The preparation of TAs in regulated industries and their reception by regulatory and other government agencies will act as a good model for future voluntary assessment activities in industry. Widespread failure in this arena would probably lead to a reduction of assessment activities on a voluntary, positive basis and result in a return to assessment work for the more negative reasons outlined above.

Most indicators show that TA and industry will have a productive relationship. However, this does not mean that there will not be problem areas with industrial assessment activities. Several of the most significant potential problems are reviewed below briefly.

POTENTIAL PROBLEM AREAS

CREDIBILITY

This is the most basic problem and should be faced realistically. Many TAs sponsored or conducted by industrial groups will be regarded by many government and academic groups as tainted by their parentage. This view will be a sound one in some cases but will be unfair in many others. Objective, methodologically sound, well-conducted assessments should not be lost in the intellectual and political rhetoric. Industry has a valuable contribution to make in a TA and each individual study should be measured on its own merits.

COST BURDEN

The costs of TA will certainly cause serious questions in industry. The costs of assessment involve more than the direct financial burden of conducting studies. Other costs include the financial and opportunity costs of lending experts to assessment teams outside of the parent organization. Costs also include the potential danger of the loss of proprietary information given to assessment teams who then publish their findings widely. All of these cost elements become important in national or international competitive environments where all of the competitors do not decide to conduct assessments.

IMPACT ON INNOVATION

One of the common statements of concern regarding TA is that it will slow down the rate of innovation in industry and in the economy generally. These concerns are genuine, especially in the increasingly competitive international economy. While the concept of growth for its own sake is rapidly becoming regarded as questionable, even in some businesses, it is difficult to convince one company, industry, or nation to voluntarily slow down its own growth unless it is assured of some form of quid pro quo from its competitors. Organizations like the OECD will have an important role to play in assuring that these innovation impact considerations are resolved satisfactorily on an international scale.

SUMMARY

The inputs from TAs should be also added into the process of constant decision-making in industry. This can only occur if industry takes an active role in conducting its own assessments as well as utilizing the work of government and academic agencies. TA will have achieved its greatest success if assessment inputs are routinely used in decisionmaking rather than if they are only imposed by regulation on certain types of decisions. The problem areas reviewed above are important but on the balance business can be expected to play a valuable role in the movement for widespread use of TA recommendations. The author feels that the realities of modern economic life in the OECD nations demand that industrial assessment activities become widely accepted and encouraged. Industry makes many of the most important decisions today on technology adoption and will continue to do so in the future in Western economies. TA mechanisms that only examine the secondary impacts of these decisions after they start to emerge will be a limited success. Regulation as used in traditional regulatory bodies does not appear to be the best model for the future.

Appendix 2: Technological Imperatives In Telecommunications

Much of the interest in the question of substitutability has resulted from a recognition that new communications and computer technologies offer many capabilities that may reduce the utility value of personal travel when compared to these services. Promoters of specific technologies often claim that their innovations alone will reduce the need for travel. These claims are optimistic and perhaps unfounded when viewed in isolation. However, the combined capabilities of the various emerging technologies will certainly have an impact on the substitution issue. Several of these major thrusts in technology are reviewed below.

TWO-WAY BROADBAND SYSTEMS

Most of the literature in this field has been concerned with an expansion of the capabilities offered by co-axial cable currently being used to deliver cable TV signals. These broadband channels can be converted to interactive use through the use of additional electronics to provide low-speed (audio grade) or broadband (video grade) return paths from the receiving location to the central distribution point (the “head end”). These return path capabilities can also be provided through the use of the regular telephone channel. The significance of these systems is that they create the ability to deliver “on demand” selective visual information over the broadband channels. These systems have the theoretical capability over time to add random switching so that each subscriber can call any other subscriber in a fashion similar to telephone calls today. These calls could be audio, audio-graphic, or audio-visual in nature. It is still questionable whether the providers of cable systems will invest the additional capital required to provide these types of capabilities. The recent difficulties in the cable TV industry have strengthened the view that widespread use of interactive television into the home is further off than many have predicted in the past few years.

Two-way broadband systems could provide a certain amount of selective, private delivery of information to subscribers in residential areas leading to some forms of intra-urban substitution (where most systems are installed and will be installed for the next decade or so). These possibilities have led to a number of forecasts on the potential of working from home.

The availability of a host of consumer-oriented capabilities has been forecasted by those expecting the development of a “wired city” (a misnomer since most cities are already wired for power and telephone systems). These services include:

Remote shopping;
Remote banking;
Electronic security services;
Electronic education;

Electronic voting;
Consumer information retrieval systems; and
Remote medical systems.

As noted above in the introduction, the papers presented by other members of this panel discuss some of the implications of the use of these types of systems on business-oriented intra-urban travel. The use of these technologies could also lead to substitution of certain forms of non-business intra-urban travel. The BPG of Bell Canada has conducted a modified Delphi study of the potential acceptance of these types of services in the home. The results of this research are described elsewhere. This work is being continued currently with a detailed **TA of** the positive and negative secondary impacts that may result from the use of "wired city" services. The intra-urban substitution issue is one of the items that will be reviewed in this project. There are other technologies that are generating interest in the substitution thesis. One of these is video teleconferencing.

VISUAL TELECOMMUNICATIONS TECHNOLOGIES

The use of these systems to augment substitution has been forecasted by many observers. Interpersonal visual communications can take the form of randomly switched calls between individuals using a technology such as the U.S. Bell System's Picturephone. Interpersonal visual communications can also take the form of point-to-point teleconferences between groups of individuals using systems such as Confravision in the U.K. or Bell Canada's Conference TV system. The Confravision system has recently been extended to Sweden, and other European countries are reported to be planning to join this growing network. In the U. S., the Bell System has introduced a three city (Washington, New York, and Chicago) conference television based upon Picturephone technology. The Australian Post Office has also been using a Confravision system for several years. One of the prime reasons advanced for using these systems is to cut back inter-city travel.

The systems discussed above are all directed toward inter-city communication. The question of intra-city video conferencing has also been tested but not on such a wide-scale basis. The Metropolitan Regional Council around the New York City area has been using a multiple location video conference network for local use during the past year. This system has been used to replace travel within the New York City area for meetings between the local politicians and civil servants, and for remote training sessions. Interactive television systems (audio return paths only) have been used at Stanford University and The University of Southern California for several years to reduce student travel to classes or provide educational training to employees right at their remote job locations. Both inter- and intra-city systems offer the ability to interact with images of speakers at remote locations and to share pictures, diagrams, and graphics.

It should be restated here that significant future substitution would not be expected to take place through the use of Conference TV or Videophone alone. It is the combined pressure from the **overall collection of technology capabilities that is being reviewed here.**

COMMUNICATIONS SATELLITES

Communications satellites have grown from experimental vehicles to key components of national and international communications systems in the past decade (both for broadcast and interpersonal communications). Canada was the first country in the world to use synchronous orbit domestic satellites for broadcast and interpersonal communications within a nation. While there are abundant east-west communications systems within Canada, the satellite permits communications into the far north of Canada where other systems could only provide delayed broadcast or periodic telephone service. This technology is viewed as an important means of linking residents of the North into the communications mainstream of Canadian life. In the U.S. domestic satellite service has recently been introduced by the Western Union Company. This system will also provide nation-wide telecommunications service to both end users and other common carriers.

Communications satellites may be a factor in other substitution questions as well. These satellites have been projected as means of linking up many urban cable TV or local broadband systems into nationwide networks. They may also be used to provide lower cost video channels for interpersonal visual communications *systems* such as Videophone or Conference TV. However, in both of these cases, their impact is secondary since the satellite only provides raw communications channels to these other systems, which in turn provide user-oriented services that could augment the substitution process. Analysis of the impact of future broadband communications or visual teleconferencing systems should include the impact of any satellite communications as a sub-component rather than as an entity in itself,

INFORMATION STORAGE AND RETRIEVAL SYSTEMS

Communications technologies in themselves are not the only technologies that will have an impact on the substitution process. The complex merging of *com*puter power and communications systems is leading to a whole new order of significant technologies. The development of “on-line” (i.e. communications-linked) time-sharing systems that provide a host of personalized information storage and retrieval capabilities, text editing, and computational power is creating the possibility of utilizing remote work centers with the required access to computer systems needed to accomplish a task. Developers of very advanced, but user-oriented (the “dumb” user from a computer viewpoint) systems see them as creating “augmented knowledge workers” over time. (9) They foresee an evolution in work styles and capabilities as knowledge or post-industrial workers utilise the power in these systems. This could have considerable impact on the intra-urban substitution question since these systems can be routinely accessed from any location that has a telephone.

