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INDUSTRIAL ENERGY CONSERVATION

DOCUMENTS

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HEARING

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BEFORE THE

SUBCOMMITTEE ON

ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

COMMITTEE ON

SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-SIXTH CONGRESS

FIRST SESSION

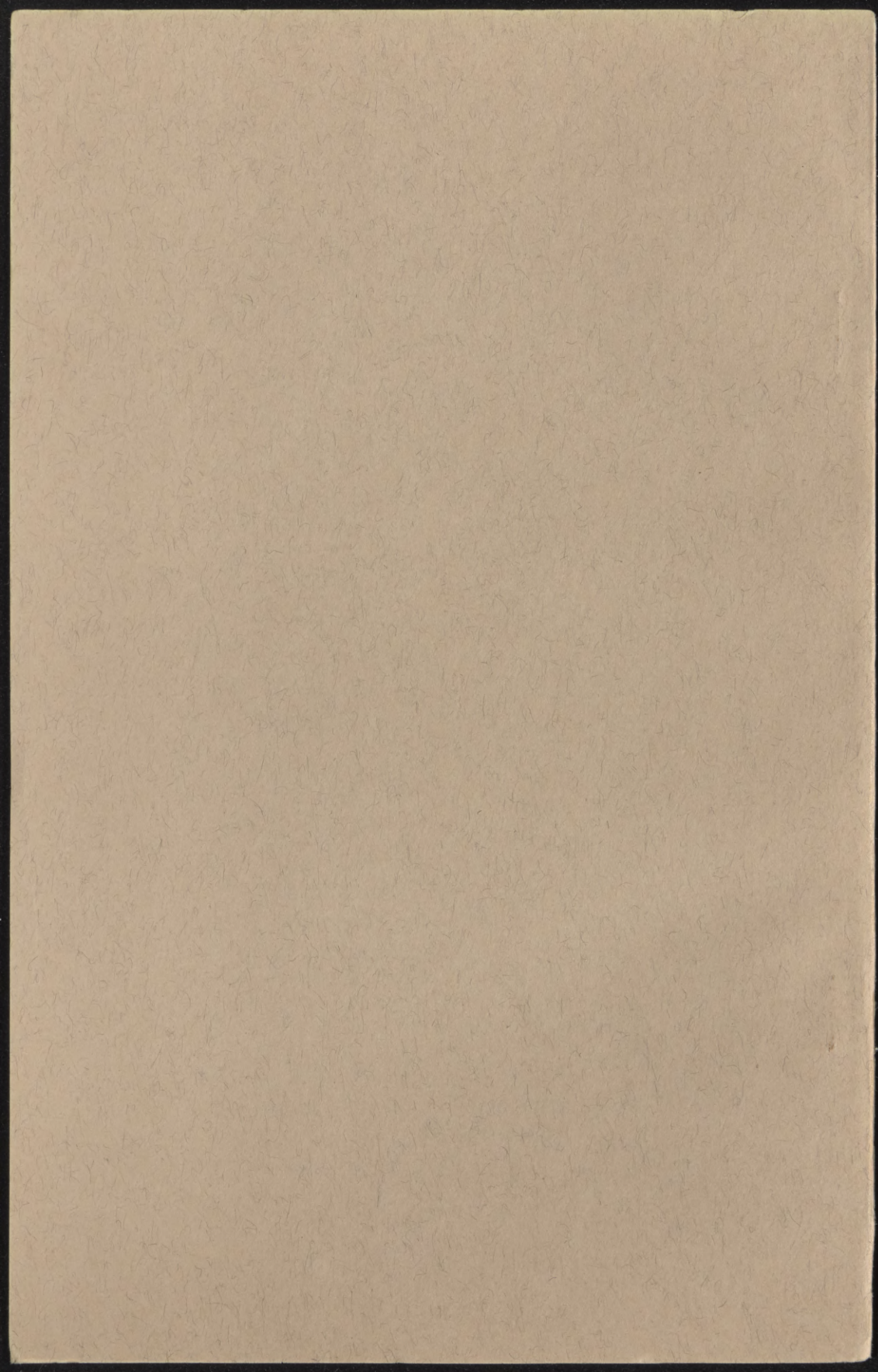
SEPTEMBER 11, 1979

[No. 49]

VOLUME X

Printed for the use of the
Committee on Science and Technology





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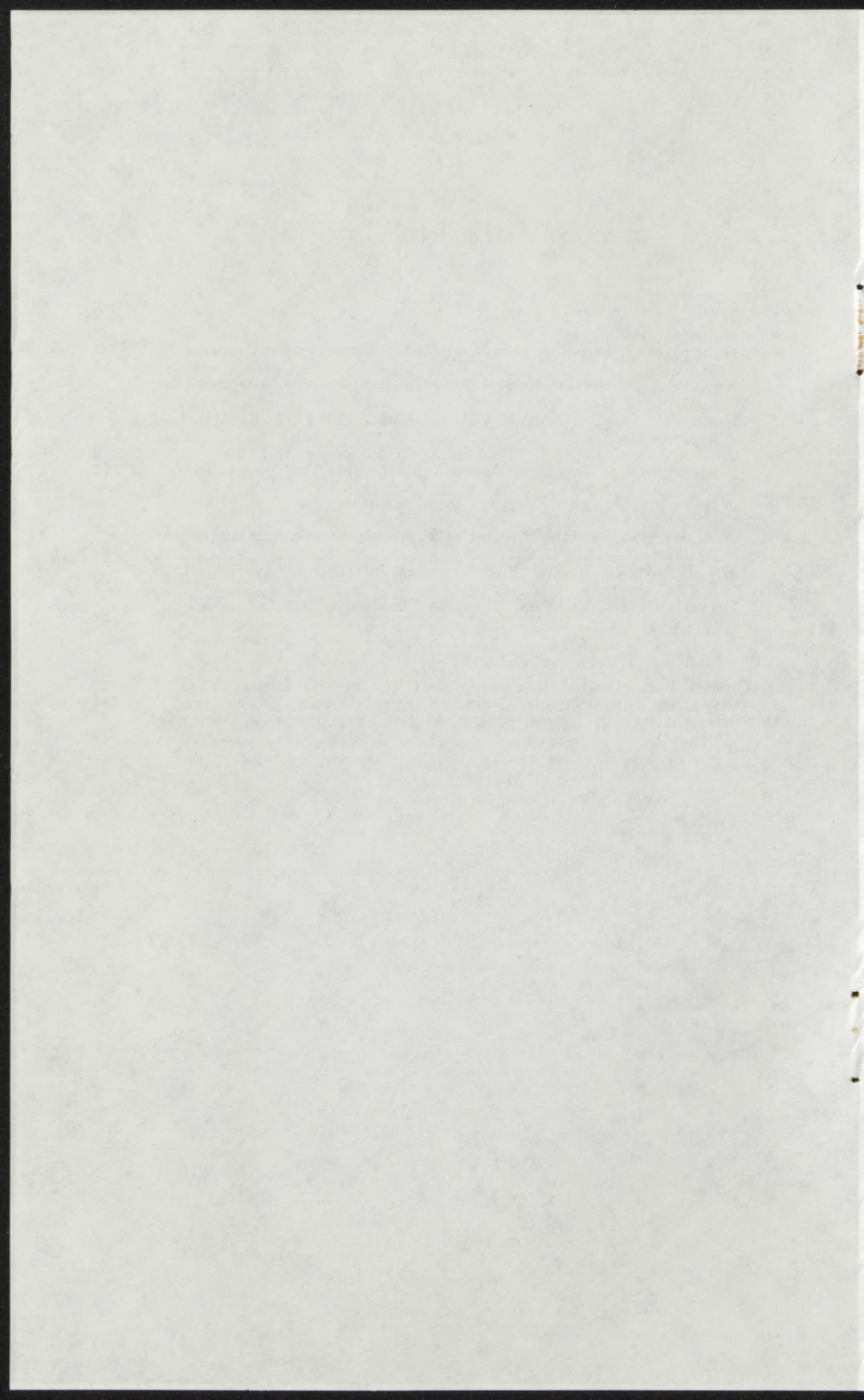
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INDUSTRIAL ENERGY CONSERVATION

SEPTEMBER 11, 1979

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT
AND APPLICATIONS,
Washington, D.C.

The committee met, pursuant to notice, at 9 a.m., in room 2325, Rayburn House Office Building, Hon. Richard L. Ottinger (chairman of the subcommittee), presiding.

Mr. OTTINGER. The Energy Development and Applications Subcommittee this morning is going to enter the very important topic of industrial conservation.

I see great potential for energy conservation through cogeneration, through improvements in industrial use of energy and through the Federal policies which affect them.

I don't think it is necessary to reiterate the importance of reducing our dependence on imported oil. The challenge facing us to modernize our industrial capacity in order to reduce costs and vastly improve energy efficiency has received too little attention. The attention is generalized.

Last year industry used 37 quads or 35 percent of all energy consumed in the United States. That is a lot of energy. Big users', even small users', changes in efficiency can cause big changes in our energy demands.

The improvement potential really appears to be very large, and I would like to use cogeneration as an example at this point.

Cogeneration is the simultaneous production of electric power and process steam. It is accomplished by upgrading the heat that is used in the industrial process to steam for the production of electricity, and it can be done either at the front end or the back end of the industrial cycle. Cogeneration is common in Europe. West Germany produces 26 percent of its power through cogeneration and Britain 20 percent, while the United States produces on the order of 5 percent.

Simultaneous production of power and steam requires one half of the energy of separate production. Perhaps this is why several analysts have suggested U.S. industry could save 20 percent of total industrial energy used through economically sound cogeneration investments.

I believe the economics of this were based on oil at \$18 per barrel. I think it would be very worthwhile to reexamine the results under prices that are now being contemplated for the future, that range from perhaps \$28 to \$40 per barrel. Obviously, there are obstacles to this technology, as there are to many others. Some are institutional; others

are technical. Cheap power rates for big users in the absence of marginal cost pricing are discouraging simple cogeneration. Higher technology cogeneration equipment has not been in demand and, therefore has not been under development until recently. Unfortunately, the energy conservation challenge rests all too often on the aging plant and equipment with frequent absence of technological creativity. These are important parts of the problems. We will hear more about this from one of our witnesses this morning.

In field trips in which we visited a number of industries, it became apparent that there are certain industrial conservation measures that industry will take because it is sufficiently advantageous for them to make that investment. The return on investment is quick enough so that it becomes more attractive than other opportunities to use their capital. But there is a range of conservation investments in which I think we in Government have to be particularly concerned. That is in those instances where industry feels that it is not advantageous enough for them to make the investment with their own capital, but where the savings are very substantial nonetheless, and where it is in the national interest to have those measures undertaken.

I feel very strongly there ought to be a Federal participation to make it economically advantageous for industry to make those substantial savings which they otherwise would not make.

The cogeneration example and one we will hear about this afternoon in the aluminum industry are two examples of conservation technology with enormous potential as we consider the alternatives to synthetic fuels. I believe we must fully examine the potential for investment needs of conservation.

Past history and current studies indicate that innovative conservation investments are readily available with greater immediate and long-term payoffs than any other options that are now being considered.

We are pleased to have before us today a very distinguished group of witnesses.

I think that it would be my preference to hear all the witnesses together, then have questions. Otherwise, I fear we will not get all the testimony.

We have Mr. Doug Harvey at the witness table at the present time, the Director of Industrial Energy Conservation for the Department of Energy, and I wonder if we can have Mr. Roger Sant, director, Energy Productivity Center, Carnegie-Mellon Institute of Resources with the Department of Energy and Conservation field, Mr. Robert O. Reid, executive vice president, Energy & Environment Analysis Corp., Mr. Clemente Gomes, chief, financial analysis, Kaiser Aluminum, and Mr. Beno Sternlicht, technical director, Mechanical Technology, Inc.

I think that Doug Harvey with very limited support until recently, particularly from the Office of Management and Budget, has been doing an exceptionally good job in pursuing one of our most promising energy alternatives.

We are pleased, indeed, to have you with us today and have you lead off.

Mr. HARVEY. Thank you, Mr. Chairman.

Mr. OTTINGER. With respect to the witnesses, we will put your statements in the record and you may summarize if your statements are too long, as is the case with Mr. Harvey. For sure, I would ask that you summarize.

[The prepared statement of Hon. John W. Wydler is as follows:]

PREPARED STATEMENT OF MR. WYDLER

Mr. Chairman, there has been much discussion of the co-generation option since the advent of the Administration's National Energy Plan (NEP). There have been a variety of studies done since the passage of the National Energy Act (NEA) varying from strong advocacy positions on this approach to realistic assessment of the true potential of industrial co-generation. Unfortunately, the NEA has some major defects in that it did not contain any incentives for the utilities to participate in co-generation in a meaningful way. Thus, it did not provide mechanisms for stimulating the use of waste heat distribution schemes by utilities. Furthermore, it effectively barred industries from generating electricity by applying to them the many disincentives attendant to complex State and Federal regulatory structures.

I should note that even recent studies which have gone over board in glorifying co-generation pointed out the serious limitations of the National Energy Act.

Certainly from our Committee perspective, the Department of Energy (DOE) and National Aeronautics and Space Administration (NASA) Co-generation Technology Alternative Studies (CTAS) must be factored into any meaningful technology assessment. That study identified the most promising advanced industrial co-generation systems on the basis of both technical promise and economic feasibility. The study considered only new and replacement market opportunities and assumed that retrofit activity is not very likely. I believe that this latter assumption is a reasonable one since I cannot envision any sensible industry tearing out a system before its useful life is exceeded unless they are given major economic incentives to do so.

I don't believe that investment tax credits on capital investments for cogeneration should be so high as to rival tax credits for new supply technologies which are competing with cogeneration schemes.

I believe that those who are very bullish on conservation have overlooked a serious problem—the question of fuel mix is a key limitation on the ultimate promise of the industrial program. Most companies have done all the easy things in conservation in the way of institutional fixes and changes in business habits to make significant near-term savings. The long-term choices are dependent on clear government signals including a go-ahead to the utilities to become involved but I don't believe that reasonable encouragement here will achieve more than half the outlandish savings that certain conservation buffs have predicted by the year 2000.

I believe it is important that this Committee and the Congress continue to come down hard on the side of energy supply because the major conservation achievement will ultimately depend on hard-headed business choices of the most attractive economic options and major industrial savings cannot be simply wished into being.

[The biography and prepared statement of Mr. Douglas G. Harvey follow:]

DOUGLAS G. HARVEY

Biographical Sketch

In the spring of 1975, Mr. Harvey as a consultant was asked by the Energy Research and Development Administration (ERDA) to develop the Industrial Conservation program. Mr. Harvey joined the staff of the ERDA in August 1975 on a full time basis as Assistant Director of the Division of Buildings and Industry. He came to this position after twenty three years of industrial experience. Seventeen of those years were devoted to space power systems with Martin Marietta Corporation and Sanders Associates, Inc. During this period he gained extensive insight into the materials and engineering aspects of metals, ceramics, plastics and other basic structural materials. More recently, as Vice President, Energy and Environmental Systems of Hittman Associates, Inc., Mr. Harvey gained significant experience in the problems of balancing energy consumption with environmental quality. He is the author of two books: Radioisotope Power Generation; and the Automobile Energy and the Environment. He is a graduate of Trinity College (1952) with a BS in chemistry, and MIT (1953) with an MS in nuclear chemistry. In June of 1956, the Division of Industrial Energy Conservation was established as a separate operating entity and Mr. Harvey was appointed Director of that Division. With the formation of the Department of Energy, the responsibilities of the Office of Industrial Programs was expanded to incorporate the industrial reporting efforts of FEA and the business awareness program of DOC. Mr. Harvey was named Director of this office in January 1979.

TESTIMONY OF MR. DOUGLAS G. HARVEY

DIRECTOR, OFFICE OF INDUSTRIAL PROGRAMS

DEPARTMENT OF ENERGY

HEARING ON POTENTIAL AND PROBLEMS

OF INDUSTRIAL ENERGY, CONSERVATION RD&D

SUBCOMMITTEE ON ENERGY DEVELOPMENTS

AND APPLICATIONS

UNITED STATES HOUSE OF REPRESENTATIVES

EXECUTIVE SUMMARY

Industrial energy conservation - The more efficient use of energy by the industrial sector - is a vital factor for consideration in formulating national priorities and is linked to economic stability, job security and industrial growth. The industrial sector consumed about 36 percent of all U.S. energy in 1978. The sector consumes 20 percent of national oil consumption and 50 percent of the national gas consumption. Process steam and direct process heat account for over two-thirds of industrial consumption.

During the period from 1950 to 1972, industrial production rose to 250 percent of the 1950 levels while energy consumption increased only 180 percent. Industry also has responded strongly to the EPCA and NECPA conservation targets and data received to date indicate that the targets for 1980 will be met. Trends analyzed on data reported does not indicate that the easy fixes (housekeeping, etc.) have been exhausted and it is reasonable to assume that industry will continue to exhibit reduced consumption per unit of output for sometime. The question is how long and how much?

Projections of industrial energy consumptions differ considerably. A projection by the Energy Information Administration projects up to 64 quads by the year 2000. Assuming continuation of 1972 conditions and applying the 1950-1972 relationship of industrial energy consumption and production reflects a projected consumption of 67 quads in the year 2000 without additional conservation. In view of this and the fine performance of industry over the past 5 years an optimistic projection was developed showing an increase in consumption to about 45 quads in the year 2000.

The private sector reaction to the energy crisis has included "housekeeping" action as well as some significant investment in more efficient equipment which generally had been well proven in actual operation in industrial environments, industry - especially the well established production industries such as steel and paper - are reluctant to introduce a new process which is not well proven. The reluctance varies from industry-to-industry and is due to several factors including size of existing capital investment, availability of capital, higher priority targets, inability to parallel process lines, fragmented industries without R&D resources, low fraction of product cost is energy, multi-industry applications, etc. Industries differ widely in their willingness to innovate and accept risk. The aerospace industry is highly innovative whereas the textile industry is considerably more conservative, less innovative and fragmented. In summary, the private sector will take some significant actions but fertile opportunities in new high risk, high impact technologies will not be pursued by industry alone.