COMPUTER NETWORKS

The evolution of several advanced forms of computer networks in North America will reinforce the tendencies outlined in the above section. Linking through relatively inexpensive communications networks permits specialization of computer capabilities at various geographic locations. The Advanced Research Projects Agency (ARPA) has financed the development of one such system in the U.S.A. that is now being extended (via satellite) to Europe, Hawaii, and the Far East. This resource-sharing of specialized computer systems will assist in further augmentation of knowledge workers and impact on the need for both intra- and inter-urban travel. Several commercial versions of these forms of computer networks are being introduced in the U.S. The Trans-Canada Telephone System is also introducing a common user-packet switched-data network in the next year. Plans for experimental networks have been also announced by most European telecommunications authorities and by the Japanese telecommunications organization.

COMPUTER-AUGMENTED CONFERENCING (CAC)

CAC connects a number of individuals with computer terminals to the computer in a synchronous or asynchronous mode, permitting them to approximate the interactions that they might experience if they were engaged in face-to-face communication as well as providing new capabilities not currently available with face-to-face or electronic communications. The number of participants in a computer-augmented conference can vary from two to as many as twenty or more. Since the communications process is asynchronous, many conferees can input their comments to the conference at the same time: when they have finished their input, the computer delivers the messages that have arrived during the input phase. A text editing facility may also be included in the CAC package.

Computer conferencing provides another means of merging computer and communications systems power to help create alternatives to travel. The technique is also being used as a research vehicle by the BPG. In the past, audio-teleconferences have been sponsored by the group among over twenty” different individuals associated with institutions studying various aspects of the substitution question. This program has been expanded to include interactive computer conferences on the same subject.

OTHER TECHNOLOGIES

This analysis of the technological issues that are stimulating interest in the substitution area is only a brief overview of the energy possibilities. Each of the technologies discussed above can be explored in much greater detail in the various references given. Many other relevant technologies that will have a bearing on the future process of substitution have not been discussed. These include, intelligent terminals , video discs and cassettes, audio cassettes, video data banks, audio data banks, computer-based education systems, facsimile transmission, graphic communications, still-frame TV transmission, artificial intelligence systems, and voice input to computers. The main purpose of this section of the article was not to be all-inclusive, or to review any particular technology in detail, but to give a flavor of the technological revolutions whose combined strength will certainly cause a conscious re-evaluation of many future decisions to travel.

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APPENDIX D– EXHIBIT NO. 1

ASSESSMENT OF SOLAR HEATING AND COOLING FOR AN ELECTRIC UTILITY COMPANY

AUGUST 1975

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ASSESSMENT OF SOLAR AND COOLING FOR AN ELECTRIC UTILITY COMPANY*

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I. INTRODUCTION

If commercialization of systems for solar heating and cooling of buildings is to be successful, then consideration of the interaction between these systems and electric utilities is essential. Widespread use of solar heating and cooling systems stands to affect utility generation capacity requirements, fuel requirements, and load factor. Costs of electricity will affect customer decisions regarding installation of solar devices. In the pact, very little thought has been given to how applications of solar energy in buildings can benefit both the operation of an electric utility and the energy user. This paper reports results of a study of applications of solar energy in residential and commercial buildings in the Southern California Edison Company service area. Economic comparison were made which considered both the direct costs and benefits to the utility customer related to the use of solar equipment and the indirect costs and benefits related to effects on the electric utility of demands for back-up electrical energy. Benefits to utility and customer were thus accounted for without any prejudice based on existing institutional arrangements.

The basic objective of the study was to understand the Interaction between elements of the heating and cooling energy supply system well enough

*This paper describes results from research sponsored by the Southern California Edison Company by agreement with the National Aeronautics and Space Administration.

so that utility objectives and directions for R&D activities in solar heating and cooling could be defined. In pursuit of this objective, it was necessary to: 1) assess the potential impact of solar usage on the utility in question, Southern California Edison, and 2) identify conceptual solar systems having a potential positive societal impact. An a priori assumption of the study was that the magnitude of the impact of solar usage would depend on the cost competitive status of solar equipment, its regional applicability, the number of applicable buildings, and the magnitude of associated loads. Research and development needs are established in cases where the impact can be accelerated and made more positive via solar energy system design.

Just as the cost and availability of electricity will influence the market penetration and design of solar energy systems, solar energy usage for heating and cooling will influence electricity load growth and cost. We will show that solar energy systems are optimally designed when they supply only a fraction, 60-80% of the total heating and cooling energy requirement. Utility electric systems will be affected differently by a load imposed by an all electric heating system than by a load associated with backing up a solar heat source. Since electricity cost is sensitive to the nature of the demand placed upon the electric system, the impact of solar usage on electricity costs can be positive or negative depending upon the design of the solar energy equipment.

Our study was thus a "technology assessment" in that it dealt with a more complete system than is usually considered in evaluating solar heating and cooling systems. To achieve an overall societal benefit by integrating solar devices into this system requires that the total cost of heating and cooling energy be reduced. This total cost is essentially the sum of three components: 1) the cost of the solar equipment, 2) the cost of conventional fuel, and 3) the cost of conventional energy supply equipment (e.g. power plants and transmission and distribution systems). Achieving a reduction in the total cost in general will require that the solar energy systems be designed to operate so that the utility's peak demand is reduced as much or more than its average demand, (i.e. its load factor is improved) and that the proportion of premium fuel usage is reduced. We will have achieved very little if the aggregate cost of installed solar equipment is not offset by the sum of the reductions in the cost of the other two components.

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11. APPROACH TO THE STUDY

Southern California Edison serves 7.5 million people in a climatically divesee area of 50,000 sq. miles as indicated in Figure No. 1. The study confronted a three dimensional problem involving microclimatic zones, buildings, and the heating and cooling systems for the buildings. Our approach was to treat each dimension In turn. Then, with performance and economics calculated for selected systems and selected buildings in selected microclimatic zones, we assessed the market penetration potential of solar energy systems and the sensitivity of this to incentive and economic assumptions.

The study was limited to solar heating and cooling systems for individual commercial and residential buildings. Solar heating and cooling systems designed to serve more than one building were not considered, nor did we consider concepts which use solar energy to generate electricity or concepts using solar total energy systems which provide both electricity and heat.

The first step of the study involved organizing weather data in a way which would allow the estimates of building heating and cooling loads and collector performance to be efficiently and accurately calculated. Our procedure for organizing and using weather data allowed statistically weighting and ordering of different types of days in each month of the year, e.g. hot-cloudy, cold-sunny, hot-sunny, etc. This allowed us to determine the fraction of the total energy requirement that could be served by a given size solar installation. Coat optimum system designs could then be defined. The approach is commended to others as a cost effective strategy for simulating the operation of solar energy systems in buildings; see Reference 1.

Baaed on reduction of data from 14 weather stations in Southern California, five microclimatic zones distinct with respect to solar applications were identified, as indicated in Figure 2.

Applications of solar energy were studied in three of these micro-climatic zones: the coastal zone, the inland zone, and the high desert. The two other zones were not explicitly examined. These zones are the low desert and the San Joaquin Valley. Both have low population levels within the SCE service territory compared to the three zones selected and are similar to the high desert zone.

Four buildings were studied: two residential buildings, a 2250 ft^2 single family, a 9-unit multiple family dwelling, and two commercial buildings: a 6-story, 50,000 ft^2 office and a 145,00 ft^2, 3-story department store. The buildings all exist in Southern California, and data is available on their actual energy consumption for heating and cooling.

In addition to analyzing the buildings as they exist, separate computations were made for the same buildings as they might be designed in the future baaed on energy conservation oriented design practice. Energy conservation features were specified for three of the four buildings. This was not done for the department store. The department store had no windows, and the heating and cooling loads in such a building are relatively insensitive to the weather.

In total, over 60 combinations of specific solar energy systems for specific buildings with and without energy conservation features in specific locations within the Southern California area were analyzed. The combinations of systems and buildings examined are summarized in Figure 3. Performance of the solar energy systems was calculated using a generalized multinodal thermal analyzer program (SINDA). Building heat capacities were considered in calculating building heating and cooling demands on an hourly basis. The computer models were calibrated against available heating and cooling load data. For the single family dwelling hourly data was used to calibrate the computer model. For the other buildings monthly and yearly data were used. The model for calculating the solar energy available from any of the collector included both the effect of direct and diffuse solar radiation. A simplified model of the solar energy storage subsystem was used which assumed the storage subsystem to be lossless except for the leas of energy not used on the day it is collected. A discussion of our approach to the use of economic data to assess the potential impact of solar usage in Southern California is contained in Section XI.

III. DATA AND ASSUMPTIONS

The best base data was used. All of the thermal paremeters for the baseline and energy conserving case study buildings are consistent with ASHRAE handbooks. The weather/insolation data developed in Reference 1 were used to drive both building models and solar collection system models. Note that the insolation data of Reference 1 could be low by 15%, thereby making the performance calculation somewhat conservative.

Costs were estimated in constant dollars with 1974 as the base year. The 1974 Dodge Manual and the 1974 National Construction Estimator were used for conventional costs. Costs for unconventional equipment (like solar collectors) were estimated on the assumption that commercial scale production facilities existed for the component in 1974. Implicit in using constant dollars as a base for comparison is the assumption that inflation will affect all components about the same. This assumption is better for some cost factors than others. Specifically, the relationship of electricity cost to the inflation rate cannot be projected accurately. This was taken into account by considering three scenarios for gas availability and electricity price in the market penetration analysis.

In order to make comparisons between solar heating and cooling systems and conventional systems, certain assumptions have been made concerning both conventional and solar technology. Only technology which could be commercially available by 1980 was considered. Solar collectors with efficiencies as good as the beat prototypes currently available were assumed. Heat actuated and vapor compression chillers approaching the practical limits of performance were assumed. This meens that solar energy cooling must compete with electric vapor compression chillers having a C.O.P. of about 3.0 (including condenser fan power), even though vapor compression chillers currently typically fall short of this high performance. Energy was *assumed* to be stored as sensible heat in tanks of water. Although It is theoretically possible **to** store energy as the heat of fusion in various salts and waxes, these storage mediums have yet to be proven practical and economical. The results of the study would not be significantly altered if other storage media were considered.

IV. GENERAL OBSERVATIONS

One way of taking the utility/customer interaction into account in economic analyses is to compare solar energy costs with only the component of total electric energy costs that are actually displaced by solar. In substituting solar energy for electricity, two things can be accomplished. Both have a positive societal impact which can be reflected, imperfectly, in economic terms. First, solar energy can displace the fuels required to generate electricity. The costs of these fuels, as reflected in cents per kilowatt-hour of electricity, can range from a few tenths of a cent per kilowatt-hour for nuclear fuels all the way to two or three cents per kilowatt-hour for various grades of oil used for generation. Second, solar energy end-use systems, when substituted for electric end-use systems, could reduce the load on the electric system at peak times. The demand at these peak times effectively determine the magnitude of the investment in generating and transmission equipment an electric utility must make to reliably serve its customers. If the solar devices operate to reduce heating and cooling related electricity demand during these peak periods, credit can be taken for the costs of increments of electric system capacity rendered unnecessary. As a result of the recent dramatic increases in oil prices, overall capacity and fuel related cost component for the Edison system now have roughly equal weight in determining electricity price.

A solar energy system, having no storage associated with it, could not offset capacity requirements unless the utility load curve and the solar availability curves were uniformly coincident. No situation has been found in which this is the case. Thus, without storage, the value of the solar output is simply the cost associated with the fuel it displaces, which can be thought of as the oil which must be burned to deliver the additional electricity required during the daylight hours. . This value was once thought to be insufficient to afford realistic competitive prospects to any solar heating and cooling application. We find that now with fossil fuel prices greatly impacting the generation cost picture, there are some solar energy systems which appear to be justifiable on their fuel displacement potential alone. Water heating for larger buildings is an example.

In considering solar energy systems that include storage, either intrinsically or by design, the displacement of fuel and capacity depends not only upon the average energy requirement for a system but when the system places the greatest demand on the electric system. Loads which reinforce the overall electric system peak are less desirable than loads which have no time dependence. Water heating is what might be termed a balanced load since it is relatively weather and season insensitive. On an aggregated basis, it contribute both to fuel consumption and the requirements for additional generating capacity. In this case, it is probably appropriate to compare solar costs with the electric billing rate. Electric apace heating, on the other hand, for summer peaking utilities, such as Southern California Edison, could be termed a semi-off-peak load. Note that electricity is not presently the dominant energy source for apace heating in Southern California. Even if it were, solar usage for space heating would have little effect on capacity requirement , and the fuel displaced would be the cheaper fuel involved in utility base load generation. With storage and proper control however, solar augmented heat pump systems would allow the delivery of electric heating energy in a way beneficial to the electric system load factor.

Given the need to analyze solar energy systems from the point of view of the utility and customer combined, it is important to realize that there are a number of alternative means to incorporate favorable or unfavorable impacts on utility econmics into the individual customer's decision-making process. Examples include different rates for peak and off-peak periods and such incentivea as leasing, installation and servicing of preferred systems or other cost sharing on the initial installation. This will require serious consideration in the near future as solar devices begin to penetrate the market.

V. REGIONS

In general, climate affects the optimum size of solar energy system components more than it does the overall economic status of the system. For example, Figure 4 illustrates the difference in economic characteristics of systems sized for the high desert region versus systems sized for the beach in the case of solar hydronic heat pumps. Although the collector area differs by a factor of 3 between zones, differences in the effective solar energy coats are less than 10%.

The relative economic position of solar energy is determined by three factors which vary between zones: (1) the climate, specifically the amount of sunshine, (2) the effect of climate on the utilization factor of the solar equipment, and (3) the economies of scale associated with the total installed cost of solar HVAC systems. For space heating and cooling systems this is seen more clearly in the smeller buildingg, which have weather sensitive heating and cooling loads. For example, in the case of apace cooling, where weather in the inland zone and especially in the desert areas results in a higher utilization factor, economic attractiveness of solar cooling systems does improve as the location moves inland.

On the other hand, in the case of solar space heating of a single family dwelling, the economics are slightly more attractive in the coastal zone. Although the heating load la lower in the coastal zone, it is also more uniform. The more uniform load results in a higher utilization factor on the solar equipment, which more than offsets economies of scale and better solar availability in the inland and high desert areas.

The fact that economics of solar heating are not particularly weather sensitive, in spite of significant climatic variations, is encouraging. The development of broad regional or national markets for solar hardware need not be hindered by the need for geographically specific studies of economic viability.

Energy conservation measures which reduce the size and first cost of solar heating systems also reduce the economic attractiveness of these systems in residential buildings. It was found that energy conserving features such as insulation and reduced infiltration had the effect of shortening the effective heating seasons and reducing utilization factor on the solar heating equipment. These measures increased payback periods vis-a-vis conventional alternatives by 25 to 30%. By contract, in larger buildings which are less weather sensitive and which have relatively steady heating and cooling loads, energy conserving design tends to have the opposite effect. It shifts the load toward heating and thus improves solar economics by providing a more balanced and effective utilization of the solar equipment.

VI. APPLICATIONS IN DIFFERENT BUILDINGS

The prospects for successful application of solar cooling were found to be relatively poor in all of the buildings considered. Based on present technology of heat actuated chillers, first cost recovery (payback) periods of greater then fifteen years were required for well insulated single family dwellings and greater than 11 years in larger buildings. In considering solar water and apace heating for the various case study buildings, once again considerations on the utilization factor of solar equipment predominated. The multiple family dwelling was found to be the preferred building application for solar heating. The multiplicity of units and the resulting load diversity results in a higher load factor on the solar equipment than for the single family dwelling.

Generally, the multiple family dwelling offers the shortest payback periods for water heating, ranging from 3-1/2 to 5 years based on the choice between a central system and systems for individual units. Payback periods for space heating plus water heating range from 5-1/2 to 7 years, based on comparing solar hydronic heat pump system costs with the electricity costs for conventional electric heating systems. Larger multiple family dwellings show more attractive economics based on economies of scale in the solar energy system.

In the case of single family dwellings, water heating offers a payback period of ten years, while space heating and water heating offers a payback period of 6 to 8 years compared to electric resistance heating at the 1974 billing rate.

The climate control systems for the large commercial buildings such as the six story office building considered in our study are largely used for cooling. Because the maximum possible economies of scale are achieved in such applications, solar cooling systems with optimally sized storage cone closest to showing attractive economics for these large buildings, i.e. a tan to 15 year payback period can be achieved.

Unfortunately, from the point of view of optimizing the cooling energy supply system, it would be better if the preferred application for solar cooling were s smell building. Since smell buildings are the key factors in the weather sensitive component of a utility load curve, solar cooling for such buildings with appropriate storage would reduce the weather sensitivity and thus improve the load factor.

It was hoped that solar cooling system without thermal energy storage could reduce the demand for electricity during peek demand periods. Figure 5 chows quite clearly why this will typically not be the case. The peek cooling load, and thus the electric system load, continues beyond the period of solar availability into the evening hours. Because of this, the addition of energy storage, i.e. "coolness" storage, in connection with the cooling system greatly enhances the competitive status of the end-use system. Systems for solar heating and cooling and coolness storage in these buildings may afford the flexibility required to reduce the weather sensitivity in the utility load curve to the benefit of the electric system load factor and to the ultimate benefit of the utility customer. However, coolness storage alone appears to be far more cost-effective then solar cooling. This will be discussed further in Section X.