Various Federal policy options are being evaluated which could be considered: regulatory policies (performance standards, mandatory targets, etc.); incentive policies (cost-shared RD&D, tax credits, etc.) and complementary policies (voluntary targets, technology transfer, etc.). A program of cost shared RD&D as currently proposed in the President's 1980 budget, can result in significant energy savings or fuel switching potential in the industrial sector by providing new, proven, high efficiency options to the private sector with favorable influences on the environment, competitiveness, employment and inflation.

In order to assure that the DOE industrial energy conservation program is non-redundant to industry-alone efforts, that it does not reduce industry's incentives and that the Federal involvement with large companies is selectively appropriate, the projects are very carefully screened and prioritized in a rigorous selection process. Analyses are performed on risk, cost and benefit. The acceleration of energy savings realization are studied. The degree of cost sharing is considered. The ability of the proposer to perform the RD&D and, given project success, satisfy the market, is considered along with other judgements before selecting a project for funding. The degree of pre-project versus post-project risk and return on investment (ROI) is a major concern and it is the objective of the program to move projects from a risk/ROI position unacceptable to the private sector to a point where the results of RD&D will be expeditiously implemented by the industry, given project success.

The question often arises regarding why the Government cost shares technology development with large corporations in many instances as well as small and medium sized concerns. The reasons for not excluding large companies include the fact that large concerns consume large amounts of energy, they usually possess the resources to cost share and conduct the technology developments and dominant firms expend a disproportionate share of private R&D funds within each industry. Without Federal involvement the results of R&D within an industry would likely be held by the dominant companies. Federal cost sharing assures wide dissemination of RD&D results.

The RD&D elements of the DOE industrial energy conservation program constitute over 95 percent of the program and are organized in two basic thrusts: the RD&D of general technologies which have application across a wide spectrum of industrial processes (the horizontal thrust) and the RD&D of technologies that are applicable to processes of specific energy-intensive industries (the vertical thrust).

The horizontal thrust efforts include RD&D directed at recovery and utilization of waste heat (high temperature recuperators, industrial heat pumps, waste heat boilers, etc.); combustion efficiency improvement (oxygen enriched combustion, air/fuel ratio controls, etc.); alternative fuels (waste plastic conversion, refuse-derived fuels, etc.); alternative feedstocks (acetylene from coal, methane from CO, etc.); and industrial cogeneration (topping and bottoming cycles).

The vertical thrust activities include RD&D in high temperature processes (high performance slot forge furnace, direct reduction of aluminum, etc.); low temperature and end product processes (hydropyrolysis in paper making, increased efficiency in paint curing, foam finishing of textiles, etc.); and agricultural and food processes (improved irrigation systems, energy integrated farm systems, fertilizer production, high efficiency food processes, etc.).

Although the DOE Industrial Energy Conservation Program is just a little over three years old, it is already having impact. Measurable energy savings of over 3.5 trillion BTUs annually are attributable to the RD&D efforts to date. Specific successes to date include fumes-as-fuel in coil coating which saves up to 85 percent of the natural gas-the principal fuel - used in that process; pipecross reactor for improved fertilizer production which has already been installed in twelve plants; conversion of waste polypropylene to sulfur-free fuel oil for which implementation by a petrochemical concern is now in progress; foam finishing of textile products which has been used to date to process over two hundred fifty million yards of product in fourteen plants, a high efficiency slot forge furnace which is already being commercialized; and several others. The program is highly cost effective - among the most cost effective in DOE - and has conservatively estimated energy savings goals of 1.5 quads annually by 1985 and 5.5 quads annually by the year 2000.

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I. INTRODUCTION

It gives me great pleasure to address this Committee on the subject of Industrial Energy Conservation. It will come as no surprise that this is my favorite subject of conversation and I want to express my appreciation to this Committee for giving me and the distinguished members of industry the opportunity to express our views on this vitally important and timely subject.

The very fabric of our national economy is woven on the premise of a healthy and expanding industry. The phenomenal growth in industrial production, which has tripled since 1950, has been predicated on the abundance and low cost of energy. In recent years, however, there is evidence of serious threat to our national economy and specifically the industrial sector. The debilitating loss of strength in the dollar overseas; the loss of competitive position of U.S. industry in world and domestic markets; the inflation of the last few years; and the inequities in the balance of payments; are all symptoms of this threat.

To state that these problems are caused solely by the energy crisis would be an over simplification, but I doubt that anyone would deny that rising costs and decreasing availability of fuels have contributed significantly to this malaise. The industrial sector has been seriously affected by these factors as evidenced by the following:

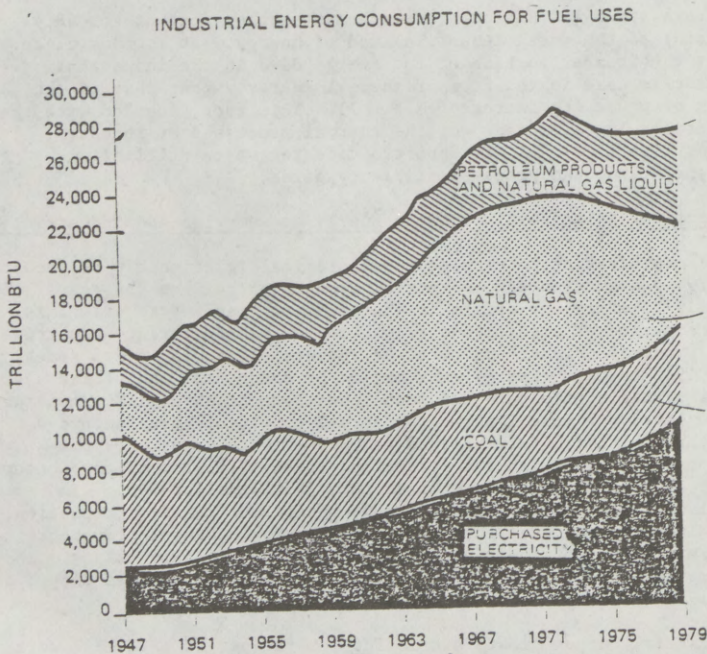
- o During energy crisis periods, the industrial sector is often forced to shut down operations and lay-off workers, e.g., in the winter of 1975, over 30,000 workers were laid off for six weeks in the steel industry alone due to lack of natural gas.
- o Energy costs in general are causing significantly increased operational costs and are contributing to the inflationary pressure in the U.S.
- o U.S. industry is finding it increasingly difficult to compete in world markets. A major steel plant employing over 5,000 workers was recently forced to shut down in Youngstown, Ohio in the face of foreign competition.

Although the development of new supply technologies is extremely important to all end use sectors, it is equally important to consider conservation--the more efficient use of energy--in formulating our National priorities. It is my objective today to define the potential for conservation in the industrial sector and to discuss an appropriate Federal role in achieving this potential.

II. How Energy Is Used By Industry

In 1978, about 36% of the energy consumed in the United States was used by the manufacturing industries (SIC 20-39). This sector consumes directly 20% of the national oil consumption and 50% of the national gas consumption. A description of the fuel mix and energy consumed is presented in Figure 1.

FIGURE 1



NOTE: ELECTRICITY IS SHOWN AS FUEL

In the industrial sector, energy is converted to heat and work, as well as used as a feedstock for chemical manufacture. In 1978, the total industrial use of energy was 27.3×10^{15} Btu for all purposes, including about 3×10^{15} Btu used as feedstock and raw materials. The breakdown of the total industrial use of energy by form is as follows:

Process steam	40.6%
Direct process heat	27.8%
Electric drive	19.2%
Feedstock for chemicals	8.8%
Electrolytic processes	2.8%
Other	0.8%

Process steam and direct process heat together account for 68.4 percent of the total industrial use of energy. It is thus clear that the greater portion of the energy used in the industrial sector is used in the form of thermal energy rather than in the form of power (by factor of 3.5: 1). This fact, coupled with the generally low efficiency of the thermal processes of industry, gives rise to opportunities for waste utilization, cogeneration, and process efficiency gains.

III. Historical Relationship Between Energy Consumption And Industrial Output

It is interesting to examine the historical relationship of industrial energy consumption and industrial production between the years 1950 and 1972 before any crisis in energy supply was perceived. This was a period of significant growth in the manufacturing industries. The production index indicates an industrial growth of 2.5 times the 1950 levels. Energy consumption by these same industries also grew significantly but at a much lower rate to about 1.8 times the 1950 level. Figure 2 shows the actual growth of both factors compared with the curve fitted compound growth rates (for the purpose of this graph the Production Index (PI), and Energy Consumption Index (EC), were normalized to a 1950 level of 100). In analyzing the growth in energy consumption per unit of production, the industry has over this period shown significant improvement in the efficiency of their energy consumption using only 72% as much energy in 1972 to produce an equivalent level of goods as they did in 1950.

Industrial output growth statistics for the period 1972-1977 were taken from the Statistical Abstracts of the United States and projections through the year 1995 were based on Data Resources, Inc.'s HIGHTREND forecast developed for the Energy Information Administration (EIA). The growth rate in industrial production for total manufacturing is shown in Table 1.

FIGURE 2

PRODUCTION AND ENERGY CONSUMPTION

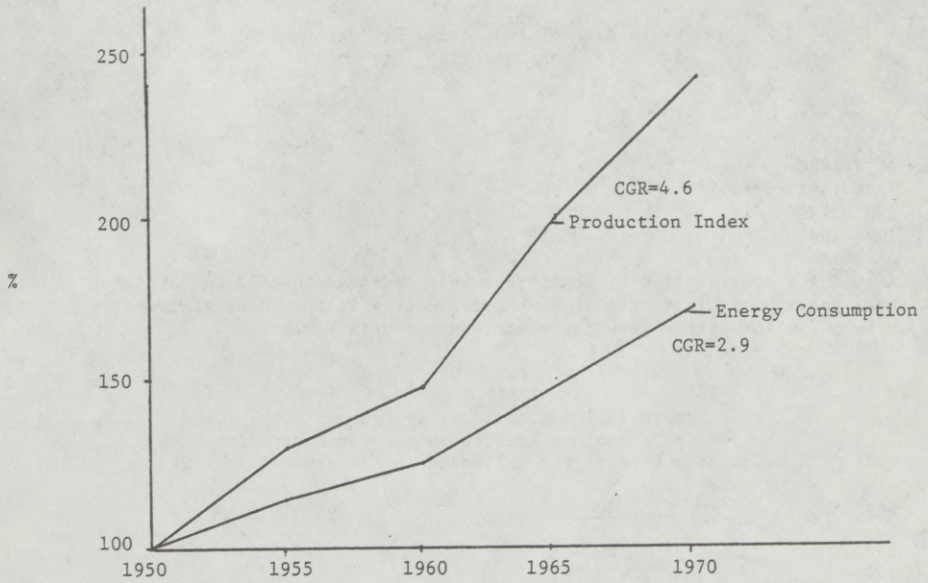


TABLE 1
Growth Rate of Industrial Production
for Total Manufacturing (Percent)

<u>Year</u>	<u>Percent</u>
1972-1977	3.0
1977-1980	6.0
1980-1985	4.8
1985-1990	4.8
1990-1995	4.8

Assuming a continuation of conditions which existed in 1972 and applying the same income elasticity of demand for energy in the industrial sector results in the energy growth projections shown in Table 2.

TABLE 2
Growth in Industrial Energy Consumption
Under Static Technology Conditions and Constant Prices
(Includes Electricity Expressed in Primary Fuel)

<u>Year</u>	<u>Quads</u>	<u>Growth Rate</u>
1972	29.92	1.92
1977	32.90	3.35
1985	42.83	3.07
1990	49.82	3.07
1995	57.95	3.07
2000	67.41	

These values have no factual significance except to serve as a baseline for the energy that would have been consumed by the industrial sector assuming the same trends in efficiency improvement that had occurred prior to 1970.

IV. Industrial Conservation During The Period 1972 to 1978

This period of the middle seventies was a traumatic and unnerving time for all Americans, and one which marked a significant transformation for the industrial sector. The Arab embargo of 1973, the administration's declaration of "Project Independence," the passage of the Energy Policy and Conservation Act (EPCA) and the National Energy Conservation and Policy Act (NECPA) legislation, and the skyrocketing cost of energy have provided the political and economic milieu of these tumultuous years. Industry has reacted by affirmative and strong action.

In 1975, Congress passed the EPCA, which required major corporations to report their progress in reducing energy consumption. The 50 largest corporations in each of the 10 most energy consumptive industries were required to report. (This law has now been amended with the passage of the NEPCA, to include all corporations using over 1 trillion Btu/yr in all of the 20 manufacturing two-digit SIC codes). Energy saving targets were established for each of the original 10 two-digit codes. The latest data received from industry indicates that the goal of meeting those target reductions by 1980 will be met or exceeded.

Figure 3 shows the actual energy savings achieved by the reporting corporations in each of the ten industries. It must be remembered that these data do not represent the total industrial population in each two-digit code, and therefore, do not constitute a statistically accurate, comprehensive data base, but the trends indicated provide significant insight into anticipated future performance in the industrial sector. In each graph of Figure 3, the compound energy reduction rate is indicated. Weighting these compound rates by the fraction of total industrial energy consumed in each two-digit code gives an overall compound reduction rate of 4.7% less energy consumed per unit product by the sectors represented. Since the reporting corporations represent most of the largest firms in each two-digit code and it is known that the firms represented by the population have very comprehensive energy savings programs, and since only one-half of the 20 manufacturing two-digit industries are included it would be incorrect to infer that industry as a whole has achieved a compound energy reduction rate of 4.7% per year from 1972 to 1978. It can be inferred, however, that the trend in industry has been to significantly reduce energy consumption per unit output during this period.

Another interesting trend can be inferred from the data presented in Figure 3. Many recent analyses have stated that the "housekeeping" chores and simple innovations have been made by industry at this point. Further conservation can only be achieved by significant capital investment and, therefore, the progress to date should not be used to predict the future. Were this the case, one would expect the graphs of Figure 3 to have the following shape:

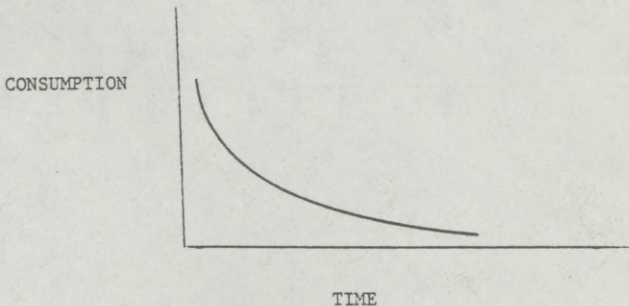
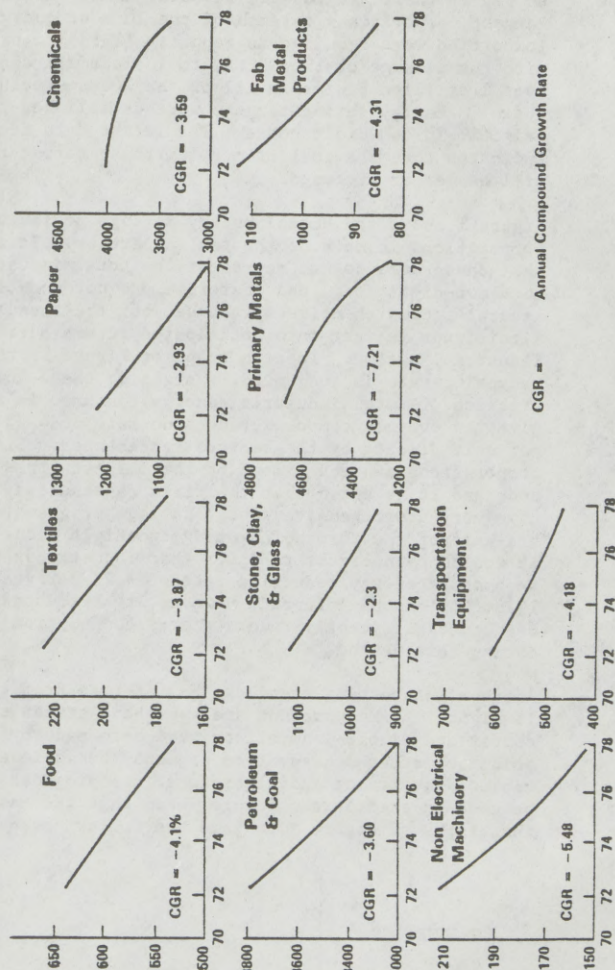


FIGURE 3
ACTUAL ENERGY SAVINGS BY INDUSTRY (10^{12} BTU)



Although it is inaccurate to establish the curve shape from four data points, it can be said that none of the industries sampled show reduction rates resembling such a curve. They are either straight lines or increasingly negative functions. It is a reasonable assumption to state that industry will continue to exhibit reduced consumption per unit output for sometime in the future. The question is how long and how much?

Private conversations with several industries and Trade Associations indicate that internal corporate targets have been set which would continue the exhibited trends to 1985.

A second measure of the change in efficiency per unit production has been derived by examining the total energy consumed by industry in all manufacturing industries¹ and comparing this to the production index of this same population of industry as published in the Statistical Abstracts of the United States. The raw data for both parameters vary highly from year to year and must be subjected to regression analysis to establish trends. Since compound growth is an exponential function, the data were subjected to an exponential regression analysis. Both the raw data and the exponential growth curves are presented in Figure 4. Since energy consumption per unit output is the quotient of two exponential functions, the compound growth rate of this parameter is the difference:

$$\begin{aligned} \text{CGR}_{\text{E/P}} &= \text{CGR}_{\text{E}} - \text{CGR}_{\text{P}} \\ &= .6 - 3.02 \\ &= -2.42\% \end{aligned}$$

This compares with the compound growth rate of -4.7% calculated from the more limited sample of the reporting program.

V. Projected Industrial Energy Consumption

The projection of future consumption always involves a number of assumptions which may or may not come to pass. The EIA has made a series of future projections of energy consumed by end use sector. As a reference mark, I have used the EIA series B projections contained in the 1978 Annual Report to Congress (Pgs. 312-313). Table 3 shows the results of this projection.