VII. COLLECTOR TECHNOLOGY

COLLECTOR COSTS

The issue of collector cost has long dominated solar economics discussions. We conclude from our analyses that the cost of the solar collectors will probably not dominate the budget for solar heating and water heating systems installed on Southern California homes. If collectors can be produced for $2.77/ft^2 (1974 $) f.o.b. the factory and installed for an additional $2.93/ft^2, then the non-collector costs exceed the collector cost for systems with leas than 1000 ft^2 of area. Detailed cost estimates for non-collector costs based on accepted 1974 data are plotted in Figure 6 and show that non-collector costs increase to ***70%*** of the installed cost for systems as small as 100 ft^2. These 100 ft^2 systems would be adequate to serve an energy conserving single family dwelling in the coastal zone of Southern California and will cost in the neighborhood of $2,000 if collector cost goals are realized.

COLLECTOR DESIGN

A collector with two cover glasses and a selective coating has been found to be economically justified for the water heating and space heating applications if the cost of a durable selective coating is less than .15 $/ft^2 (f.o.b. the manufacturer). For solar augmented heat pump systems an **unglazed** collector is adequate. Collector currently being used for swimming pool heating may be suitable in this application. The evacuated tubular collectors show considerable promise for improving the coat effectiveness of solar cooling applications.

VIII. SOLAR COOLING TECHNOLOGY

The load on the Southern California Edison system reaches its maximum during the summer months. The daily load on the Edison system is typified by the curves in Figure 7. The difference between summer and winter load characteristics is attributable to an increase In demand related to apace cooling in residential and commercial buildings during the summer months. Approximately 25% of the Edison load is weather sensitive. In extreme climatic regions the air conditioning impact is striking. For example, the summertime daily demand peaks in some desert areas can exceed the tinter peaks for these areas often by as much as a factor of three. All prospects for curbing the growth of this summer peak are of great interest to affected electric utilities.

Our careful look at solar cooling technology baaed on various thermodynamic cycles was very discouraging. The moat significant technical barrier to the economic application of solar cooling using thermodynamic cycles is the low coefficient of performance (C.O.P.) of heat actuated chillers. The single stage LiBr absorption machines have a practical C.O.P. of .65, and the organic rankine cycle vapor compression heat pump solar cooling schemes have an overall C.O.P. of under .40 for collector temperature in the range of 200 to 250°F. Since the cost of the thermal energy from the solar collector is roughly competitive with electricity, a C.O.P. for the heat actuated chiller in the range of 1.5 to 3.0 will be needed to make solar cooling economically competitive (from the owner’s point of view) with electricity driven vapor compression machines. Even at 1400°F a 50 to 200 hp. water rankine cycle expander only has an efficiency of 24% resulting in an effective C.O.P. of .72. Organic rankine cycle prima movers are limited to temperature below 650°F and C. O. P. of leas then .75. Therefore there is little prospect that concentrating collectors with rankine cycle prime movers will compete with conventional air conditioning with economic condition. projected for the next decade. A prototype double effect lithium bromide chiller has been operated with steam at 250°F with a C.O.P. of 1.33. Use of this chiller could reduce solar cooling system payback periods by 30%. However, research is clearly needed on heat actuated chillers with even higher C.O.P. if solar cooling is to compete in the near term with electric vapor compression chillers.

U*-Factor modulation appears to offer an attractive alternative to solar thermodynamic cycle cooling. The technology is conceptually simple. It involves controlling absorption of solar energy and radiation of heat from the building surface. An intuitive interest in this concept has emerged from the discouraging outlook for solar cooling using thermodynamic cycles. However, the economics are not easily established, the application of U-factor modulation integrate traditionally separate disciplines of mechanical engineering and architectural, and the concepts demonstrated to date are radical departures from conventional construction. None the less the idea la only a few years old, and it has been demonstrated to work to stabilize internal temperature. Harold Hay's "Skytherm" house and the "Drum Wall", "Sky Lid", and "Bead Wall" designed by Steve Baer all appear to work. Homes based on these principles, if not these specific designs, would contribute less to the cooling loads on an electric utility. Work is needed to optimize these systems making better use of backup energy sources. Innovation on the basic ideas are needed to make them less architecturally constraining.

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*U . the overall heat transfer coefficient of the building.

IX. SIZING BASED ON ECONOMIC CRITERIA

Solar energy systems should not be sized to carry 100% of the heating load if capital is to be used efficiently. The use of marginal cost analysis for sizing is important if capital Is to be efficiently deployed. The use of average cost for sizing would suggest a broad range where the size of the system makes little difference economically. The marginal cost approach shows the inefficiency of oversizing solar energy systems.

As en example of the marginal cost approach to sizing a solar energy system, consider a solar water heating and space heatlng system for a 2250 ft^2 single family dwelling in the inland valley region. The auxiliary energy saved and the system coat is first calculated as a function of the solar collector size. The marginal coat of solar energy* is then calculated as a function of system size. The results of this analysis are plotted in Figure 8. TWO scales are supplied for capital recovery factors (crf) of 0.2 and 0.1. For example, using the crf = .2 scale a solar energy system should not be installed to produce solar energy unless the (average coat) price of the auxiliary fuel is .045 $/Kwh. If the price of auxiliary fuel is .055 $/Kwh, the marginal cost analysis suggests a collector area of 20 m^2 (215 ft^2). This collector area will supply about 66% of the heating and water heating load of the building used in this example. 66% is typical of the percentage associated with optimal collector sizes for all of our case studies for residential buildings. The proper share is higher in commercial buildings.

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*Marginal Coat = crf x $\frac{\partial(\text{cost})}{\partial(\text{auxiliary energy saved})}$

Where crf = the capital recovery factor.

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X. PROMISING APPROACHES TO SOLAR HEATING SYSTEM DESIGN

As noted earlier, solar space heating systems appear to have the potential of becoming economically attractive from a building owner's present point of view. Use of off-peek-power cooling can improve the economic attractiveness of solar heating when the impact of off-peak power usage on electricity costs is accounted for in the analysis. In the southwest, solar heating systems will only need 100 to 200 ft^2 of collector area in an energy conserving home. In this size range a water storage tank, heat exchanger, and the plumbing needed to transfer solar energy heat to a forced air duct is approximately 1/2 the total cost of the solar heating system. These components can also be used in connection with an electric air conditioner operating at night for off-peak-power cooling. The payback period on the incremental cost of adding a solar heating system to an off-peak power cooling system is thus reduced by a factor of two. Therefore even though solar heating with electric back-up only saves fuel, it comes close to being attractive when coupled with off-peak-power cooling. Solar heat is stored in winter and electrically produced 'coolness" is stored in summer. This combined system can displace both fuel and peak load on the utility.

One solar energy heating system has been identified which is attractive on the basis of fuel caved even without an off-peak-power cooling function. This system is the solar augmented hydronic heat pump in larger apartment and commercial buildings. This system is inexpensive because useful energy can be collected at 700P. The required solar collector need not have any glazing to be affective. The complete solar hydronic heat pump system is illustrated in Figure 9. It may be possible to eliminate the cooling tower in some locations where nocturnal radiation is adequate to handle the cooling load.

solar system was assumed to be a commodity substitution investment decision. The investment analysis involves calculation of the rate of return on the investment in a solar energy system from saving electricity or natural gas. As conventional fuel prices increase compared to the cost of solar energy systems, solar energy systems because more competitive with electricity and natural gas. Once the return on investment reaches a minimum acceptable level, solar energy systems begin to penetrate the market.

The minimum acceptable rate of return was assumed to be different for different building Industry submarkets reflecting the relative conservatism of respective submarkets. For example, the commercial submarket was assumed to have rate return requirement equal to the cost of money (8-12%) whereas the single family submarket required rates of return equal to 18-20% reflecting the higher first-cost sensitivity of the single family submarket (see Figure 10). These assumptions were identical to requiring a 5 to 5-1/2 year payback before solar energy systems would be used in the single family submarket and 8-10 years before use in the commercial market.*

Penetration rates for the new and retrofit markets ware chosen to reflect the historical resistance of the building industry to innovation. Historical statistics on the penetration rates of mobile homes, heat pumps, central air conditioners, and others were considered in selecting penetration rates for solar energy systems.

Energy Scenarios

The second set of factors influencing market penetration are the future prices and availability of natural gas and electricity. One of the

*A survey of the adoption of new products in the building industry indicates that payback periods of 5-7 years are often required by potential new users.

most difficult problem in trying to assess the impact of solar energy in the next twenty-five years is the uncertainty regarding the price and supply of fossil fuels. In order to deal with this uncertainty, three scenarios are developed which bound the maximum and minimum penetration rates for solar energy: 1) The Gas Curtailment Scenario 2) The Historical Growth Scenario and 3) The Retarded Energy Growth Scenario.