¹ EIA Annual Report to Congress Volume 2, 1978 DOE/EIA0173/2

FIGURE 4
ENERGY CONSUMPTION AND INDUSTRIAL PRODUCTION

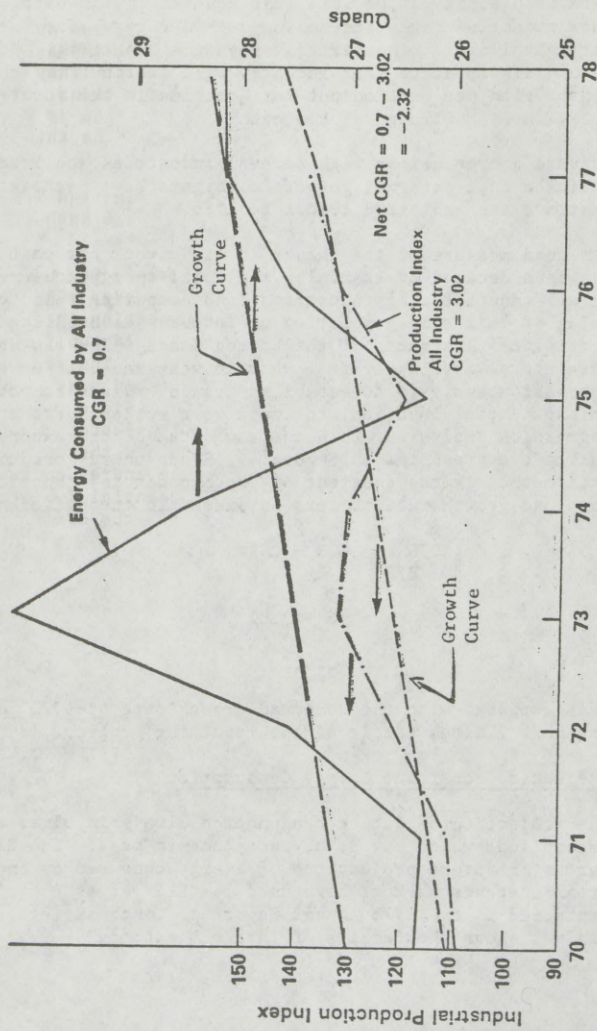


TABLE 3
Projected
Industrial Energy Consumption*
EIA Series B
(Quads)

	<u>1977</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Oil					
Distillate	.8	.6	.5	.5	N.A.
Residual	<u>1.5</u>	<u>1.5</u>	<u>2.7</u>	<u>4.2</u>	<u>N.A.</u>
Subtotal	2.3	2.1	3.2	4.7	N.A.
Natural Gas	8.3	8.7	8.6	7.6	N.A.
LPG	<u>.4</u>	<u>.5</u>	<u>.6</u>	<u>.7</u>	<u>N.A.</u>
Total Liquid and Gaseous Fuels	11.0	11.3	12.4	13.0	15.3
Electricity (expressed as quads primary fuel)	8.7	13.3	17.3	21.3	25.3
Coal/Others	8.6	12.1	15.7	20.0	23.6
TOTAL	<u>28.3</u>	<u>36.7</u>	<u>45.4</u>	<u>54.3</u>	<u>64.2</u>

*Series B Projection, EIA Annual Report to Congress 1978, pgs. 312-313.
Year 2000 estimates are an extrapolation of the 1995 estimates.

This projection is based on the following assumptions:

- o World oil prices increasing to \$31.50/bbl by 1995 in 1977 dollars
- o Natural gas prices are deregulated in 1985
- o The alternate fuel price cap under the incremental pricing provisions of the Natural Gas Policy Act is set at the price of distillate fuel oil
- o The exemption criteria for coal fired boilers under the Fuel Use Act is set at 1.3 times the cost of using imported oil.

Industry, however, appears to have reacted to the energy crisis in a manner not completely predictable by classical economic theory. The extremely fine performance of improving energy efficiency over the past five years implies that such reaction may indeed continue in the future. Thus as a minimum for projected energy consumption by the industrial sector, I have chosen the projection shown in Table 4.

TABLE 4
Optimistic Future Industrial
Energy Consumption

<u>Year</u>	<u>CGR</u>	<u>Energy Consumption (Quads)</u>
1972		27.45*
1977	0.48*	28.11*
1985	1.50	31.67
1990	2.00	34.97
2000	2.50	44.76

*Actual Values

These projections together with the DRI baseline are presented in Figure 5.

VI. The Influence of Government Cost Shared RD&D

The industry reaction to the energy crisis has consisted of a series of measures ranging from "Housekeeping" to significant capital investment in more efficient equipment. In general such changes have involved equipment that has an operating history in the industry involved either in the U.S. or abroad. There are numerous examples of the types of changes being made and a few are given below:

- o In the cement industry conversion of U.S. kilns to the dry process coupled with installation of suspension preheaters is becoming commonplace. Both the dry process and the preheaters are widely practiced in Europe and are well known technologies. No technical risk is involved.
- o In the aluminum industry, there has been a gradual and ordered conversion of the Hall cells to larger more efficient units. Again the technology is well proven.
- o There are numerous industries that are employing cross flow heat exchangers to recover energy from the discharge of a portion of the process.

There is little true innovation involved in these changes, but rather the application of well proven engineering principals.

Industry in general and especially the well established production industries, are extremely reluctant to introduce a process change that is not well proven in the actual industrial environment. They are not always willing to accept risk and there are very sound business reasons for this:

Blackman et al.¹ performed a factor analysis to establish an innovative index or propensity to accept risk for various industries. The results of this analysis are presented in Table 5. It is observed that with the exception of chemicals and allied products, the most energy-intensive industries are extremely unwilling to accept risk (for factors previously cited).

In summary, linear industries such as steel, cement, glass and aluminum are extremely reluctant to introduce any technology that jeopardizes their production. Only fully demonstrated technologies will be considered.

Firms within fragmented industries such as food and textiles often do not have the RD&D funds or engineering departments to innovate. They, too, are very reluctant to introduce new technologies unless fully proven.

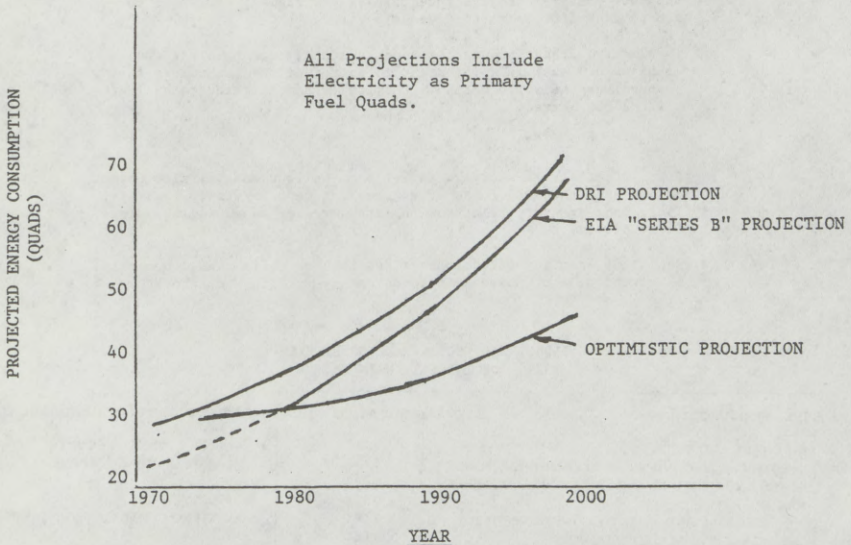
Nonlinear, nonfragmented industries, such as refineries, chemicals, electronics, etc., have RD&D funds and are willing to innovate.

TABLE 5
INDUSTRIAL SECTOR RANKING BY VALUE
OF INNOVATION INDEX

INDUSTRIAL SECTOR	INNOVATION INDEX	REASONS FOR RISK AVOIDANCE
AIRCRAFT AND MISSILES	3.004	• LINEAR INDUSTRIES WITH LARGE CAPITAL EQUIPMENT
ELECTRICAL MACHINERY AND COMMUNICATIONS	1.418	
AUTOS AND OTHER TRANSPORTATION EQUIPMENT	0.718	• FRAGMENTED INDUSTRIES WITH NO CENTRAL ENGINEERING
MACHINERY	0.224	
PROFESSIONAL AND SCIENTIFIC INSTRUMENTS	0.091	• SLIGHT COMPETITIVE MARKET ADVANTAGE BY PROCESS CHANGE (EASY TO DUPLICATE)
CHEMICALS AND ALLIED PRODUCTS	-0.057	
RUBBER PRODUCTS	-0.345	• ENERGY PRICE INCREASES CAN BE PASSED THROUGH TO CONSUMER
PETROLEUM PRODUCTS	-0.443	
NONFERROUS METALS	-0.538	
FABRICATED METALS AND ORDNANCE	-0.590	
STONE, CLAY, AND GLASS	-0.669	
TEXTILE MILL PRODUCTS AND APPAREL	-0.689	
PAPER AND ALLIED PRODUCTS	-0.694	
FOOD AND KINDRED PRODUCTS	-0.703	
STEEL	-0.725	

¹Blackman, A.W., et al, "An Innovation Index Based on Factor Analysis," Technological Forecasting and Social Change, Vol. 4, pp. 301-316, 1973

FIGURE 5
PROJECTED ENERGY CONSUMPTION



o Capital Intensity

The amount and value of capital equipment required to produce a dollar of product is an extremely important factor. The greater the invested capital, the less the propensity to accept risk. The capital sunk in existing inefficient equipment and the high cost and scarcity of new capital are deterrents to change.

o Linearity of Process

Although end process could have parallel production lines, in certain industries the individual items of equipment are so expensive the economic feasibility of parallel process lines is low. Innovation in a linear process stream may place at jeopardy not only the capital involved in the innovation but also the return on investment for the entire process line. through the loss of production occasioned by failure of the innovation. Hence, such industries are usually reluctant to introduce innovative process changes. Major industries considered linear are steel, cement, glass, pulp and paper (integrated mills), aluminum and textiles. Nonlinear industries are chemicals, refining, and food processing.

o Fragmentation of Industrial Sector

Several industries are made up of a large number of smaller firms (textiles, food, cement, etc.). Such firms do not have extensive engineering or research staffs to perform RD&D.

o Availability of Discretionary Funds

Funds for the innovative process are generally divided between two types of corporate dollars: expense (or operating) funds and capital equipment funds. During the analysis and laboratory test phase dollars spent usually are derived from expense funds, i.e., come directly from corporation profits. The prototype or pilot phase may be either expense or capital funds (depending upon the accounting principles followed), while the full-scale industrial implementation phase is normally capital funds. These principles of accounting are extremely important since they are the primary factor which governs a corporation's willingness to innovate. Most corporations are willing to reinvest a portion of their earnings into the future, e.g., into the analysis and laboratory phases. It is at this point that many innovations, even some very promising ones, die. The capital required for equipment to verify a new concept must compete with all of the capital expenditure requirements of the corporation. Such expenditures include environmental control equipment, safety equipment, plant and facility expenditures for increased production and the like. Most corporations have a fixed debt/equity ratio that limits the capital available for all purposes. The innovative processes or products cannot be included in the equity pool until their asset value can be determined, i.e., completion of the full innovative process. Thus, they fall into the category of discretionary capital.

o Increased Competitive Position

One of the primary factors motivating industry to innovate is the improvement of the investing corporation's share of the market and its competitive position. Any innovation has a finite time over which a market advantage can be achieved. For a very solid, unbreakable, inimitable patent that time is 17 years (perhaps 6 or 7 years longer if one considers ancillary and peripheral patents). Most innovations, however, give a market advantage over a range of only 3 to 5 years. Thus, the internal rate of return of capital invested in such an innovation must pay back the investment over a time period equal to or shorter than this period. Although the residual advantages continue, a minimum of a 3-year payback is required by most corporations.

VII. Federal Policy Options to Improve Energy Use Efficiency

While the potential for economical energy conservation in industry is large, the propensity for private industry to achieve this potential is limited by factors previously discussed. The fact is that many investments that would provide large national energy and related benefits are not undertaken by private corporations.

There are numerous policy options which the Federal Government could consider for implementing energy conservation and fuel switching in the industrial sector. They fall into three general categories: regulatory, incentive, and complementary options.

Regulatory policies considered in this analysis include:

- o Minimum Performance Standards for Selected Equipment
- o Mandatory Energy Productivity Targets
- o Energy Taxes
- o Mandatory Fuel Switching for Selected Equipment

Incentive policies considered in this analysis include:

- o Cost-Sharing in the Development of Conservation Technology
- o Financial Incentives for Installing Specific Technologies
- o Relaxation of Existing Policy Inhibiting Conservation

Complementary policies considered include:

- o Voluntary Energy Productivity Targets and Energy Reporting
- o Technology Transfer, Technical Assistance, and Promotional Efforts.

We are currently evaluating these policy options against a group of selection criteria or principles which work together harmoniously to optimize the goals of industrial energy conservation. Briefly stated these criteria are as follows:

1. Energy Savings Impact

This principle relates to improving the thermodynamic efficiency of industrial process streams. Improvements in thermodynamic efficiency will reduce the amount of energy used per unit of production in the United States.

2. Fuel Switching Impact

It is of critical importance that the dependence of industry on imported fuels be reduced. The substitution of abundant domestic fuels for oil and gas may or may not improve thermodynamic efficiency.

3. Risk/Return Stratification and Diversity

Beyond simple housekeeping improvements, energy savings or fuel switching can only be achieved by capital expenditures on new equipment. If such equipment is fully proven in an industrial environment, the risk associated with the investment is low, but the energy savings may also be relatively low. Innovative technologies, with potentially higher savings and hence higher return on investment involve higher risk with regard to initial cost and their ability to reliably perform. The portfolio of options would motivate industry to invest in a broad spectrum of technologies including those carrying high risks and offering correspondingly high returns.

4. Compatibility With Other Federal Mandates

The portfolio must meet the constraints, set forth previously, which are imposed by other vital Government interests. It is important that the policies avoid negative impacts on employment, inflation, the environment, the competitive position of U.S. industry in the world, and the free enterprise system.

5. Administrative Cost-Effectiveness

Each policy should meet a minimum standard to expected conservation return relative to the costs of its administration. Policies which require large bureaucracies for their enforcement must be carefully scrutinized on several grounds, not least among them their administrative cost-effectiveness as compared to alternatives.

6. Avoidance of Displacement of Industrial Initiatives

Policies should avoid paying for or forcing industry to take conservation steps it would have taken anyway. The impacts of each policy must be considered in comparison with likely future events without the policy. Displacement of industrial initiatives with government incentive programs generally would result in unneeded Federal expenditures, and a decrease in private motivation.

7. Expediency of Implementation

In light of our growing dependence on foreign fuels, reduction of demand has become a matter of national urgency. Thus, each option must be weighed against its ability to bring the desired change in a timely manner.

Although this analysis is not as yet complete, one factor has become clear. There is an urgent and continuing need for a Federal cost-shared RD&D program.

VIII The Case For Federal RD&D

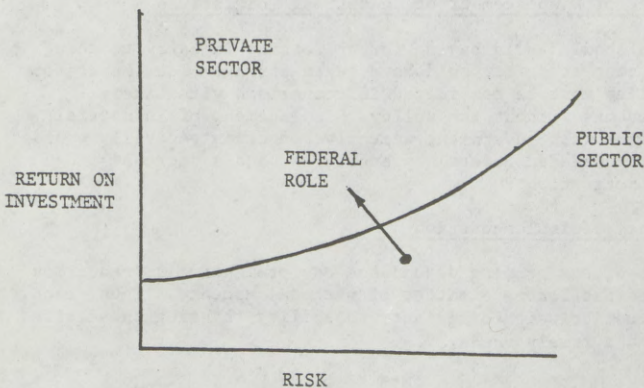
Of the policy options considered, a cost shared RD&D program has a positive influence on all of the selection criteria. It has the ability to significantly accelerate the introduction of high risk technology (with significant energy savings or fuel switching potential) into the industrial marketplace. Conservation technologies generally have high positive impact on employment and competitiveness, productivity, and reduced environmental impact. It will also be shown that such investment of Federal funds is extremely cost effective.

There are two perceived weaknesses of a strong Federal cost shared RD&D program; that Federal investment will reduce industry's incentive to perform RD&D itself; and that the Federal involvement with large companies is inappropriate. Both of these weaknesses can be avoided if the strategy of project selection is carefully formulated.

Projects are selected on the basis of: high energy savings potential, acceleration of implementation, nonredundancy with efforts of private industry, the degree to which benefits accrue to fragmented industry without research funds, and the degree and appropriateness of cost sharing. Candidate projects are selected based on extensive analyses of risk, cost and benefit.

The Industrial Energy Conservation Program project selection process perhaps gives the greatest insight as to the entire strategy behind the Federal role. In this process, there is a recognition that each industry has certain return on investment criteria which vary with risk. This is depicted by the "private sector" area in Figure 6.

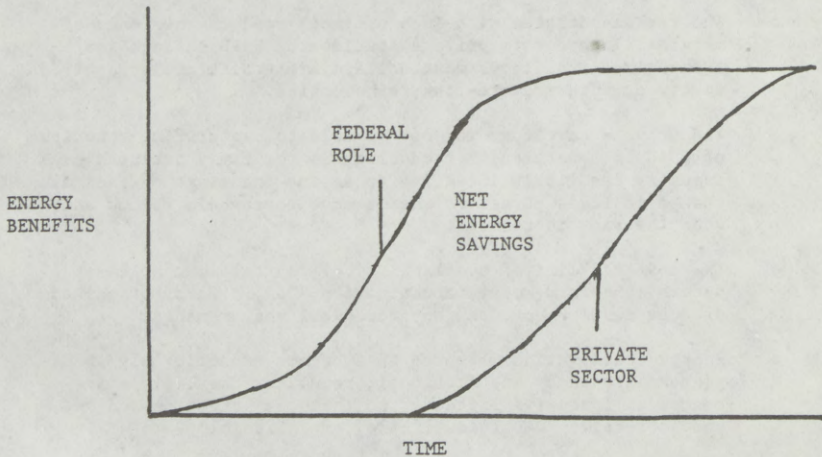
FIGURE 6
RISK-VS-RETURN ON INVESTMENT



There is considered to be another area, consisting of somewhat higher risk or lower ROI programs suitable for Federal funding. This is shown in Figure 6 as the "public sector." The thrust of the Federal program is to perform sufficient RD&D on these programs to lower risk and increase ROI such that they become suitable candidate projects for private-sector sponsorship.

This philosophy of project selection for RD&D simulation of existing but underutilized technologies is intended to have the effect shown in Figure 7. That is, energy benefits are achieved sooner than would be the case were the private sector left to its own initiative. The shaded area, therefore, shows the net benefit of the Federal program.

FIGURE 7
Impact of RD&D for Industrial Conservation



The Federal government, through a cooperative cost-sharing program with industry, can demonstrate the technical feasibility, reliability and cost of innovative technology to the point where risk is substantially reduced and the probability of industry implementation greatly increased. It is this role that is advocated in this option.

Critics of this option, however, ask "Why doesn't industry do these demonstrations itself?" The answer to this question involves several factors which vary considerably from industry-to-industry:

- o As pointed out previously, industry will eventually pursue more new development when the cost of fuel rises to the point where fuel cost represents a more substantial fraction of operating cost. The resulting time delay, however, costs the nation millions of barrels of oil that could have been saved in the interim period.
- o The initial reaction by industry to fuel cost increases will be to raise prices since all firms in a given industry are affected equally. This inflationary trend is also detrimental to the national economy.
- o The risk associated with such projects renders them only of marginal interest to private developers; RD&D dollars and eventual capital investment dollars are traditionally applied to low or intermediate-risk technologies.
- o The private developer may not be able to capture the benefits of RD&D if a particular technology is not truly patentable. Industry has little incentive to assume the risks of radical change if it is perceived that competitors would follow suit when the risk is reduced.
- o The cost and limited availability of capital in many cases defers long-term energy conservation RD&D in favor of market product development, and environmental requirements.
- o Energy conservation measures that become economic only when preconditioned by institutional, regulatory or legislative change will receive little or no industry attention and yet should receive RD&D funds if they are plausible.

A second criticism of this option asks the question, "Why should the government cost-share any programs with large corporations, especially those dominant in their sector?" Obviously the Federal cost-shared programs would be performed with a size spectrum of industrial firms--small, intermediate and large. To exclude large and even dominant firms from participation in this program is not in the Federal interest based on the following logic:

- o Dominant firms expend a disproportionate share of R&D dollars within each sector.
- o From such investments some of the most meaningful new concepts arise.
- o Those concepts which involve high risk, even with potentially high benefit receive lower priority within the company than lower-risk technologies, and hence their market introduction is significantly delayed.
- o Any such programs pursued in the absence of Federal funds remain the sole property of the firm; furthermore, duplication of costly, but proprietary, RD&D reduces the efficiency of expenditures.
- o Federal involvement in these programs assures:
 - Significant acceleration of proving or disproving high-risk technology.
 - Increase in the private firm's rate of investment by accelerated emphasis.
 - Minimization of the monopolistic trend for the dominant firms by assuring wide dissemination of the RD&D results.

Regarding this last point, it is important to highlight the conditions attached to government cost-shared developments. A condition of Federal participation is the assurance that successful innovations be made available to the entire industry. At a minimum, licensing at reasonable royalty is required. Timely commercialization is assured since, if the specific developer does not adequately meet the market demand, the government has march-in rights to take over any proprietary position.

The Office of Industrial Programs is currently cost-sharing projects with all sizes and types of industry. The criteria for funding eligibility does not discriminate by company size but only by potential energy saved, projected internal rate of return to industry, and overall program risk.

Corporation size, however, is a factor in establishing the degree of cost-sharing by the private participant.

Having refuted the perceived weaknesses of this option, let us now examine the strengths.

IX. The Focus of the Federal RD&D Program

The industrial sector comprises a myriad of processes which at first inspection appears overwhelming in scope. In formulating the Federal RD&D program we have approached this problem by dividing the effort into two basic thrusts: development of technologies applicable to many industries (horizontal approach); and development of technologies specific to energy intensive industries (vertical approach).

1. Horizontal Approach

Figure 8 illustrates the typical operation of hundreds of processes where fuel is consumed to cause beneficiation of material feedstock into products. Waste heat is discharged and material waste or by-products are also produced. The horizontal approach examines options for decreasing fuel consumption or substituting abundant fuel for scarce fuel in such operations. There are three fundamental areas to investigate waste energy reduction and/or utilization; waste material reduction and/or utilization; and cogeneration. Let us examine each of these separately.

o Waste Energy Reduction and Utilization

The combustion of fuel involves a mixture of fuel and oxidizer, usually air, with the generation of heat, carbon dioxide and water. If the air is too lean combustion results in quantities of carbon monoxide and unburned

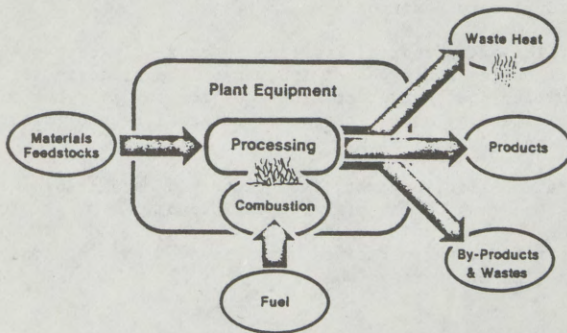


Figure 8. Horizontal Approach

hydrocarbons, while too much air involves heating the nitrogen in the air with no benefit. Thus the control of air to fuel is an important potential conservation opportunity. This is accomplished by simple flame adjustment and stack monitoring for CO in small boilers but large multiburner boilers are more difficult to adjust. DOE is developing a device which performs this function at each individual burner.

A second alternative for improving combustion efficiency involves inexpensively increasing the oxygen content of the combustion air. Even minor enrichment can significantly increase combustion efficiency. Thus two approaches to oxygen enrichment are being pursued.

In direct heating processes (kilns, furnaces, etc.) vast quantities of high temperature heat is discharged to the atmosphere through the stack. DOE is developing a family of high temperature recuperators to recover this wasted energy.

A portion of the recovered energy can be used to generate electricity in a bottoming cycle. Thus, DOE is currently developing a family of bottoming cycles to match the energy available.

In process steam industries (paper, textiles, chemicals, etc.) vast quantities of energy are discharged to the environment in the form of hot water or low quality steam. It is possible to reuse this energy if it can be thermodynamically upgraded. We are developing a family of heat pumps to perform this function.

o Waste Material Reduction and/or Utilization

In many industrial processes involving reduction, insufficient air is purposely used to effect a reduction of an oxide or hydrocarbon feed to elemental form (carbon black production, blast furnace, basic oxygen furnace, etc.). In these instances large quantities of carbon monoxide are discharged or flared. We are developing several processes which would enable cost effective use of this CO. One of these processes shows significant potential for converting dilute CO waste streams to concentrated methane (pipeline quality gas).

In polypropylene production about 10% of the output is in the form of a waste product known as atactic polypropylene. Due to its temperature dependent viscosity and other properties, atactic polypropylene is difficult to handle and is currently landfilled by manufacturers. DOE sponsorship was given in 1977 to the development, testing, and evaluation of a pilot plant designed to convert atactic polypropylene to fuel oil.

The process involves combined thermal and catalytic cracking of atactic polypropylene within a fluidized bed furnace. Successful completion of the pilot plant tests has led to DOE support for an industry commercialization program, including the construction and operation of a commercial size demonstration plant. Successful conclusion of this project will eliminate a waste product disposal problem and make a significant contribution to the United States and world oil supply. Exportation of the technology to other countries is likely and will further help to improve the United States balance of payments. United States production of fuel oil from waste polypropylene in the year 2000 is potentially two million barrels of oil annually.

Other programs in this area include conversion of waste tires to fuel, lubricating oil re-refining, the use of refuse derived fuels in kilns, blended cement, use of waste glass, remanufacturing and the use of coal to produce acetylene as a chemical feedstock.

o Cogeneration

Cogeneration is the sequential production of power (electrical or mechanical) and useful thermal energy from the same primary energy source. Cogeneration saves energy because better use is made of the thermodynamic "availability" of the primary energy source. The term "cogeneration" has been broadly applied to a wide range of multi-purpose power plants for application to industry and community systems. The real potential for energy savings through cogeneration is larger in the industrial sector and less seasonal. Industrial cogeneration offers significant potential savings and added electrical generating capacity. Fully developed industrial cogeneration could easily provide 10% of our generating capacity and would reduce our total energy consumption by about 5%.

Industrial topping cycle cogeneration takes advantage of the fact that a process which requires low to moderate temperatures can utilize the heat rejected from appropriately designed power conversion equipment. The power conversion equipment thus operates at a much lower effective heat rate (typically 5000 BTU/kw-hr. vs. 10,000 BTU/kw-hr. for central station power) because the reject heat is utilized in the industrial process and therefore, not charged to the operation of the power conversion system. Where the electrical power can be utilized, the greatest energy savings accrue from the highest efficiency thermodynamic cycles whose heat rejection rate and temperature

is capable of meeting the requirements of the industrial processes. In effect, large amounts of electrical power are produced as a by-product of the thermal energy demand. The full potential of cogeneration will only be realized if such high efficiency thermodynamic cycles are employed in cogeneration.

High efficiency thermodynamic cycle systems which are commercially available and commonly accepted (internally fired gas turbines and medium speed diesel engines) require the use of expensive premium fuels (gas or petroleum distillates). It is therefore, an important technological objective to develop modifications to these cycles which offer maximum power yield while capable of operation by low grade and abundant fuels.

The DOE Office of Industrial Programs has initiated an industrial cogeneration demonstration program to develop and demonstrate efficient fuel flexible cogeneration systems. Four projects have thus far been selected for Federal cost sharing. They are:

- o An externally fired, waste wood fueled combined cycle system which provides four megawatts and 50,000 lbs/hr. of process steam for an integrated paper mill. The system will be built by Solar Turbines Division of International Harvester. The plant will be owned and operated by Simpson Paper.
- o An externally fired, wood and agricultural waste fueled gas turbine which provides two megawatts and 50,000 scfm of hot air for a potato processing plant. A fluidized bed combustor is used in the system. The system will be designed and built by Energy Inc. and operated by American Potato Company.
- o A multi-fuel fired slow speed two cycle diesel systems providing 28 megawatts and 218,000 pounds of steam per hour to a pharmaceutical manufacturing plant. The system will be designed and installed by Thermoelectron. It will be owned and operated by Hoffman-LaRoche. A recent and possibly significant breakthrough has been made in a two cycle diesel test engine. It has been demonstrated that this cycle is capable of running on coal-water slurry with a small amount of pilot oil for ignition. If this concept proves to be operationally feasible, it would greatly improve the fuel flexibility of this highly efficient engine.

- o A high back-pressure coal fired steam plant providing 3.5 megawatts and 250,000 lb/hour of steam to a textile finishing plant. Engineering will be done by Chas. T. Main, Inc. The system will be owned and operated by Riegel Textile Corp.

2. Vertical Thrust

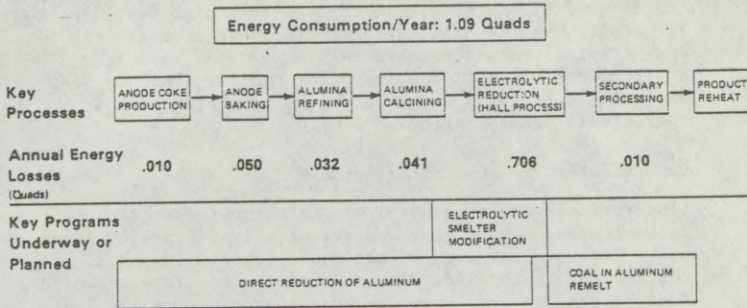
The objective of this portion of the program is to develop technologies that could very significantly decrease the energy consumption in our most energy intensive industries. The cost shared projects in this area, if successful, would enable U.S. industry to "leap frog" foreign competition. Revolutionary process changes may be capable either of retrofit in existing equipment or may require entirely new plants.

The major industries and the estimated current annual energy consumption are as follows:

INDUSTRY	CONSUMPTION (QUADS ANNUALLY)
STEEL	3.8
PETROLEUM REFINING	3.0
CHEMICALS	3.0
PAPER	2.5
AGRICULTURE & FOOD	2.4
ALUMINUM	1.1
CEMENT	.6
TEXTILES	.5
GLASS	.3

The opportunities within each of the major industries are identified by a Second Law (of thermodynamics) Analysis to identify the high loss points as reflected below using aluminum as an example.

Aluminum



As shown in the example, the large thermodynamic losses occur in the reduction of aluminum.

Projects are then selected and directed to the high loss points such as above as electrolytic smelter modification and direct reduction in the above example.

Each of the major process activities are discussed in the following paragraphs.

The Iron and Steel Industry

There are many major opportunities for the development of energy conservation process changes in the steel industry. One problem which hinders exploitation of these opportunities is the fact that an integrated steel mill contains very large, very expensive equipment. Development and demonstration of advanced equipment often involves far more funding than that available to the DOE program, and such programs must be passed over at least for the present. Projects that we have funded and are now reaching successful fruition include:

o Cupola Furnace Modifications

A cupola furnace is used by the foundry industry to make iron, generally for castings. It is analogous and somewhat similar to a blast furnace but much smaller in size. The air emissions associated with cupola operations include large quantities of CO and hydrocarbons, and hence cupola operators were forced to install a gas fired incinerator in their stacks to comply with environmental regulations. This not only consumed more energy in the form of natural gas but also made cupola operation marginal from an economic standpoint. Two years

ago, DOE funded a program which modified the cupola furnace itself and introduced air in tuyeres at a high level in the furnace (above the main charge). This air oxidizes the CO and HC emissions and renders them acceptable from an environmental standpoint. The pilot test program has been extremely successful and we are now proceeding with an operational demonstration.

o High Performance SLOt Forge Furnace

Slot furnaces are in general use throughout the steel industry to heat steel for forging and are usually fired with light oil. Because many such furnaces are located in small businesses, it is difficult to obtain an accurate estimate of their total energy use. The best approximation available is that about 0.2 quad is consumed in slot forge furnaces annually.

The furnaces are usually inefficient, even in well-operated shops. Efficiencies of 5 to 10 percent are common. Under DOE sponsorship, Hague International of Portland, Maine, a manufacturer of furnace equipment, has developed a slot forge furnace that offers improvement through recuperation, excess air control, counterweighted slot-closing doors, and other conservation mechanisms. Recognizing the problems involved in marketing replacement furnaces, Hague International has also made available retrofit packages for existing furnaces. The data obtained thus far indicates that reductions in fuel usage of approximately 50 percent are available from retrofits, while savings of nearly 70 percent are achievable through furnace replacement. The Hague furnaces can be successfully operated with either light or residual oil, and data is being collected to establish whether it can utilize coal/oil slurries.

During FY 1979, a definitive and carefully monitored demonstration is being undertaken. The purpose of the demonstration is to provide evidence and quantification of the potential savings for the forging industry through use of this type of furnace.

The potential savings from this technology are estimated to be approximately 0.13 quad annually. However, because of the fragmented nature of the forging industry and the fact that many operators will select partial pretrofits which can cost as little as \$20,000 against a total system cost in excess of \$100,000, a savings of 0.07 quad per year of light oil seems a more realistic goal.

- o Nitrogen Based Carburization: The objective of the project is to demonstrate a new technology which uses a nitrogen-based carburizing atmosphere. The project has two goals: (1) to quantify the energy, cost and operating benefits of the nitrogen-based atmospheres over endothermic atmospheres. Implementation of this technology has the potential of reducing the natural gas resources used for carburizing atmospheres by approximately 75 percent. Potential natural gas savings in heat treating would approximate .01 quad per year.

- o Hot Inspection

A program that we have just recently initiated involves hot inspection of steel slabs. The largest consumption of petroleum or natural gas in the production of steel occurs in the reheating of slabs to enable hot rolling toward a final flat rolled product. The present practices within the industry allows hot slabs that have been rolled from an ingot or have been continuously cast to cool to ambient temperature in a slab yard. They are then visually inspected and obvious surface defects are removed by a manually operated scarfing torch. These slabs are then scheduled, reheated, and further processed. The purpose of the proposed research is to develop a system that inspects the hot slab of steel immediately after it is cast and while it is still hot. This would allow direct rolling (with possible incremental heating) of hot slabs while maintaining a high quality surface. The potential energy savings from not having to reheat these slabs is 2-3 million Btu/ton, or about .25 quad per year.

- o Electric Arc Furnace Studies: A large fraction of United States steel production is by electric arc furnace melting. Although modern arc furnaces are rather efficient (75 percent is possible in a well run operation) the amounts of electricity used are sufficiently large that even a marginal improvement is worth pursuing.

The Massachusetts Institute of Technology, under contract with DOE and in consultation with major electric arc furnace users, has undertaken to develop analytical models for arc furnace performance that will lead to increased efficiency through improved operating practice. It is anticipated that successful development of the analytical models and their subsequent operation will lead to indicated improvements in electric arc furnace design and operation.

DOE also intends to fund studies on saving energy through improved materials handling practice in electric arc furnace shops, especially with regard to melting direct reduced iron. Implementation of this technology can save over .04 quad per year.

- o Fluidized Bed Heat Treatment: Many metal parts are heat treated to improve their mechanical or other properties. Heat treatment is generally performed using natural gas or electric heating, and the heating processes are usually very inefficient because of the poor heat transfer characteristics of the furnaces.

Quite large amounts of energy could be saved by performing heat treating in fluidized beds, which offer superior heat transfer characteristics as compared to conventional furnaces. Several specialized applications have already been developed, but it is desirable to demonstrate the feasibility of retrofitting a major type of conventional heat treating furnace for fluidized bed-type operation.

DOE also intends to fund studies on saving energy through improved materials handling practice in electric arc furnace shops, especially with regard to melting direct reduced iron. Implementation of this technology can save over .04 quad per year.