The gas curtailment scenario postulates a continuing reduction in the supply of natural gas so that by 1978 there is an embargo on all new natural gas hookups; existing firm customers at that time are postulated to continue to buy natural gas. The result is a switch in fuel use for new buildings to 100% electric (all electric residential buildings comrise about 10-15% of the new market as of 1974). The price of electricity rises from the current $.035 per Kwh at a 4% annual rate above inflation (that is, a 4% growth rate in constant 1974 dollars); gas prices rise at the rate of inflation in this scenario. This scenario will produce the highest solar energy penetration since solar competes beet with electricity, and this scenario postulates running out of natural gas for new hookups end moderately high growth rate for the price of electricity.

The "historical growth" scenario postulates a constant price of electricity at $0.035 per Kwh.* The price of natural gee is postulated to double by 1978 end thereafter increase at a 5% per year rate above inflation. With this growth in the price of natural gas, no embargoes on new hookups occur in this scenario.

*1974 Dollars

The third scenario, the "retarded energy growth" scenario postulates a constant residential electricity price at $0.035 per Kwh (in 1974 dollars)* until 1985, after which time the price declines in real terms slowly (-.33% per year). After doubling at 1978, natural gas price remains constant (in real terms) through 2000 according to this scenario.

A summary of these three scenarios is given in Figure 11. Each scenario has four components; one for energy price, one for energy use mix on existing buildings, one for energy use mix on new buildings and one for energy conservation. Each energy scenario assumes that all buildings built after 1975 will be energy conserving (have additional Insulation in the walls end reduced infiltration).

Solar Energy System Coat

The third major factor which affects the impact of solar energy concerns the assumed cost of solar energy component and system. The primary analysis of impact was performed assuming a solar collector cost of $2.77 f.o.b. the factory. This la estimated to be the mass production price for a double glazed flat plate collector with a selective coating but no metal parts. Installation on the roof of a building is estimated to bring the installation cost to $5.11 per ft^2. (This does not include the costs associated with non-collector components such as storage tanks and manifold plumbing).

Financial Incentives

The analysis included the possibility of financial incentives which reduce the effective first-cost of solar energy systems. The incentives

*Prices for other rate classes are assumed to vary in proportion to residential prices.

could take a variety of forms - low interest loans, tax credits, accelerated depreciation allowances, tax exemptions. Each type of incentive can be interpreted as a reduction in the initial coat of the solar energy system. From our analysis of proposed and pending legislation at the Federal level, some form of incentive appears to be likely. (For example, HR5860,which provides a 25% incentive to residential users of solar energy,has passed the House and is in conference). The impacts of solar energy were studied using three different incentive levels; 1) no incentive, 2) 25% incentive and a 50% incentive.

The Single Family Market

Scenarios for the future solar energy share (percentage) of the total energy used for heating and cooling and water heating by single family homes are tabulated in figure 12. The percentage in figure 12 are the aggregation of all estimated adoptions in both the new and retrofit markets in each of the three most significant microclimatic zones of the Southern California Edison Company service territory.

The buyer decision criterion stated as a required payback period before he will buy is related to the level of incentive. For example, if a buyer requires 5 year payback period with a 25% first cost reducing incentive, this is identical in economic terms, to requiring a longer payback period of 7 years with no incentive. Using this relationship it is possible to examine the energy savings from the use of solar energy considering different decision criteria and incentives as well as under different energy scenarios.

The gas curtailment scenario produces the greatest penetration of solar energy systems. If potential buyers are willing to accept a 5 year payback and receive no first cost incentive, then solar energy displaces 10% of the projected electrical energy needed for heating, cooling and water heating in the year 2000. If, however, potential buyers are willing to accept a 7 year payback with no first cost incentive (or equivalently a 5½ year payback made possible by a 25% incentive) then solar energy displaces 25% in the year 2000. Similarly, if potential buyers are willing to accept an 11 year payback with no first coat incentive (or equivalently a 5½ year payback made possible by a 50% incentive) solar energy displaces 36% of the projected electrical energy for apace and water heating and cooling in the year 2000 under the gas curtailment scenario.

As can be seen from Figure 12, no penetration occurs prior to the year 2000 under the other scenarios unless potential buyers will accept 11 year paybacks (or require 5½ year payback but receive a 50% incentive). If this criterion is met then solar energy will achieve a 12% penetration in the historical growth scenario and a 6% penetration in the retarded energy growth scenario by the year 2000.

Impact of Incentive

Another way of presenting these results for scenario 1 is given in Figure 13 which shows the energy displaced by solar systems on single family dwellings from 1975 to the year 2000. The lower curve in figure 13 is the growth of energy displaced by solar energy assuming no incentive and a 5½ year payback requirement before potential users buy solar systems. The middle curve shows the energy displaced by solar energy if a 25% incentive is given. The third curve presents the energy displaced with a 50% incentive. The upper curve in Figure 13 is the total energy used. The other dashed curves represent 50%, 10% and 1% of the total energy use.

These dashed curves provide a means for evaluating the impact of incentive. upon the use of solar energy. Examining the dashed curve called 10% of total energy use, it is apparent that there is a significant time difference between the times at which solar energy displaces this amount of energy at each of the incentive levels. The difference between the time at which crossover for no incentive and 25% incentive curves occurs is about 7 - 9 year., which indicates that a 25% incentive till speed the adoption of a given level of solar energy use by about 7 - 9 years. Similarly by examining the time of crossover for 25% and 50% incentive curves, the difference between a 25% and a 50% incentive can be seen to be 5 - 7 years.

Comparison between Microclimatic Regions

The market penetration of solar energy systems in each microclimatic zone for single family buildings was performed to determine difference between zones. The resulting energy displaced in the year 2000 in the gas curtailment scenerio is given in Figure 14. The results show that solar energy will achieve the highest percentage penetration in the beach zone with the high desert zone a close second. These results may seem counter-intuitive because the beach area often has fog and cloud cover particularly in the morning. several factors cause this result. First the temperate climate at the beach causes solar space heating equipment to have a higher utilization factor making the economics of solar heating slightly better at the beach. In addition space heating is a larger share of the total HVAC energy budget at the beach. Since solar air conditioning doesn't penetrate the inland and high desert markets until after 1990, the percentage of total HVAC energy displaced by solar is less in these regions.

Office Buildings

The potential of solar energy was also examined for office buildings. Figure 15 presents the energy displaced for office buildings as a function of time for the gas curtailment scenario. As can be seen from this figure market penetration of solar energy reaches a minimum of 10% in the year 2000. The lower penetration in office buildings compared to single family buildings is due to the relatively larger cooling requirement for offices. Because near term technology for solar cooling is not expected to be as economical as heating for single folly buildings, the percent penetration in office buildings is expected to be lower even though the adoption criteria are leas severe.

XII. SUMMARY OF FINDINGS

The use of solar energy for apace heating, water heating and cooling has been investigated in the residential and commercial markets of Southern California. Important conclusions have been reached concerning: the design and application of systems; the best submarkets; the growth of solar energy usage in buildings.

Five microclimatic zones have been defined in Southern California Edison's service territory. While the size of solar heating systems varies by a factor of three between these zones, the payback periods vary by less than l0%. The coastal zone has the lowest heating load and the shortest payback period for a solar heating system. Solar water heating and solar cooling systems look better in the high desert region than along the coast.

Larger buildings are more attractive for solar energy systems because of economies of scale, and this is one reason why multiple family dwelling applications are more economically attractive than single family applications. A solar water heater with a 36 ft.^{2} collector is estimated to cost over $850 ($23/ft.^{2})*. A solar apace heating and water heating system with 200 ft.^{2} of collector for a large single family home is estimated to cost $3000 ($15/ft.^{2})*, while a solar water heater for a multiple family building which requires a 1000 ft.^{2} collector is estimated to coat $8000 ($8/ft.^{2}).* A system with 12,800 ft.^{2} of collector to heat and cool a 50,000 ft.^{2} office the coat is estimated to be $100,000 (under $8/ft.^{2}).*

The shortest payback periods have been found in the multiple family and commercial markets. Solar water heating can have a payback period as

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*Eventual mass production cost in 1974 dollars.

short as 3½ years vs. electric water heating at the 1974 billing rate. The solar augmented hydronic heat pump for space heating in multifamily dwellings is estimated to have a 3½ year payback. These systems can be economically justified on the basis of the fuel savings by the utility company. Combined water heating and space heating systems have a 5½ year payback period.

In the single family market, combined solar water heating and space heating systems are projected to have a payback period in the range of 6-8 years compared to electric resistance heating. Longer payback periods are estimated for the solar augmented heat pump; however the accuracy of this estimate is much poorer. A payback period of 5½ years is felt to be needed to make a system attractive to the single family market.

Solar cooling can be used to reduce utility peak loads. However, the payback periods for solar cooling compared to electric vapor compression cooling are extremely long except when combined with solar heating systems. Even when combined with solar heating systems the payback period is optimistically estimated to be greater than 11 years in all applications. The major technical barrier to solar cooling is the low C.O.P. of the thermodynamic cycles currently being investigated.

An off-peak-power cooling system combined with solar space heating provides a technically attractive option for reducing peak load in both the residential and commercial markets. The off-peak-power cooling systems justify the cost of an on-site thermal energy storage tank. Since the tank can also be used to store solar energy for heating, the incremental cost for adding a solar heating system is reduced. While solar heating using electric auxiliary only displaces fuel, the combined system displaces both fuel and capacity.

All of the solar HVAC system concepts Investigated require auxiliary energy if capital is to be deployed efficiently: Solar cooling systems which carry over 50% of the cooling energy load only reduce the peak demand on the auxiliary electrical system by less than 25%. The peak auxiliary demand occurs on days which are hot and cloudy, whereas current Edison maximum peak loads occur on hot, sunny days. In the case of solar space and water heating systems, electrical energy may be needed every day for extended periods in the cooler months. A utility with a summer peak could supply this energy directly and via heat pumps and thus improve its system load factor.

Significant market penetration of solar water and apace heating in the multiple family and commercial markets only requires the development of markets adequate to justify mass production tooling for currently understood technology. In the single family market significant penetration can occur if: 1) mass production prices are achieved, and 2) new hook-ups of natural gas are curtailed and electric rates tend to escalate faster than Inflation, alternatively If: l)consumers are willing to accept an n-year payback on the solar equipment, or 2) incentive are provided at a level equivalent to a 50% first coat reduction.

Of perhaps greatest significance, we have found that there are ways of combining heating and cooling concepts such that use of solar energy and electrical energy is more economical for the utility and its customers than use of either alone. This suggests an optimistic view toward the near-and long-term prospects for commercial utilization of solar energy in buildings. It is with this view that the Southern California Edison Company will continue to support development of such attractive systems.

XIII. REFERENCES

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ACKNOWLEDGEMENT

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Figure 1.

SOUTHERN CALIFORNIA EDISON COMPANY SERVICE TERRITORY

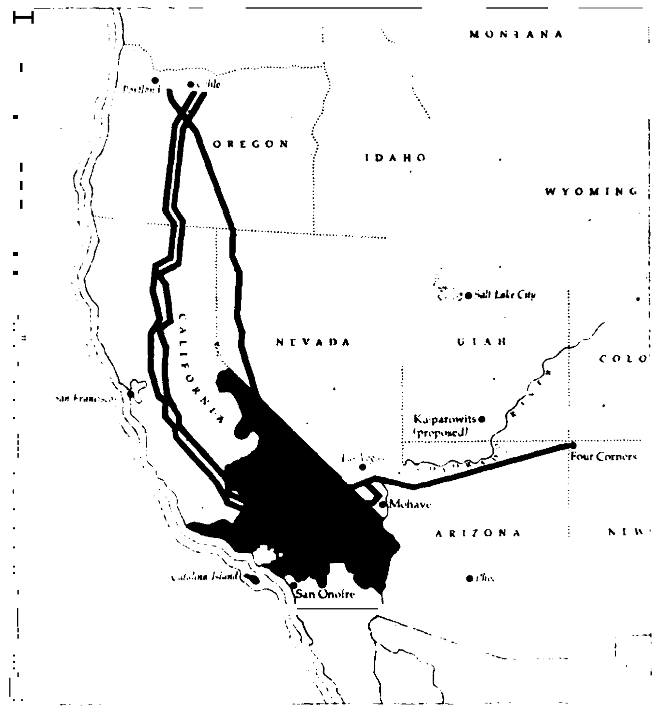

Figure 2.

SOUTHERN CALIFORNIA WEATHER ZONES

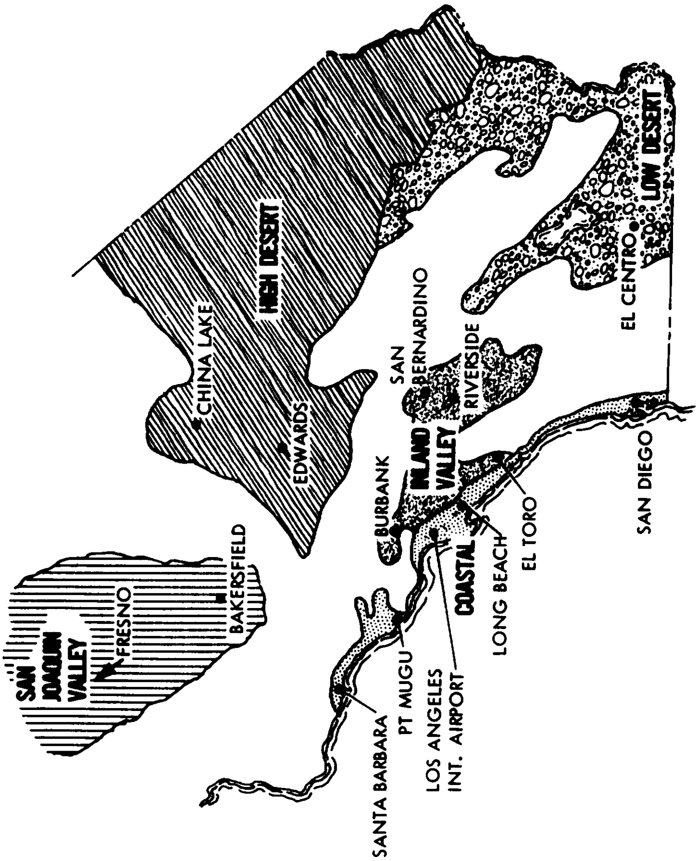

Figure 3.

SOLAR HEATING AND COOLING CASE STUDIES

SYSTEMS	BUILDINGS: 2250 ft^2 SINGLE FAMILY DWELLING	9 UNIT MULTIPLE FAMILY DWELLING	6 STORY 50,000 ft^2 OFFICE	3 STORY 145,000 ft^2 DEPT STORE
WATER HEATING	• PUMPED	• CENTRAL AUX • IND AUX		
WH + SPACE HEATING	• HYDRONIC	• HYDRONIC		
SOLAR AUGMENTED HEAT PUMP	• RESISTANCE AUXILIARY	• DISTRIBUTED HYDRONIC	• DISTRIBUTED HYDRONIC	
WH + SH + AIR CONDITIONING	• HYDRONIC • ABSORPTION CHILLER	• HYDRONIC • ABSORPTION CHILLER	• HYDRONIC • ABSORPTION CHILLER	• HYDRONIC • ABSORPTION CHILLER

Figure 4.

SOLAR HYDRONIC HEAT PUMP

- 9-UNIT MULTIPLE FAM LY DWELLING
- SOLAR SHARE = 75%
- ELECTRIC AUXILIARY
- COLLECTOR- 49° TILT 80°F

	COLLECTOR AREA, ft^2		SOLAR ENERGY COST, $/kWh	
	STANDARD BUILDING	ENERGY CONSERVING	STANDARD BUILDING	ENERGY CONSERVING
COAST	320	220	0.032	0.041
INLAND	430	270	0.031	0.042
HIGH DESERT	1100	750	0.030	0.036

Figure 5.

SOLAR COOLING ELECTRICAL LOAD PROFILE

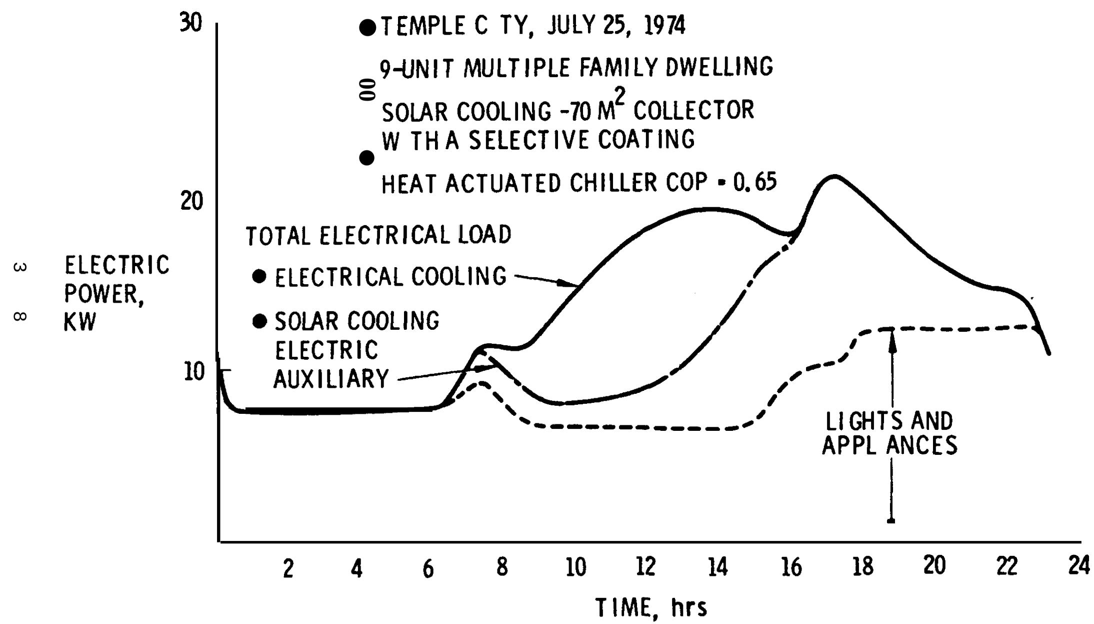

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Figure 6.