The Aluminum Industry

The aluminum industry consumes six percent of the nation's electrical power and is a primary focus of the Industrial Energy Conservation effort in high temperature processes. There are three principal energy-intensive processes in the production of aluminum: the Bayer process (using natural gas and oil); the Hall-Heroult process (using electricity) and the remelting process (using natural gas). Current and future efforts will focus on energy efficiency improvements in these three areas.

Current projects directed at aluminum include direct reduction, improved anodes, improved cathodes, and the use of coal in aluminum remelt.

Improved Aluminum Cathode: Aluminum is produced by electrolysis of a solution of alumina in cryolite. This electrolysis is carried out in a Hall cell at temperatures near 1000°C.

The cathodes of Hall cells are made of carbon and are not wetted by the molten aluminum produced. It is desirable to keep the carbon covered with molten aluminum and the layer must be sufficiently thick to ensure complete coverage on a nonwetttable surface. This thick layer develops waves under the influence of thermal and magnetic forces, and the electrolyte layer must be kept thick as well to prevent electrical shorts. The large anode-cathode spacing greatly increases electrical losses in the cell.

If a wetttable cathode material were used, a very thin metal pad would suffice as a cover, and the anode-cathode distance could be made much smaller. The resulting reduction in cell resistance could result in a saving of 0.2 quad per year by 2000.

Nonconsumable Aluminum Anode: Aluminum is produced by electrolysis of a solution of alumina in cryolite at about 1000°C, using a carbon anode made from petroleum coke, which is gradually consumed during the aluminum production process.

If the carbon anode is replaced by a nonconsumable, dimensionally stable anode there are several immediate advantages. First of all, the petroleum now needed to make coke is available for other purposes. Second, the gas evolved is now pure O_2 which can be captured and used (rather than a CO/CO_2 mixture which must be disposed of in an environmentally acceptable manner). Third, the cells can now be sealed, leading to reduced heat losses to the environment.

If the nonconsumable anode is combined with a wettable cathode, very precise control of the cell becomes possible and there are additional benefits from reduction in electricity waste. The potential saving from this innovation, assuming complete adoption, is about .1 quad per year.

Coal in Aluminum Remelt: All primary aluminum is remelted before being cast in finished shape and scrap is remelted each time it is recycled. This melting is usually done with natural gas, the alternative being distillate oil. Approximately 4,000 Btu are required to melt a pound of aluminum by the industry at present. Since approximately two pounds of metal must be melted for one pound of net use, approximately .1 quad of fuel is used. This number will increase more rapidly than the increase in primary aluminum usage, due to the emphasis on recycling.

Combustion devices are being designed which have the objective of using pulverized coal as a fuel, removing the sulfur as part of the combustion process. This will lead to a shift of .1 quad per year from natural gas to coal and also probably lead to an overall reduction in energy use because of the superior heat transfer characteristics of coal flames.

Direct Reduction of Aluminum: This process would eliminate the electricity used in electrolysis and substitute a significantly smaller amount of energy in the form of coke. The basic idea of this project is to reduce a mixture of Al_2O_3 and SiO_2 (in practice, of course, an aluminum silicate ore containing iron impurities would be blended with bauxite to produce a practical feed) with carbon in a shaft furnace.

The product would be an aluminum-silicon alloy which could be used directly in some applications (e.g., automotive castings), or refined to commercially pure aluminum by a subsequent process. This technology has the potential for saving .7 quad per year by the year 2000.

The process has as its objective the reduction of energy conservation in aluminum smelting by approximately 50 percent. This obviously is an extremely revolutionary change in aluminum production. Dr. Jarret will discuss this project in detail.

Chemicals and Petroleum Refining

These two industries, though large consumers of energy, have not received any significant funding under DOE projects. As previously stated these industries spend much more on RD&D and are more willing to accept risk than other commodity industries. They are doing an excellent job of conservation on their own. We are considering examining some advanced extraction and separation processes in the 1980 budget. The B1-Phase cogeneration concept currently under development by ET appears to have significant application to these industries and we are initiating an investigation of this potential.

Textiles

The textile industry is extremely diversified, processing a variety of fabrics and fabric blends into a multitude of end products. Its primary customers are the apparel industry, auto and furniture industries. Knit apparel, yarns and carpets are also produced as final products.

Textile plants range from highly integrated manufacturing complexes that process fibers (natural and synthetic) into finished products, to small nonintegrated contract plants that process goods owned by other producers. There are over 7,000 plants distributed over 47 States; however, the major States for the industry are North Carolina, South Carolina, Georgia and Alabama. The industry is very competitive and profits, after taxes, typically represent 3 percent or less of sales. It is a labor-intensive industry. The industry uses about 0.5 quad of energy annually, which is roughly split into 50 to 60 percent for the wet processes and the balance for the dry processes.

Dry processes consist of the yarn manufacturing, sizing of yarns and the knitting and weaving of fabrics. Wet processing consists of the preparation of fabric for dyeing, dyeing and the pre drying and finishing of the fabric.

A breakout of the energy form used in the textile industry (based on 1974 data) shows that electricity accounts for 20 percent, natural gas 32 percent, fuel oil 20 percent, coal 7 percent, and other 14 percent. Most of the energy used in the dry processes is electrical energy for motors for the machine drives and for air conditioning to maintain proper environmental conditions for the yarn and fabric manufacture. In the wet process area, most of the energy used is thermal energy in the form of steam or heated air. The steam is used for heating hot water for preparing fabrics for dyeing, for heating dyebaths and for predrying fabrics. The natural gas is mainly used for heating air in tenter frames for drying and heat-setting fabrics.

Since the major portion of the energy use in textiles is spent in heating and evaporating water, process improvements which minimized or eliminated the use of water were considered of prime importance for energy conservation. In this regard we have directed our major projects in these areas.

Specific projects in the Industrial Energy Conservation Program in textiles are as follows:

Hyperfiltration-Textiles: The objective of this project is to apply high temperature membrane technology (hyperfiltration) to textile waste streams to reuse the hot water, chemicals, and dyes in a closed loop system. The system will be applied to a continuous dye process in a textile plant to demonstrate the technical feasibility, economics, and energy savings associated with the use of hyperfiltration membrane technology. If this demonstration is successful, potential energy savings are 45 trillion Btu's per year as well as an additional cost savings in dyes, chemicals and water.

Foam Dyeing-Textiles: Textile fabrics are generally processed through aqueous solutions for preparation, dyeing and finishing of the fabric. Frequently, these steps consist of alternate fabric wetting and drying during processing, requiring a considerable amount of energy to be consumed in thermal drying ovens. The objective of this project is to develop formulations and techniques for applying cleaning chemicals, dyes, and finishing chemicals using foam as a carrier. This results in less water absorption by the fabric and consequently less energy for evaporation, as well as the elimination of most of the hot process water. The estimated savings from this technology amount to 52 trillion Btu per year.

The process has now been successfully demonstrated in the printing and finishing operation. Over 200 million yards have been processed using the foam finishing process. Demonstrated energy savings are as much as 86% on heavy fabrics. Ten different corporations are now using the process and many more are currently modifying their production line to accommodate the equipment. This project is representative of major breakthrough in technology that is capable of retrofit in existing equipment.

Loom Modification: The objective of this project is the development of simple and economic retrofitting modifications of picking and lay mechanisms of a loom for reduction of their energy consumption. It is expected that over 300,000 looms in the U.S. can be retrofitted at an estimated energy saving of over 500 million kilowatt hours per year.

Dry Textile Processing-Texturing: Many fabrics are composed of man-made fibers or a blend of natural and man-made fibers. To make man-made fibers suitable for fabric use, the fibers are texturized to provide bulk, softness, drape, etc., which are required properties of the fabric. The objective of this project is to study and develop new techniques for texturing which consume less energy than the present system of gas-fired radiant heaters or resistance-heating or resistance-heating elements. The potential energy savings to the industry are .25 million barrels of oil equivalent per year.

Dye Bath Reuse: Frequently textile wet processing is done in small lots due to varied customer demands. This processing is done in equipment called Becks where the fabric dye bath is constituted, the fabric dried, rinsed, and the bath dumped to the drain. This project is aimed at saving the spent dye bath, reconstituting it with replacement chemicals and dyes, and reusing the bath as many times as possible, thus saving the materials and hot water of the bath. This project has progressed to demonstrations of this technology. Potential energy savings of 18 trillion Btu annually are forecast.

Pulp and Paper

Pulp and Paper: The pulp and paper industry, like textiles, is also very diversified, producing over 2,000 primary products. The industry encompasses the production and sale of pulp derived from wood and other fibrous materials, pulp and paperboard, and certain by-products such as tall oil used in soap making and turpentine.

The paper industry is characterized by extensive vertical integration (pulping through papermaking) and is highly capital intensive. It ranked ninth in capital intensity among all industries of the U.S. in 1974. Because of this, and because large sums are required for new facilities, the industry is slow to change its practices and processes. Minor process changes are made if they can be retrofitted into existing facilities without large expenditures of fixed capital. Opportunities for changes usually arise only when new facilities are added. Even then, however, the process changes must be well documented and demonstrated so that there is minimum risk to production output and quality.

There are various pulping processes used by the industry, ranging from mechanical (groundwood), semi-chemical (sulfite), to chemical (Kraft). A particular process is used because of the specific properties and cost of the product best suited to the needs of the end use application (dissolving pulp for rayon, writing paper, boxboard, etc.). Kraft pulping, however, accounts for over 50 percent of the output and is the leading pulping process.

This industry is very energy intensive, using 2.5 quads of energy in 1972 in producing an output of 67 million tons of products. Of the energy consumed, 40 to 45 percent is self-generated from burning the spent pulping liquors (black liquor) and the burning of bark and hogged fuels. The balance of the energy required is purchased. A breakout of this purchased energy shows petroleum 22 percent, natural gas 21 percent, coal 12 percent and electricity 5 percent. The energy requirements for the pulping process (pulp making, chemical recovery, bleaching and finish preparation) are approximately equal to those required for pulp drying, papermaking, and paperboard making.

The program in the pulp and paper industry is equally directed toward the pulping process and the papermaking machine.

Specific projects of RD&D in paper making are as follows:

Paper Drying: During the wet processing of sheet on a paper machine, the felt absorbers pick up water from the sheet and become saturated. Vacuum is generally used to subsequently dry the felt. The objective of this project is to apply improved techniques of water removal from the felt to improve its wet pick-up. The application of a high velocity air stream, through a mach nozzle, to drive off the water in the felt offers promising potential for improved water removal. This program is expected to improve water removal. This program is expected to improve water removal by 5 to 7 percentage points, resulting in energy savings of 4 to 6 million barrels of oil equivalent per year. The technology can be retrofitted to existing paper machines.

Cold Corrugation: The objective of this program is to demonstrate the use of a room temperature curable adhesive in the forming of corrugated board. This new method, which replaces the present hot corrugation process offers major advantages including a 95 percent reduction in process heat, a 40 percent reduction in electrical drive energy, a 50 percent reduction in new equipment costs. The energy savings, based on present industry practice, would amount to 6 million barrels of oil equivalent per year. The technology can be retrofitted to existing corrugating lines.

Black Liquor-Paper: The objective of this program is to demonstrate a new process for chemical recovery from Kraft black liquor (spent pulp liquor). A 10 ton per day (pulp) pilot plant has been developed by St. Regis Paper Company; however, the process must be demonstrated at a production level of 350 tons per day. This project will show the level of production necessary to uncover problems encountered in scaleup and verify energy savings in the recovery process. This hydrolysis process is much safer than the existing Tomlinson boiler recovery process and delivers 15 percent more high-level heat. The potential energy savings for the industry are 29 million barrels of oil equivalent per year by the year 2000.

Headbox-Papermaking: The objective of this project is to study energy-saving opportunities in the formation of all grades of paper and paperboard. One of these opportunities, the use of high-consistency forming, will be evaluated in the laboratory to determine if the drainage characteristic of the paper sheet is improved. This should reduce the energy required in evaporating moisture from the sheet at the dryer end of the machine. This technology, if successful, could save 2.5 million barrels of oil equivalent per year.

Mechanical Dewatering: The objective of this program is to model the wet end of a paper machine to determine the effect of the various process variables on dewatering paper sheet. Interaction between the computer model and a pilot-size paper machine will be used to refine the computer model. After the pilot machine data and the computer simulations are consistent, a full-size paper machine will be instrumented and operated to verify the computer results. The computer model can then be used to optimize the dewatering process variables and save energy now used in evaporation of this water from the paper sheet. Expected energy savings are 84 trillion Btu annually or 14 million barrels of oil equivalent per year.

Computer-Controlled Paper Mill: The objective of this project is to conserve energy through the application of energy management, automatic control systems to a totally integrated pulp and paper mill. The project will demonstrate unit process and central operation control through a hierarchy of automatic control systems. Estimated energy savings are over 9 million barrels of oil equivalent per year.

Roof Felt Application: This project will explore a new process for applying hot asphalt to roofing felt to substitute for the present two-machine hot dip process. Roofing felt is made on a Fourdrinier machine to saturate it with asphalt. The new process involves the application of hot asphalt by spray nozzles which will apply the asphalt to one side of the partially dried felt to remove the moisture. Subsequently, the second side of the felt will be sprayed to completely saturate it, and this can be done on a single machine. The anticipated energy savings are over 10 trillion Btu per year.

Multi-Deck Dryers: An evaluation of various types of heat exchangers such as heat pipes, heat wheels, fin and tube, etc. and their ease of cleaning will be conducted for application to low temperature (600-800 F) exhaust stacks. This evaluation will consider economics (first cost and operating cost) and energy savings. If the evaluation is positive, a full sized demonstration will be conducted on a building products plant to verify economics and energy savings. Potential application to other industries such as textiles, pulp and paper mills, and forest product mills indicate that annual energy savings of .01 quad or more are possible.

General Manufacturing: This activity covers a varied number of manufactured products and industry sectors that in themselves are not one of the major energy consumers; however, in total they represent a significant portion of the energy consumed. It covers transportation equipment, appliance manufacturing, machinery and electrical equipment, concrete products, etc. Many of these industry sectors do have similar types of manufacturing operations to make their products, so there may be some commonality of processing.

Because of the various types of products manufactured by this grouping of industries, the size of their operations varies greatly from small shops of less than a thousand square feet and 25 or fewer employees to the giant automotive and appliance plants with hundreds of thousands of square feet and thousands of employees. Thus, the activity concerning energy conservation activities and the technology for implementation, as well as capital funds, are generally confined to the larger high-production facilities. However, once the technology is developed by the larger companies it can be readily disseminated across industry lines by means of the trade associations. For the small shops, however, those technologies that are highly technical and capital intensive will probably be assimilated very slowly into their operations.

Limited information exists on energy consumption by manufacturing processes in these end product industries. However, some of the data of these industry sectors are available through trade associations. Several of these industry sectors have manufacturing processes that are common or similar such as metal forming, machining, painting, heat treatment, oven curing, welding, etc.

The energy consumption of four industry sectors producing metal products such as metal stampings, transportation equipment, machinery and electrical equipment is shown on Table 6.

TABLE 6

Energy Consumption 1975

	TOTAL QUAD	ELECT. QUAD	OIL QUAD	COAL QUAD	N. GAS QUAD	OTHER QUAD
METAL PRODUCTS	.367	.093	.037	.012	.183	.047
TRANSPORTATION EQUIP.	.347	.094	.040	.046	.131	.040
MACHINERY	.330	.093	.035	.021	.137	.040
ELECTRICAL EQUIP.	.228	.081	.023	.012	.085	.030
TOTAL	1.272	.351	.135	.091	.536	.157

Thus, they offer a good potential for conservation efforts; other similar industry sectors offer similar opportunities.

Since the industries are so varied and cover hundreds of plant operations the projects in this program area are directed toward the generic processes that have broad application to the industry, or several industries, and are selected on the basis of the energy consumed and the potential of the technology acceptance.

Significant projects initiated in the consumer products area are as follows:

Coil Coating

Paint curing is a key manufacturing step in finishing many kinds of metal products. In the United States, paint curing consumes over 196 trillion Btu of energy annually, 95 percent of which is supplied by natural gas. Cutbacks in natural gas supplies can affect the many industries which use thermal curing for paint systems, as well as those industries which depend upon these products for manufacturing operations. The coil coating industry is one which is heavily dependent upon natural gas and their representative association, the National Coil Coaters Association (NCCA), approached DOE concerning a solution to the natural gas cutback problem.

One of their members, Roll Coater, Inc., agreed to join with NCCA and DOE in a cost-shared demonstration project to utilize a new technology that recovers a significant portion of the energy normally lost in oven exhaust gases. This new system, engineered by B&K Machinery International Ltd., makes use of newly developed incinerators which burn the solvent vapors circulated to them from the cured paint. This recirculation reduces the ventilating air burned along with some natural gas to supply thermal energy to the oven for curing. The final hot exhaust gases, which have some unburned solvent fumes, are incinerated in a waste heat boiler to generate steam which is subsequently used for heating the coil cleaning tanks and for building heat. This particular installation which has been in operation since late 1977, has reduced natural gas consumption by 45 to 65 percent for the oven and 65 to 85 percent with heat recovery from the waste heat boiler, resulting in a total natural gas saving of 600 million cubic feet annually. Additionally, four other installations have also been made resulting in total savings of over 1.3 billion cubic feet of natural gas. The technology is continuing to penetrate the coil coating industry.

Post-Paint Curing: Parts that are fabricated and subsequently painted on product finishing lines annually consume over 81 billion cubic feet of natural gas during curing in thermal ovens. This is an inefficient process. The objective of this project is to explore the development of radiation

curable coatings (ultraviolet) and their application to post-painted parts. This new process requires only 25 percent of the present energy consumption since the paint formulation is cured without heating. If successful, 60 billion cubic feet of natural gas could be saved each year by the industry.

Alternatives to Natural Gas in Curing: This project is aimed at eliminating the need for any natural gas in curing coated coils. Solvent vapors driven off the coatings during curing will be incinerated electrically with the resulting hot exhaust products recirculated to the ovens for curing the coatings. Annual savings are estimated at 4 trillion BTU per year.