COST OF SOLAR HYDRONIC WATER HEATING + SPACE HEATING

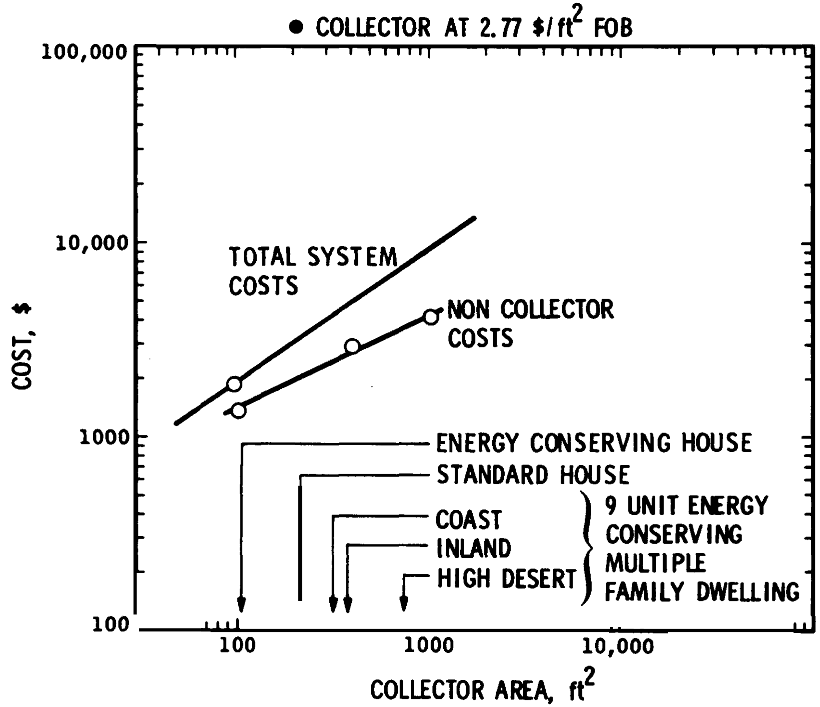

Figure 7.

SCE LOAD PROFILE

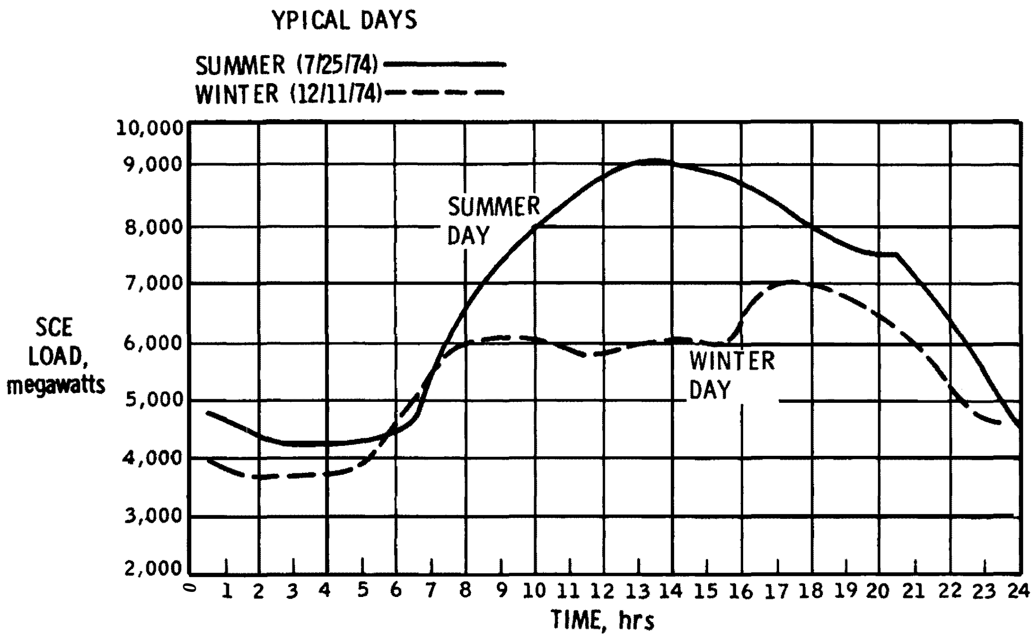

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Figure 8.

COST OF SOLAR ENERGY

WATER HEA NG + SPACE HEATING

- INLAND VALLEY REGION
- 2250 ft^2 SINGLE FAMILY DWELLING WITH 6" ROOF INSULATION

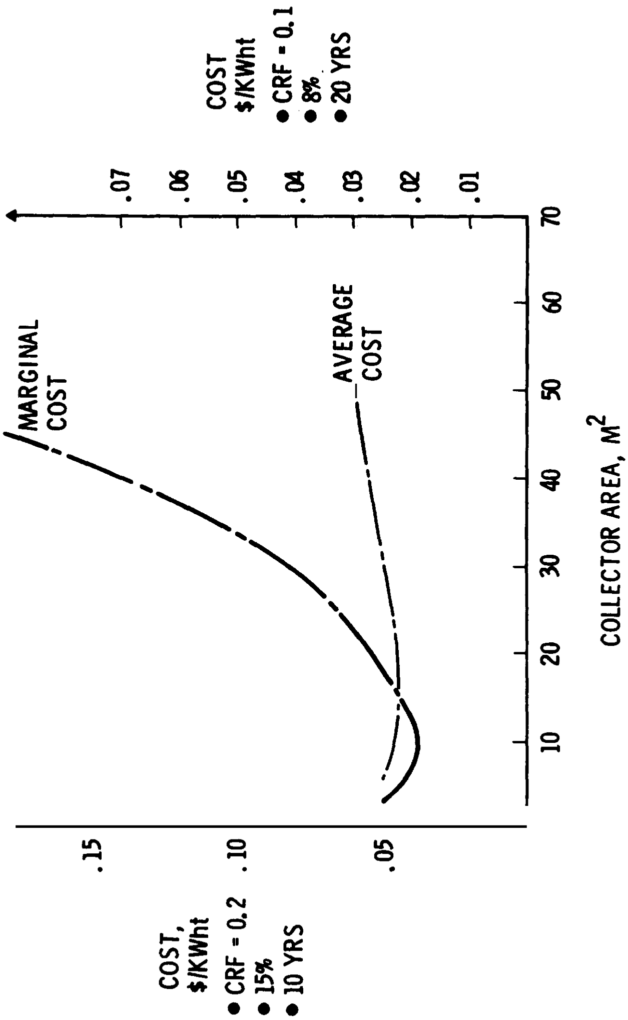
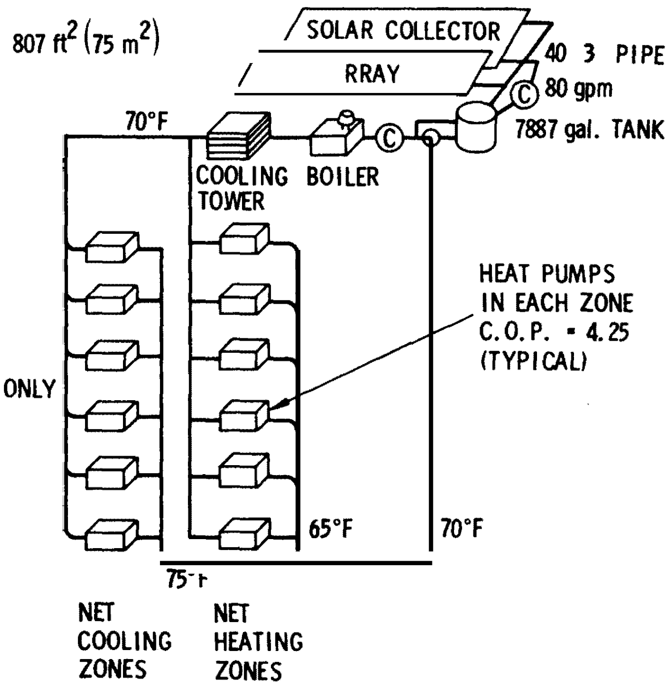


Figure 9.