High Efficiency-Arc Weld Power Supply: The objective of this project is to improve the energy efficiency of arc welding power supplies through the use of solid state controls and new inverter technology. This redesign can improve the efficiency of power supplies from the present 55 percent and a power factor of 60 percent to an efficiency of 85 to 90 percent with a power factor near unity. As a result of these improvements, potential energy savings of 42 trillion Btu's per year are possible.

Alternative Power for Hand Tools: This project's objective is to provide theoretical analyses and operational testing of pneumatic, hydraulic, standard electric (60 cycle) and high-frequency electric (180 and 360 cycles) tools for industrial applications to determine the degree of energy savings that are possible. The most efficient and practical tools will be compared to conventional pneumatic tools in a production demonstration to verify energy savings against the theoretical analyses and testing data formerly obtained. Estimated savings in the use of high-frequency electric over pneumatic hand tools are in excess of 76 trillion BTU per year.

Concrete Pipe Demonstration: A study and demonstration of concrete block curing was completed which indicated that the use of appropriate insulation on the kilns reduced energy consumption from 35 to 43 percent without affecting quality. The objective of this project is to apply a similar technique to concrete pipe curing. Product differences between pipe and block are such that demonstrations in that industry sector are appropriate to verify energy savings without loss of product quality or production rate. Potential energy savings for this industry segment, assuming a 40 percent reduction in energy consumption, is 1 million barrels of oil equivalent per year. This effort is planned to start in FY 1980.

Agriculture and Food Processes

The food system is one of the largest and most diverse segments of our economy. Historically, energy use in the food system has been growing at a rate greater than the population growth rate. This has been because the U.S. food system has substituted fossil energy and electrical power for "human energy." Another factor in this energy growth rate has been that more than 75 percent of the food on the farm is processed in some degree before being sold to the customer. Recent energy use estimates indicate that the energy demand for the entire food sector is approximately 6.0 quads per year, and a large percentage of this demand is in the form of natural gas and electricity, two of our more critical forms. The activity in agriculture and food processing focuses on improvements in overall energy use and on utilization of alternative and abundant fuel forms. The activity is partitioned into 13 segments as follows: integrated farm systems, irrigation, crop drying, alternative farm power systems, fertilizer production, milk and dairy processing, system modeling for agriculture, food processing efficiency systems, food sterilization, food packaging, sugar processing citrus processing, and meat processing.

Energy Integrated Farm Systems: Energy use on farms is diversified in both types of energy sources and location of power requirements. The pattern of use is not uniform and rather large quantities of fuel are used over short periods of time. This diversity and nonuniform pattern of use have both advantages and disadvantages. The primary disadvantage is logistics in supplying such erratic use patterns. However, from the standpoint of using alternative sources such as wind, solar and biomass there is an advantage. The integration of alternative sources along with implementation of conservation practices moves some farming enterprises near energy self-sufficiency.

The objective of this program is to investigate energy production from farm sources such as biomass to investigate the economic applications of solar and wind energy on the farm and to study efficient use of potential energy and nonenergy sources so as to promote on-farm integrated livestock-crop-energy production systems. This program will determine the differences between energy-integrated farms and conventional farms in terms of energy utilized, net profit, and soil and water effectiveness. A particularly significant application can be found in underdeveloped agricultural economies.

Irrigation: Approximately 15 percent of the total energy use on the farm is applied to pumping and distributing irrigation water. A high-priority agriculture and food process subprogram activity is the encouragement and participation in the development of new or improved technologies that will yield greater efficiencies in irrigation pumping plants and irrigation system management while maintaining high levels of productivity.

The primary thrust is to support research in energy conserving design, development, and commercial demonstrations of improved irrigation systems.

Ten projects are currently being supported. They are:

- Ground water irrigation supply system optimization
- Development and evaluation of an ultra low pressure mobile trickle application system
- Analysis of the effect of irrigation scheduling on energy consumption
- Development and demonstration of a variable speed pump
- Automation of a gated pipe irrigation system
- Low energy center pivot sprinkler irrigation system
- Redesign of turbine pump impeller and diffuser using hydro-dynamic design techniques
- Irrigated agricultural instrumentation system
- Computerized life-cycle-costing irrigation system pipeline network design program
- Effects of irrigation well efficiency on energy requirements.

Crop Drying: Liquid petroleum gas (LPG) is the primary source of energy for crop drying. Approximately 9 percent of the total energy use in agriculture relates to this activity.

Projects are sponsored under this activity to improve overall efficiency (currently less than 50 percent) and to encourage the substitution of abundant fuels for liquid propane gas without increasing operating costs. Crop drying--one of the most energy-intensive operations in agriculture--uses, on an almost exclusive basis, liquid propane gas. Moreover, like most heat treatment operations, drying is only about 50 percent efficient. Five projects are under way:

- The first demonstrates the application of electric heat-pump technology to grain drying. If implemented, this system could save as much as 300,000 barrels of oil equivalent per year.
- The second evaluates the reduction in energy requirements and improvement in grain quality resulting from a combination of high-temperature and low-temperature drying.

- The third develops a new corn drying system that utilizes cornstalk residue as a fuel source to dry the grain. Adoption of this technique could conserve more than 3 million barrels of oil equivalent per year.
- The fourth is oriented toward a feasibility study to assess the suitability of using a liquid desiccant system for commercial (corn) drying. This process, if implemented, could conserve the equivalent of 35,000 barrels of oil per year.
- The fifth is a project to develop the use of microwave vacuum drying technology for moisture removal in grain drying. At present the project is concentrating on seed drying which is extremely critical and delicate in order to ensure product quality. Present systems rely entirely on LPG, and this alternative would alleviate industry problems.

Alternative Farm Power Systems: Field operations on the farm comprise activities such as seedbed preparation, planting, tillage, and harvesting. Gasoline, diesel fuel, and LP gas are all used to power field machines and miscellaneous farm equipment which are used for field operations. The sum of the energy used for these various field operations is a significant proportion of the total energy required for crop production. The energy used for field operations, though, varies significantly with the crop, soil, and cultural practices. Consumption ranges between 3 and 20 gallons of the energy equivalent of gasoline per acre.

If at some juncture the supply of petroleum-based fuels is inadequate to meet the needs of production agriculture, the implications could be disastrous unless alternate equipment systems are available for the farmer.

To meet this potential problem, and activity is planned within this subprogram to assist in the research, development, and demonstration of alternate farm equipment systems. The objectives of this activity are:

To meet this potential problem, an activity is planned within this sub-program to assist in the research, development, and demonstration of alternate farm equipment systems. The objectives of this activity are:

- Examine equipment systems technologies for farming which are more energy efficient.
- Assist in the development of fuel alternatives for farm equipment and field machines.

Research may include and is not limited to: unconventional cycles, electric powered systems, hybrid equipment (employing a combination of two or more energy conversion/storage devices), alternative fuels, etc.

Fertilizer Production: Natural gas is the principal raw material feedstock for ammonia manufacturing plants, both as a source of hydrogen in the chemical reaction and for process heat in the production cycle. The research planned for this activity includes the development and demonstration of alternative fuels or techniques for heating the tubes in typical Haber-Bosch process, demonstration of advanced catalyst systems for less energy-intensive reaction of hydrogen and nitrogen to form ammonia, use of alternate methods of producing hydrogen, and development of unique nitrogen fixation processes to consume less energy.

One project is underway with the Tennessee Valley Authority, National Fertilizer Development Center, which is investigating processes for conserving energy in the production of fertilizers in ammoniation-granulation plants under an Interagency Agreement initiated in FY 76. This four-year project will develop new formulations which reduce moisture added in the granulation process and utilize chemical heat-of-reaction generated by combinations of ammonia and phosphoric acid as a substitute for natural gas in drying granular fertilizer.

It is estimated that fuel consumption in these plants can be cut by as much as 65 percent by using the new formulation procedures, resulting in a cumulative energy savings of 5.8 million barrels equivalent by 1985, with first savings occurring in 1979. TVA is currently refining a pipe-cross reactor and other melt-type processes, and collecting data from ammoniation-granulation plants on energy requirements for producing fertilizers by conventional processes.

Milk and Dairy Processing: On many modern dairy farms the energy required for cooling milk and heating water for sanitation uses up to 75 percent of the electrical energy on the farm. Methods are sought to reduce the energy required for cooling milk and heating water. Investigations are currently underway with DOE support to evaluate the energy savings and market acceptability of sterilization of milk with aseptic packaging. The objective of this program is to test and evaluate a "steam infusion, falling-film sterilization" process for fluid milk sterilization. This technique obviates the need for milk to pass over hot metal in the sterilization process; and thereby eliminates the "cooked" taste obtained from other such sterilization processes. Acceptable sterilized fluid milk potentially offers the significant energy conservation advantages of extended shelf-life, unrefrigerated distribution and storage, reduced travel in marketing procedures and consumer purchasing patterns, and reduced returns of outdated milk. Estimates place the potential energy saving of implementation equivalent to 10 million barrels of oil equivalent per year.

System Modeling for Agriculture: The energy use in agricultural production and food processing is being comprehensively modeled by DOE to analyze the options available for use of different technologies. The program, called AGRIMOD, has the ability to:

- Identify the impact of possible energy and natural resource constraints on food supply and process
- Evaluate the effects of policies relating to the imports and exports of food
- Assess the long-term impacts of policies on diets and nutrition
- Analyze the impacts of specific energy conservation policies in planning future programs and assess energy conservation opportunities in food system.

Food Processing Efficiency Systems: The food processing industry is diverse; there are a number of processes common to many segments of the industry. Drying is a highly energy intensive process which is common but not limited to the prepared animal feeds, wet corn milling, fluid milk, beet sugar processing industries. In all four of these industries, large amounts of thermal energy are required to evaporate water. Sanitization is another highly energy intensive process which is common to all the food processing industries. Steam from the boiler is commonly used to maintain sanitation in the food processing plant. Cooling is a third process which is common to many food processing industries. The meat packing, fluid milk, and frozen fruit and vegetable industries all require refrigeration and freezing to minimize microbial contamination of the food products they process. Specific projects underway are:

- Low energy concentration of fluid foods and food processing effluents
- Direct enzymatic extraction of starch from corn as an energy-saving alternative to production of high fructose syrup
- Energy use in seafood production and preparation
- Energy conservation in the canning industry
- Advanced dehydration in alfalfa processing to produce a leaf protein concentrate (LPC) for human consumption and improved animal feeds called Pro-Xan that reduces energy use in the conventional alfalfa process by 25% is being demonstrated by Valley Dehydrating Company. The demonstration is supported by the technical staff of the USDA Western Regional Laboratory in Berkeley, California, which developed the process system.

Food Sterilization: The preservation of foods by canning, freezing, and freeze-drying is very energy intensive. It was reported in the 1974 Annual Survey of Manufacturers that energy required for the preservation of fruits and vegetables (SIC 203) required the equivalent of 37.6 billion kWh of electricity.

Thermal energy requirements for processing canned fruits and vegetables are relatively large. Canned foods also require a large amount of energy for transport because of the large bulk weight caused by the liquid content in the container. Energy use in marketing and end user storage, though, is minimal. Frozen foods require a relatively small amount of energy in processing, but the requirement of refrigerated energy throughout storage distribution, marketing, and end use offsets the energy advantage in processing.

The food sterilization activity is oriented to the acceleration of bench-scale experimentation into new concepts of food sterilization. Bench-scale experimentation will meet either one or both of the following objectives:

- Development of technology which will reduce the energy required for thermal treatments of foods for sterilization.
- Development of technology which will assist, along with appropriate packaging, in the reduction of refrigeration energy required to maintain an acceptable product in distribution and marketing.

A project is underway to investigate the preservation of fresh solid foods by gas exchange (GASPAK).

Food Packaging: Packaging is a significant component in food processing operations and in the ultimate food product which we purchase. Packaging serves three basic purposes:

- Containment of the food product
- Maintenance of product integrity
- Assistance in gaining product acceptance by the consumer

A strong relationship exists between the formulation of a food product and the packaging required for that same product. For example, packaging requirements are usually more rigid for liquid foods than for dry solid foods. Based on this relationship, packaging has a significant impact on energy conservation in the formation of food products. The initial thrust of this activity will be to develop a systematic approach to alternate packaging concepts for sterile aseptic packages for fresh foods.

Sugar Processing: The sugar processing industry consists of two sectors, the cane sugar industry and the beet sugar industry. It is estimated that both industry sectors consume approximately 15 percent of the energy required for the food processing industry. This activity is designed to enhance the commercialization of energy-saving technologies-- e.g., vacuum pan crystallization, improved concentrating processes--in an extremely low profit margin industry that is highly conservative and resistant to implementation of untried/unproven technologies. Three projects are underway in beet sugar processing:

- Demonstration of evaporation by mechanical vapor recompression and falling film evaporation in the beet sugar industry
- Feasibility of membrane technology as a means to reduce energy requirements in the beet sugar industry
- Pre-liming of sugarbeet cassettes to reduce energy in sugarbeet processing.

Citrus Processing: In 1977, it was estimated that 230 million boxes or over 20 billion pounds of fruit were processed by the Florida citrus industry alone. As with many food industries, the processing of this fruit requires high energy usage to prepare the raw product, remove water, and preserve the final product. Over 50 major processing plants comprise the citrus industry in Florida. These plants have utilized natural gas for 60 percent of their total energy requirements. The total annual energy has been estimated at 15 trillion Btu's, or the equivalent of 2.4 million barrels of fuel oil.

The activity in this area consists of a systems analysis approach to develop improved systems for a growth industry which has suffered a neglect of innovation due to a lack of technological sophistication. To date, two projects have been initiated. They are:

- Energy conservation for citrus fruit processing
- Evaluation and demonstration of energy conserving technologies for the citrus processing industry.

Meat Processing: In 1975, the meat packing industry consumed over 100 trillion Btu's of energy, or the equivalent of 17 million barrels of oil, more than any other single segment of the food processing industry. The meat packing industry is very diverse in size, manufacturing processes, and types of product. Despite this diversity, refrigeration, by-product processing, conveyance, and sanitation are energy intensive operations common to all meat packing plants.

This subactivity is expected to develop energy consumption data to enhance management prospects of improved energy savings, through adoption and implementation of energy saving technologies such as heat exchangers, improved recovery systems, modernized steam boiler controls, etc. The industry has been constrained. Specific projects currently underway are:

- Energy conservation in the poultry processing industry
- Food processing plant systems analysis
- Muscle boning of the unchilled bovine carcass.

X. COST EFFECTIVENESS OF FEDERAL INVESTMENTS IN RD&D

Figure 10 shows that conservation is cheaper than fuel in some cases. A cost frequency distribution for thirty cost-shared RD&D technologies is compared to nominal cost ranges for conventional and new fuels. Obviously almost any of the conservation technologies that reach commercialization will cost, on an annualized basis (12-percent ROI), far less than the oil, gas, and synthetic fuels they displace. Some advanced conservation technologies exhibit lower non-energy (capital plus O&M) costs than the technology they are expected to replace. Such technologies are represented by negative costs in Figure 10.

Figure 10

COMPARISON OF FUEL COSTS WITH COSTS OF CONSERVATION USING NEW TECHNOLOGY

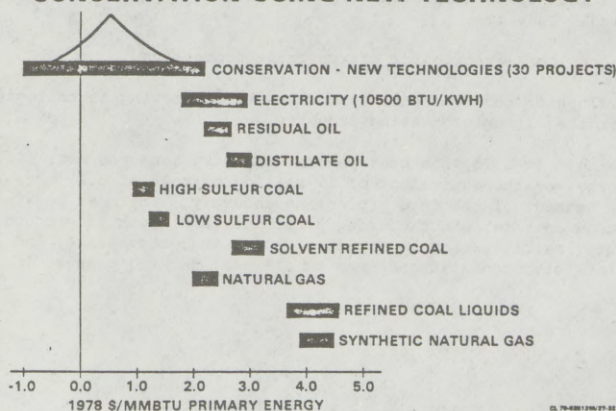


Table 7 summarizes the expected performance of the currently identified new technologies which are being, or could be developed and demonstrated through the federal cost-shared RD&D program. It is evident that the program is cost-effective to industry as well as extremely so to the nation. The average private cost per million Btu potentially saved through each subprogram varies from \$0.234 to \$1.312, with the mean value (see Figure 9) at about \$0.61. This is of course less than the cost of fuels, as shown before. The federal benefit cost ratio in Table 7 shows that, for each dollar invested by the government in the program, the value of expected energy savings through the year 2000 is \$247 to \$1,800.

Table 7

COST-EFFECTIVENESS OF THE FEDERAL COST-SHARING RD&D PROGRAM**

Subprogram	Annual Savings (quad/year)		Average Private Cost (\$/10 ⁶ Btu)	Federal Benefit Cost Ratio*
	1935	2000		
Waste Energy Utilization	1.18	2.86	0.603	1772
Alternative Materials Utilization	0.03	0.98	0.468	1019
High Temperature Processes	0.51	2.65	0.234	477
End Product and Low Temperature Processes	0.63	2.16	0.357	1023
Agricultural and Food Processes	0.34	0.99	1.312	247
Cogeneration	0.46	1.80	1.20	1800

* Present worth of cumulative national energy savings expected through 2000 divided by present worth of the required federal investment.

** Includes qualified, innovative technologies identified to date by the Office of Industrial Programs whether presently being funded or not.

XI. THE IMPACT OF THE FEDERAL RD&D PROGRAM

If one were to add the potential energy savings of all the programs I have just described the sum would be over 9 quadrillion Btu's per year. Since, however, the projects are by definition and selection "high risk" it is unlikely that his savings will be realized. To allow for failures, we have discounted this sum by about 40% and predict that the potential savings will be on the order of 5.5 Quads by the year 2000.

It would be incorrect to state that the completion of the described projects represents the ultimate potential of a Federal RD&D post shared program, however. Nearly every day new opportunities are uncovered which appear to exceed our criteria of eligibility. In our response to questions posed by this Committee we identified many additional projects capable of savings an additional 3.1 Quads by 2000.

In addition, several other areas warrant investigation such as the development of:

- o Two stage coal burning systems that would deliver clean low or medium Btu gas to existing furnaces and boilers.
- o Advanced ore beneficiation concepts (direct reduction of taconite)
- o Advanced metal extraction from ore and/or scrap (e.g. Volatile chloride extraction and fractional distillation)
- o Low cost, non-fouling, heat exchangers for low temperature transfer.
- o Chemical heat pumps for upgrading low quality waste streams.

XII. CONCLUSIONS

There is an urgent need for federal funding in cost-shared RD&D to demonstrate high risk energy savings technologies in the industrial sector. Such expenditures are extremely cost effective in comparison with other federal options and can have very significant impact on the energy consumption As I have described in my text, the President's 1980 budget makes provisions to explore conservation opportunities with potential in the industrial sector. Improvement of the energy efficiency of industrial processes has the significant side benefits of reducing inflation, increasing employment, lessened environmental insult, and increasing the competitiveness of U.S. industry in the international market place.

**STATEMENT OF DOUG HARVEY, DIRECTOR, INDUSTRIAL ENERGY
CONSERVATION, DEPARTMENT OF ENERGY**

MR. HARVEY. Indeed I will. I wrote a rather detailed statement this morning primarily to get it into the record and, I can assure you, I don't have any intention of going through that in any great detail this morning, but I think that the details that are provided on the individual projects that are currently underway, and could be underway, are important to get into the record.

I would like to thank you and the committee and the staff members of this committee for holding this hearing. I think it is a vitally important subject, and one which is going to have significant impact on the national priorities that are going to be set in the next few months and years.

I am delighted that you have given us this opportunity to highlight the importance of the entire industrial conservation effort.

There can be no question that the output of our industrial sector represents the strength of the fabric with which our very society and economy is woven. This industrial sector directly employs 30 percent of our total work force and indirectly employs about 70 percent of our total work force.

Clearly, the competitive position of U.S. industry significantly affects the balance of payments, the inflationary trends, the employment levels—essentially all of the economic indicators of our society are directly impacted by the industrial sector. Having that sector as a viable expanding technology or expanding unit of our society is essential to the future growth of this country.

It is important to look at how energy is coupled with industrial output and how energy is consumed by industry in order to get some insight into the manner in which energy can be decoupled from industrial production, to a degree. It can never be completely decoupled, obviously.

With your permission, sir, I would like to use some Vu-Graphs in highlighting this testimony, and this will perhaps provide greater lucidity to the points that I would like to make.

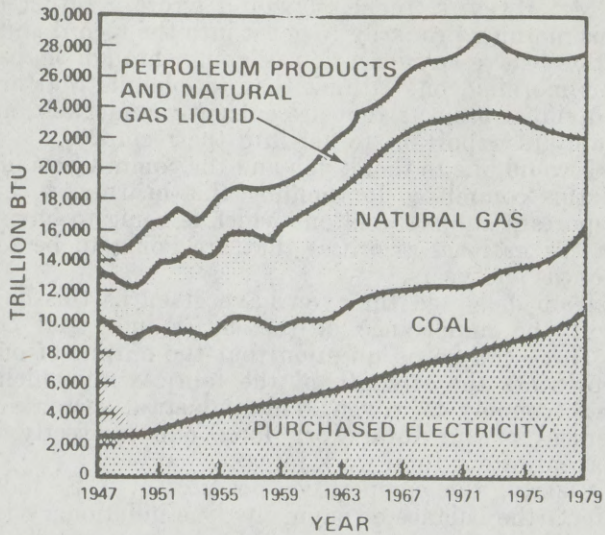
Bill, can I have the first one, please?

Incidentally, at the Vu-Graph machine is Al Streb, the director of the research and development division within the group.

The first figure shows how energy is consumed by industry and has been consumed since 1947.



Industrial Energy Consumption for Fuel Uses



NOTE. ELECTRICITY IS SHOWN AS FUEL

FIGURE 1

As you can see, there has been a significant increase in purchased electricity, in natural gas consumption, and in petroleum products consumption.

Coal is somewhat diminished. Industry consumes about 36 percent today of our national energy consumption, about 50 percent of the natural gas that is consumed nationwide, and about 20 percent of the petroleum that is consumed nationwide.

But this energy is consumed in order to provide certain functioning within an industrial process.



Breakdown of Industrial Demand

<u>Demand</u>	<u>%</u>
Process Steam*	40
Direct Process Heat	28
Electric Drive	19
Feedstock	9
Electrolytic	3
Other	1

FIGURE 2

Figure 2 shows this demand broken down by various demand functions within the industry itself.

Processed steam, for example, uses about 40 percent of the total energy.

Direct process heat, such as heating of steel ingots, remelting of aluminum, glass kilns, and brick kilns, and so forth, consumes about 28 percent of our national energy; electric drive about 19 percent; feedstock 9 percent; electrolytic processes such as the reduction of aluminum oxide to aluminum metal consume about 3 percent; and miscellaneous other demands, about 1 percent.

It is interesting to examine how energy production has increased between the period 1950 to 1970, and how energy consumption increased during the same period [figure 3].



Production and Energy Consumption

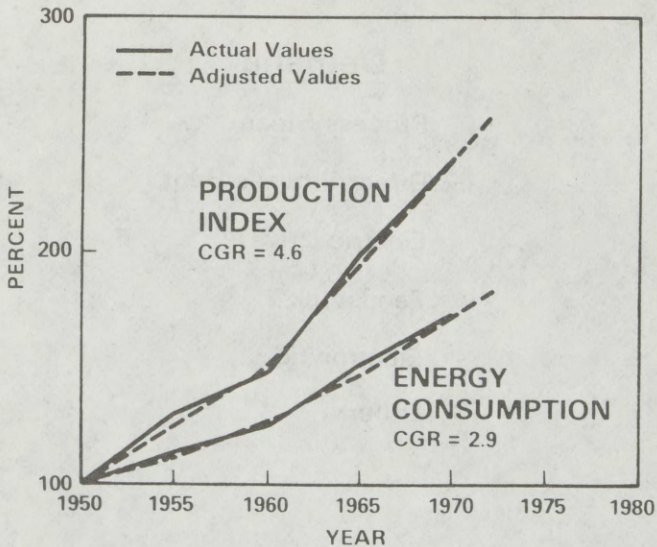


FIGURE 3

I have normalized all of these data to a base 100 for 1950. You can see that the industrial production has increased by a factor of $2\frac{1}{2}$ in this time period 1950 to 1970, while the energy consumption has increased only about 1.8 times. In other words, industry uses 78 percent of the energy that they consumed in 1950 in order to produce the output of 1970.

Now, of course, the period between 1970 and today has been one of great trauma throughout our society, specifically regarding energy.

As you know, we have a reporting program that is mandated by Congress in both the EPCA and NECPA legislation, and I have recently analyzed the most recent data that has come in under this reporting program.

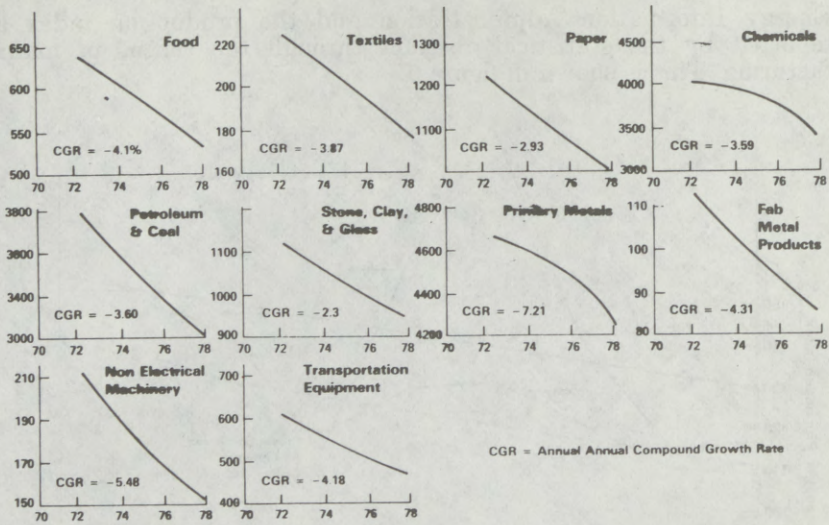


FIGURE 4

Figure 4 shows some of this data. I doubt if you can read the numbers on this figure, but you can see the trends. The top left-hand corner is the food industry, the textile industry, paper industry, the chemical industry, and so forth.

There has been a definite decrease in energy consumption per unit output in each of these 10 major industries.

This, however, does not represent a comprehensive data base. It has to be taken in the light that not all of the companies in each of those sectors are required to report. Consequently, the larger companies, which have very extensive energy conservation programs, probably dominate the statistics associated with this type of analysis.

If you combined all of the compound growth reductions, you would end up with a reduction of 4.7 percent in energy consumption per unit of output per year.

Now, there is another interesting trend that can be observed from those curves.

There have been many statements made recently that this reduction in energy consumption has been occasioned by industry's doing the "housekeeping things" and making nominal capital investments. Were that the case, one would expect those curves to be flattening out, but they don't seem to be doing that. In fact, they seem to be continuing down and, in some cases, with a negative slope. For example, in primary metals, there seems to be a negative slope.

We believe this to be caused by the fact it took a while for industry to react to the increase in prices and to the energy shortages. The impact of capital investment that they made was delayed until that equipment could be delivered, perhaps 2 to 3 years' delay.

But we feel that the industry is going to continue to conserve energy at a significant rate. Perhaps the more accurate determination of this can be gained by examining the information reported to the

Energy Information Administration and the production index as reported by the statistical abstract through the census of manufacturing. This is shown in figure 5.

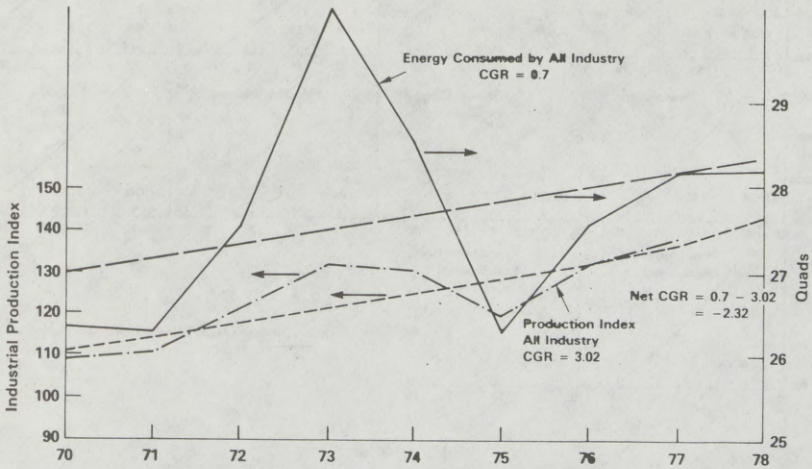


FIGURE 5

The top solid line curve is the actual energy consumed between the year period 1970 and 1978.

I have done a curve fitting analysis and the top dotted line represents the energy compound growth rate and it is 0.7 percent per year.

The bottom curve has to do with the production index, and that has been increasing very closely to the traditional rate of about 3 percent per year. If one subtracts those two compound growth rate levels, you get a compound growth rate in energy consumed per unit of production of minus 2.3 percent per year.

We think this is a closer indicator of how industry has responded to the energy crisis of the last few years.

Now, this is useful only in trying to guess at what the future energy demand for industry will be. There have been many, many projections of this. I have presented two on figure 6.



Projected Energy Consumption

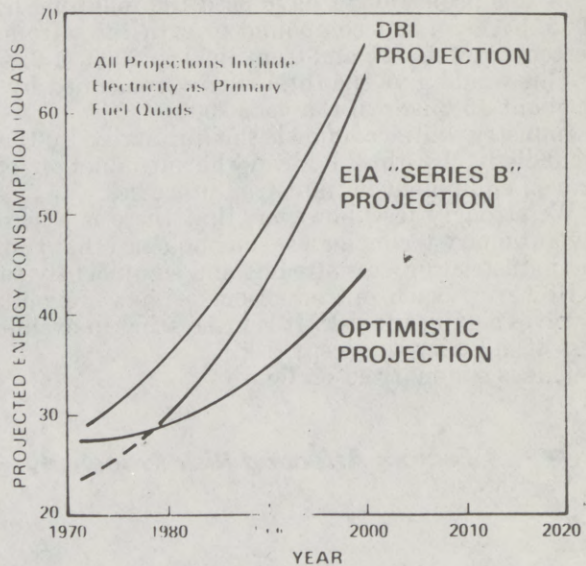


FIGURE 6

The top curve is the DRI projection which was made back several years ago based on 1970 technology. It essentially says that the amount of energy that would be consumed by the industrial sector as a function of time, if 1972 technology were used, would be about 67 quads in the year 2000. This serves as a base line for our further predictions.

The Energy Information Administration has recently, in the 1978 report to Congress, come out with a series of projections which make several assumptions regarding the future price of energy. The series B projection from an econometric analysis predicts that in primary fuels—where electricity is expressed as primary quads of energy—the future energy consumption by the industrial sector would be about 64 quads.

This doesn't seem to be happening, however. As I indicated on a previous slide, the industry seems to be responding to this crisis not only in terms of econometric measures, because as the price of energy increases, the demand for energy would decrease by some elasticity value.

I think there are some other factors at force here. We don't quite know what they are. But certainly, there is a nationalistic spirit that I observed in the industry where they feel it is their civic obligation to reduce energy consumption. I don't mean to say industry has become altruistic. I don't believe that.

I do feel that the fear of complete cutoff of energy of various types has caused significant investment to be made that is not completely explainable by econometric analysis. So I have shown on this chart an optimistic projection.

In this projection, I have used the following figures: From 1977 to 1985, a 1½-percent compound growth rate; from 1985 to 1990, a 2-percent growth rate and from 1990 to 2000, a 2½-percent growth rate.

This would give the total energy consumed by the industrial sector at about 45 quads in the year 2000.

Industry will accomplish this primarily by the use of evolutionary technology, by that I mean the introduction of modern but well-proven equipment in industrial processes.

We strongly feel, however, that there is a significant potential for revolutionary technologies—technologies that can significantly change the industrial process streams and significantly save energy.

However, such introduction of new revolutionary technologies involves significant risk. It is interesting to examine, then, the willingness of industry to accept risk.

This is summarized on figure 7.



Factors Affecting Risk Propensity

- Capital Intensity
- Linearity of Process
- Fragmentation of Industry
- Availability of Discretionary Funds
- Increased Competitive Position

FIGURE 7

Now, there are many factors that affect this willingness, including certainly, the capital intensity of the individual industry involved. The aluminum industry, the steel industry, the pulp and paper industry are all extremely capital intensive and relatively unwilling to invest additional capital, major additional capital that decreases the return on capital invested.

The second factor is linearity of process. This has to do with the ability of a given process stream to parallel units of operation. For example, in the chemical industry it is relatively easy to parallel distillation columns and examine a new process technology for separation. You may have a distillation column on one side and a freeze

separation unit on the other side using the same process stream relatively inexpensively. You can't do that in the steel industry where the blast furnace represents a very large piece of equipment. You can't parallel them easily. The same is true of the digester in the pulp and paper industry. These are very large expensive pieces of equipment.

Now, the third factor has to do with the fragmentation of the industry.

In the textile industry, for example, there is something like 3,700 firms for the finishing of textiles. Not one of those firms has significant R.D. & D. funds, so they are very reluctant to innovate. So it seems there is a very significant Federal role in developing technologies for fragmented industries as well.

The fourth factor has to do with the availability of discretionary funds. Clearly, industry is forced to invest in a number of technologies that comply with various Federal regulations, such as the Environmental Protection Agency regulations on effluent and emission standards, OSHA regulations and so forth. This uses up available capital that might be spent on advanced technology.

Finally, increased competitive position has always been a primary criteria for investment of new funds. Unfortunately, process technology generally does not improve significantly a corporation's position in its market. Generally, it is relatively easy for competing firms to duplicate process technology improvements. Consequently, little competitive advantage is gained. We generally estimate about a 3- to 4-year advantage would be gained by a process change that significantly reduces the energy content of a process stream. Incidentally, that is probably one of the major reasons that the hurdle rate in most of the industries with which we deal requires about a 3-year payback.

Let me go on to another analysis looking at the same kind of thing.

Several years ago, Blackman and several other investigators examined by factor analysis the innovative index for various types of industries. Their results are shown in Figure 8.

INDUSTRIAL SECTOR RANKING BY VALUE OF INNOVATION INDEX

INDUSTRIAL SECTOR	INNOVATION INDEX	REASONS FOR RISK AVOIDANCE
AIRCRAFT AND MISSILES	3.004	● LINEAR INDUSTRIES WITH LARGE CAPITAL EQUIPMENT
ELECTRICAL MACHINERY AND COMMUNICATIONS	1.418	
AUTOS AND OTHER TRANSPORTATION EQUIPMENT	0.718	● FRAGMENTED INDUSTRIES WITH NO CENTRAL ENGINEERING
MACHINERY	0.224	
PROFESSIONAL AND SCIENTIFIC INSTRUMENTS	0.091	● SLIGHT COMPETITIVE MARKET ADVANTAGE BY PROCESS CHANGE (EASY TO DUPLICATE)
CHEMICALS AND ALLIED PRODUCTS	-0.057	
RUBBER PRODUCTS	-0.345	● ENERGY PRICE INCREASES CAN BE PASSED THROUGH TO CONSUMER
PETROLEUM PRODUCTS	-0.443	
NONFERROUS METALS	-0.538	
FABRICATED METALS AND ORDNANCE	-0.590	
STONE, CLAY, AND GLASS	-0.669	
TEXTILE MILL PRODUCTS AND APPAREL	-0.689	
PAPER AND ALLIED PRODUCTS	-0.694	
FOOD AND KINDRED PRODUCTS	-0.703	
STEEL	-0.725	

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FIGURE 8

This is kind of interesting because it shows what we intuitively have said in the last slide, they conclude that the steel industry is least willing to accept risk. Steel is very capital intensive, and linear. The jeopardy of production output by introduction of a new technology could far outweigh any small advantage that would be gained in energy saving and reduced operational cost.

If the output is disrupted, it becomes a very significant factor to the return on the overall capital of the steel rolling mill, for example.