SOLAR ×YDRONIC HEAT PUMP



- ENERGY CONSERV NG OFF CE
- INLAND ZONE (BURBANK)
- TEMPERATURES ILLUSTRATIVE ONLY

Figure 10.

RETURN ON INVESTMENT

$$\text{ANNUAL SAVINGS} = \text{INCENTIVE) (FIRST COST)} \quad \text{RO} \frac{(1 + \text{ROI})^{\text{LIFE}}}{(1 + \text{ROI})^{\text{LIFE}} - 1}$$

MINIMUM REQUIRED

VARIES WITH USER

	NEW	RETROFIT
HOME-OWNER	18%	20%
APT. OWNER	15%	18%
COMMERCIAL OWNER	8%	12%

Figure 11.

SCENARIOS FOR MARKET PENETRATION

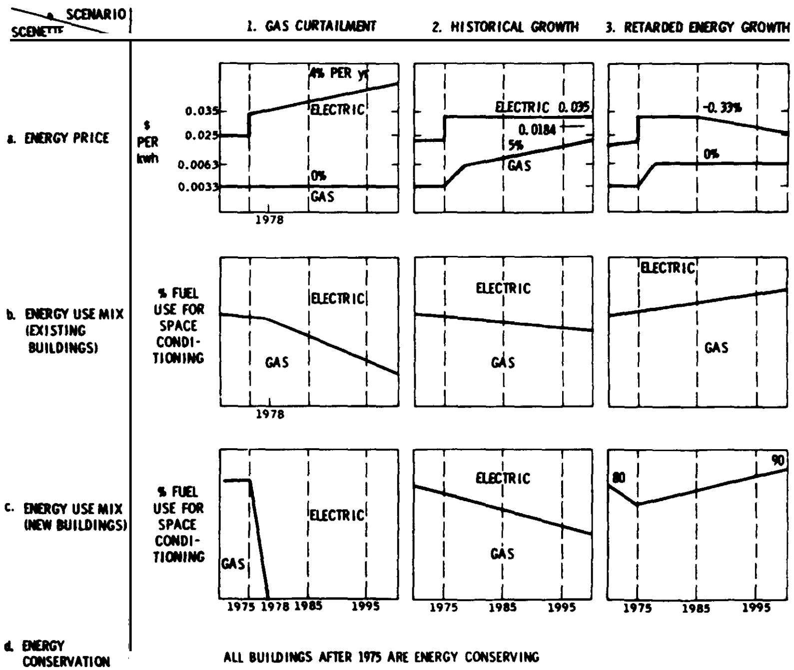


Figure 12. Solar Energy Savings *Scenarios* in the Single Family Market.

Adoption Criteria and Incentive Level		Solar Energy Savings, percentage		
Payback Period, yrs.		5-1/2	5-1/2	5-1/2
Incentive		0	25	50%
or			- or -	- or -
Payback Period			7	11
Incentive			0	0
Gas Curtailment Scenario	Y 1980	0.0	0.0	3.3
	E 1985	0.0	2.1	11.2
	A 1990	0.7	7.0	20.8
	R 1995	3.7	15.7	29.4
	2000	10.2	25.2	36.1
Historical Growth Scenario	Y 1980	0.0	0.0	0.5
	E 1985	0.0	0.0	1.9
	A 1990	0.0	0.0	4.4
	R 1995	0.0	0.0	7.8
	2000	0.0	0.0	12.1
Retarded Energy Growth Scenario	Y 1980	0.0	0.0	0.4
	E 1985	0.0	0.0	1.3
	A 1990	0.0	0.0	2.6
	R 1995	0.0	0.0	4.0
	2000	0.0	0.0	5.5

*New and retrofit installations are accounted for. Payback periods refer to new installations. Retrofit payback periods are about 10% less.

Figure 13.

ENERGY DISPLACED BY SOLAR SYSTEMS

GAS CURTAILMENT, SCENARIO, ALL ZONES, SINGLE FAMILY

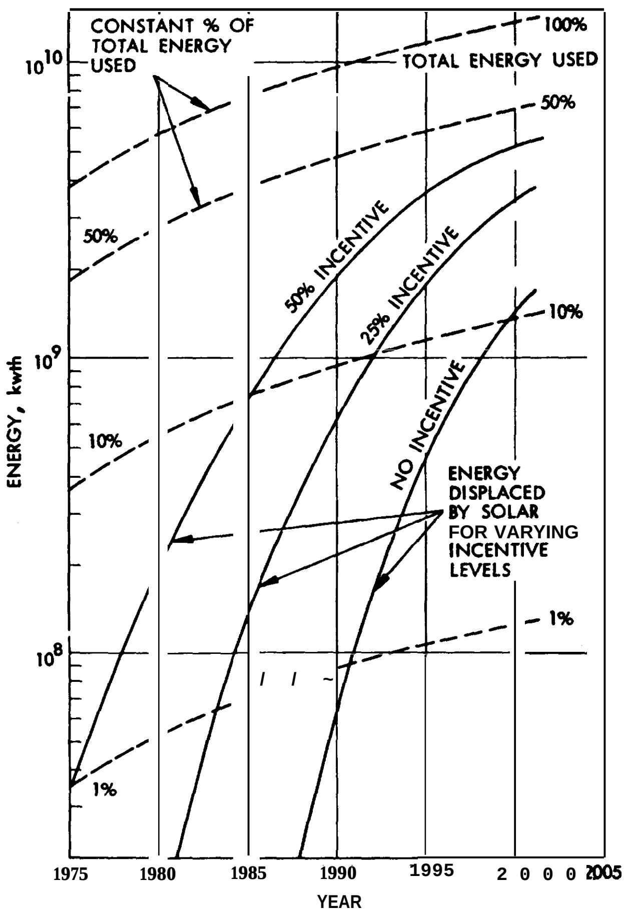


Figure 14.

MARKET PENETRATION FOR SINGLE FAMILY

SCENARIO 1, EACH ZONE, YEAR 2000
(PERCENT PENETRATION)

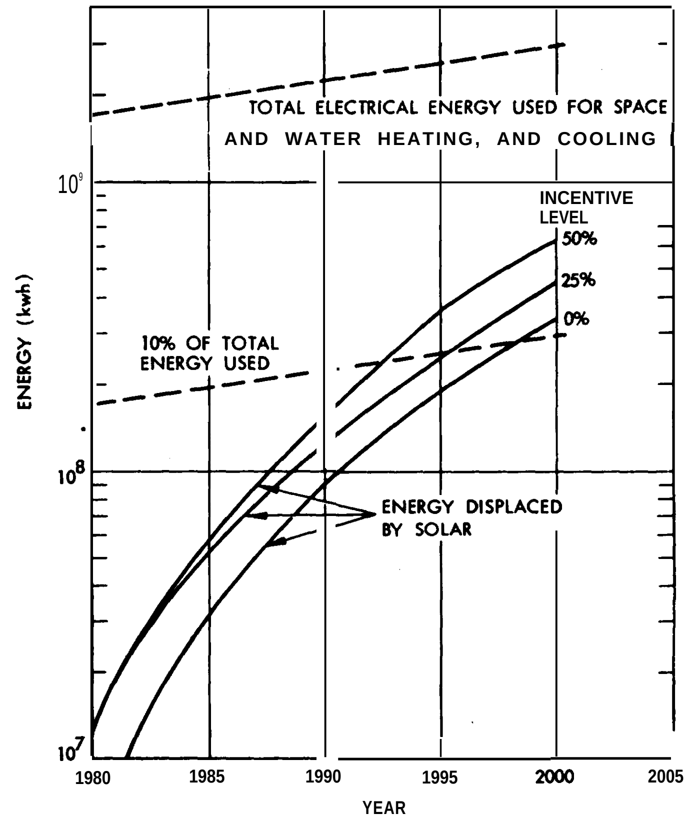
	NO INCENTIVE	25% INCENTIVE	50% INCENTIVE
BEACH 2530×10^6* kwh	14	32	44
INLAND 8400×10^6 kwh	8	23	34
HIGH DESERT 2140×10^6 kwh	13	24	30
ALL ZONES 13880×10^6 kwh	10	25	36

* TOTAL ELECTRICAL ENERGY FOR HEATING. COOLING AND WATER HEATING IF SOLAR ENERGY IS NOT USED

Figure 15.

ENERGY DISPLACED BY SOLAR ENERGY SYSTEMS IN OFFICE BUILDINGS

SCENARIO 1, ALL ZONES



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