Likewise food and food products, textile mill products, paper and allied products are all in the bottom of this list and are relatively unwilling to accept risk.

Toward the top of the list we find chemicals and allied products, for example. The chemical industry is not linear and not as capital intensive. It has greater R. & D. funds available. Its technologies are highly proprietary. The chemical industry is very willing to accept risk.

This gives us some insight, then, into how we should shape a program to reduce energy consumption in the industrial sector if we are going to look at revolutionary technologies.

The objectives and approach of the Federal programs in this area essentially are to develop and demonstrate these new conservation technologies that are a significant departure from current practice.

We are trying to increase energy use efficiency, substitute abundance for scarce fuels, and optimize energy use through material utilization.

I will show you an example of that in a moment.

All of the hardware programs are cost shared programs with industry. We have essentially two approaches to this overall program: A horizontal thrust that examines technologies that have application to a large number of industries and a vertical thrust that develops technologies that are specific to a given industry.

Our targeted annual savings are $1\frac{1}{2}$ quads directly from this program by 1985, and about $5\frac{1}{2}$ quads by the year 2000.

Can I have the next slide?

Project Selection

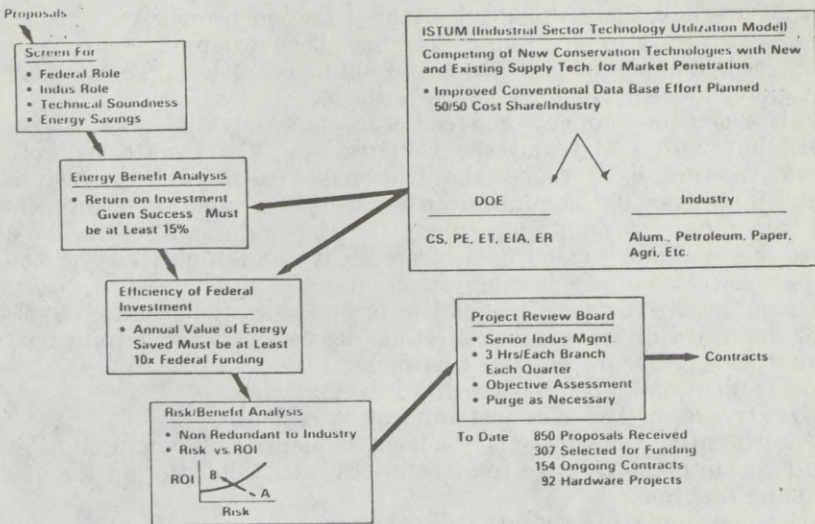


FIGURE 9

Now, in order to assure that we are achieving our objective of developing technology that would be adopted by industry, and at the same time is not redundant to industry's private effort in developing new technologies, we have developed a series of criteria by which we select every single project that is funded by the Government.

The first major criterion we use is one which has to do with the penetration of the new technology into the marketplace. If a technology can be proven to be reliable and the risk is removed from it, it would not enter the marketplace if it then does not have a suitable return on investment.

We have set the minimum criterion of 15-percent return on investment after taxes. This implies that we are able to predict what that return on investment will be and, of course, a great deal of subjective judgment goes into that determination.

The second criterion has to do with the efficiency of the Federal investment. It has to do with the size of the marketplace versus the Federal dollars put into that technology. What we would like to achieve for each technology we develop is that for each dollar of Federal investment with reasonable market penetration, that technology will return a minimum of 10 dollars' worth of energy savings per year.

Now, the third factor has to do with not being redundant to industry's own efforts. We examined a body of technologies that industry did develop on their own—the evolutionary technology I discussed before—and they fall within the left-hand side of that solid line on that bottom little chart.

If a technology falls outside of that line, that is, the risk versus the benefit—and we measured risk in terms of economic risk, technical risk, and institutional risk; the benefit we measured in terms of the return on investment—exceeds that line, then it is suitable for Federal investment.

We have a formula for the line. I need not go into that at this point in time.

Now, we have been doing all of this selection primarily in-house. That is, a group of my senior staff has been examining each and every project at major milestones and annually, at least, to establish that they, indeed, meet all of the criteria.

This has come under some criticism, not only in talking with DOE, but with OMB and the Congress and the Senate as well. So we recently have asked the National Academy of Science to establish an oversight committee to assist us in evaluation of projects and evaluation of long-range plans for the industrial sector. We think this will add a good deal of credibility and objectivity in the project selection and planning function.

Let me briefly review a few of the technologies that we are developing, and I will leave most of this discussion to my industrial counterparts, who are also on this panel.

As I mentioned before, we have technologies—

Mr. OTTINGER. If I can just interrupt a second.

Unfortunately, Congress is a place frequently of competing demands. I am going to have to meet briefly with conferees on the gas rationing program.

My colleague, Mr. Volkmer, will take over.

I will get back to all of you, and I will get back as quickly as I can.

Mr. HARVEY. Thank you, Mr. Chairman.

Mr. Volkmer, I promise I won't go into any great detail on any of those. All of these projects have been described in my written testimony.

As I mentioned earlier, we have divided our program into two basic thrusts, a horizontal thrust that looks at technologies applicable to a wide spectrum of industries, a vertical thrust that looks at specific industrial processes like steel, aluminum, and pulp and paper, and so on.

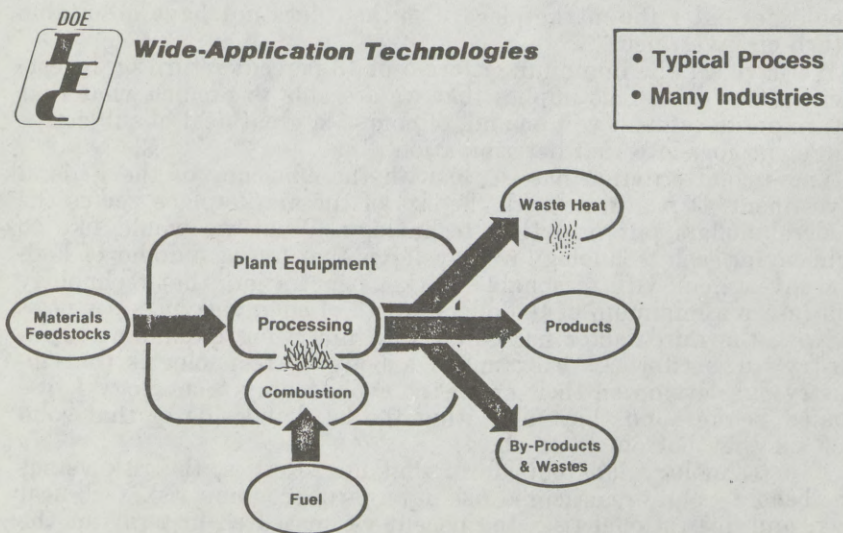


FIGURE 10

Looking at the wide application technology, figure 10 shows a basic process. Any basic process requires materials. It requires some kind of energy input whether it is fuel, thermal energy, or electrical energy, and it produces a product. Very often, in the production of that product, waste heat is generated, or byproducts or waste products are generated. This is basically a diagram which we could apply to any new technology.

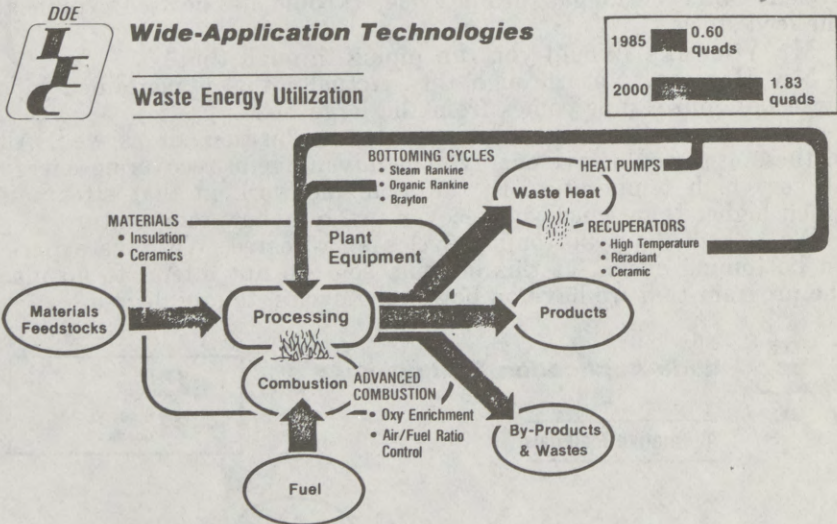


FIGURE 11

Figure 11 shows the activities that we have in waste energy utilization.

We are working on the improvement of combustion—on the bottom of the chart—where we have developed an air-fuel ratio device that significantly reduces the energy consumption in multiburner large industrial boilers. We are looking at techniques for increasing the oxygen content of the combustion air, a program of oxygen enrichment. Looking at the waste heat side—that heat which is discharged after the process has been completed—we are developing a family of recuperators that are capable of operating under very high temperature conditions, higher temperature than is currently available in the marketplace.

The highest temperature recuperator that is commercially available today operates at about 1,400°. We have now operated a ceramic recuperator that looks like this. [sample] These are the flue gas passages; these are the inlet air passages. This type of device is a cube. It is placed in the stack of a high temperature direct heating process. We have operated this type of a system at 2,600° F., and recovered hot air at better than 2,000° F. It looks like promising technology, it has some difficulties.

In a dirty flue, particles would deposit on these flue passages and would start to close them off, creating a pressure drop. Therefore, this type of recuperator has to be operated in clean flues, primarily.

We have another modular ceramic recuperator that has much larger passages that has potential to be applied to glass kilns.

Mr. VOLKMER. How do you transfer the heat that you collected?

Mr. HARVEY. Very good question.

It can be done 3 ways.

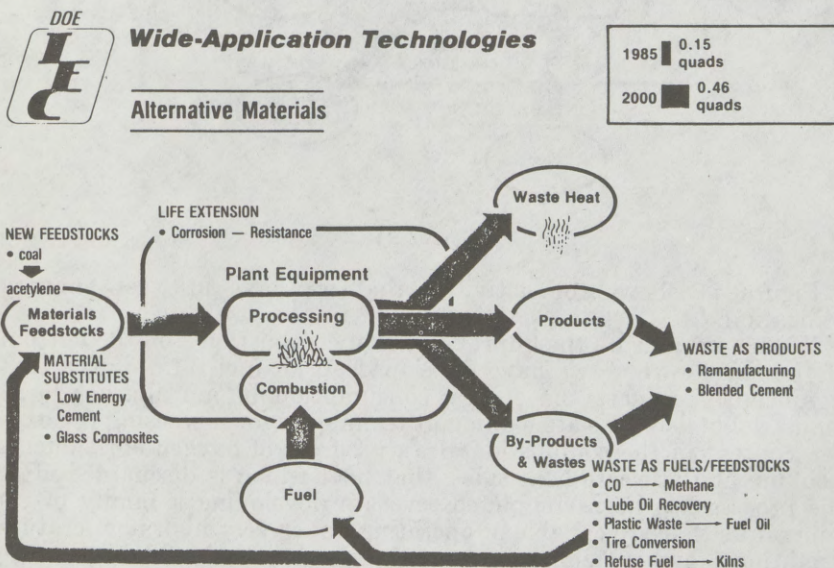
You see down further to the left of that top line, (in figure 10) bottoming cycles. The energy is recovered by this recuperator is 2000°, it could be used to heat a bottoming cycle, [organic Rankine cycle, steam cycle, or gas turbine cycle]. It could also be used to preheat the feed stock.

Mr. VOLKMER. Would you run piping through that?

Mr. HARVEY. Not through this. Actually this is contained in a large box and a pipe comes from the large box.

Now, it can be used to preheat the combustion air as well. All of these uses would save energy. The advantage of recovering energy at very high temperature is, the available work in that stream is much higher than when you recover energy at low temperature.

We talked about bottoming cycles to a degree. We have experts on bottoming cycles, at this hearing, so I do not intend to go into the program that we have on bottoming cycles, to any degree.



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FIGURE 12

Figure 12 shows interesting work in materials utilization.

Now, this program operates in that bottom right-hand box of the figure on the byproducts and waste. There are a number of waste products in industrial processing that are currently being landfilled. For example, in the polypropylene industry, we produce in this country about 4 billion pounds of polypropylene, for indoor/outdoor carpeting, plumbing pipes, and other types of applications.

About 10 percent of that production is in a form that is not useful as a polymer; and it is called atactic polypropylene. It is this white, gummy substance I show here, [sample] and is currently being landfilled.

We developed a catalytic fluidized bed process that converts this to fuel oil at about 96 cents a million British thermal units. We developed a pilot plant to do this. It has been very successful. We have burned the oil in boilers with no problems. The oil is sulfur free. It is a very good quality oil. Novamont Corp. is installing a full-scale plant to use this technology. We will put some money in to document the performance of that technology in a full-scale industrial environment.

Mr. VOLKMER. What is the cost efficiency on the conversion on that?

Mr. HARVEY. Very, very high. We are getting better than 85 percent conversion of this material into useful fuel.

Mr. VOLKMER. What is the energy efficiency? In other words, are you getting more energy with that oil than it is costing to produce?

Mr. HARVEY. Oh, very much. In fact, it is done in a fluidized bed such that the gas that comes off, representing about 10 to 15 percent loss of conversion, is used to fire the boiler, so it is energy self-dependent.

Mr. VOLKMER. Once you get it started, it almost maintains itself?

Mr. HARVEY. That is exactly right.

Now, when I quote a price of 96 cents, we assume we are getting the feed stock here for nothing.

Another very interesting byproduct or waste product program that has tremendous potential is one called cothane. It is a process by which dilute carbon monoxide streams can be converted to pure methane through a two-stage catalytic process. There are very, very many dilute carbon monoxide streams in the industrial sector. Carbon black production, basic oxygen in the steel industry, blast furnace in the steel industry, all produce copious quantities of carbon monoxide. This is either flared and emitted to the atmosphere as carbon dioxide, or when diluted, discharged directly to the atmosphere. If we can produce pipeline quality methane from these streams, we would have a very significant revolutionary technology that could be applied.

Let's go on to the next slide.

Mr. VOLKMER. While you are doing that, I would like for you to sidelight, if you can give us some idea how much carbon dioxide we would not be emitting to the air.

Mr. HARVEY. I will get that number for you. [38 million tons per year.]

Mr. VOLKMER. I am not meaning carbon monoxide; I am talking about some of the flaring—

Mr. HARVEY. Unfortunately, whenever you burn fossil fuel, you come up with CO₂.

Mr. VOLKMER. When you convert to methane, are we still going to produce carbon dioxide?

Mr. HARVEY. We are still going to produce some. Carbon monoxide is absorbed on a catalytic bed. It dissociates into carbon and carbon dioxide and then steam is passed over the catalytic bed and the steam reacts with the carbon on the bed and it makes carbon dioxide

and methane. You have to wash out the carbon dioxide through several processes, and you end up with pure methane, which still produces carbon dioxide when it is burned. I cannot stop you from producing carbon dioxide in burning fossil fuels.

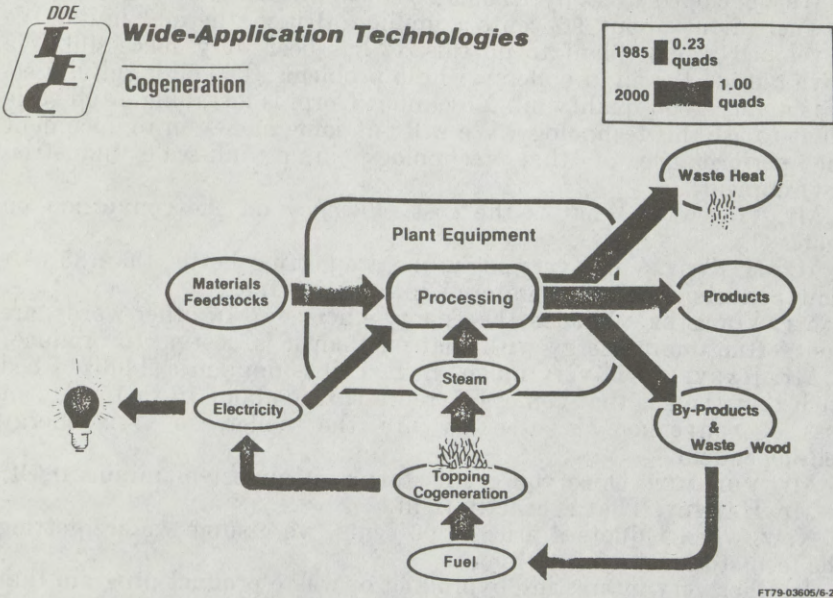


FIGURE 13

Figure 13 has to do with cogeneration, and as Chairman Ottinger said earlier, it represents a significant potential for energy savings in the industrial sector. Cogeneration is not new in the industrial sector. It has been used in the pulp and paper industry for 30 or 40 years.

The problem is basically this. If one uses the cogeneration system of back pressure steam turbine, the actual efficiency is not very much increased over conventional power generation and boiler production of steam. Indeed, if one is to get significant advantage from cogeneration, it is necessary to develop systems that have higher thermal to electrical efficiencies.

Now, the obvious ones are the gas turbine and diesel engines. Gas turbines and diesels today burn our most precious fuels, natural gas and distillate. They don't look very attractive in their current form. Our program is directed toward converting gas turbines and diesels to alternate fuels. In the gas turbine area, we are looking at indirect fired fluidized bed combustion systems that heat a heat exchanger that in turn heats the air that is expanded through the turbine. We have one that is being developed, that is fired with waste wood. In the diesel area, we have made I think a major breakthrough in the last week that you will be the first to hear about. The two-cycle diesel that is being used extensively for marine propulsion has no valves and, is a very tolerant engine for dirty fuels. It can burn residual and burn crude oil today. We have been investigating the possibility of burning coal with

this engine. We have successfully burned solvent refined coal and also burned coal oil slurry. Last week we successfully burned for 1 hour a 70 percent water, 30 percent coal slurry.

Now, that is a pretty big accomplishment. That says a diesel engine could potentially work on coal.

Incidentally, we call this Stiesel. It is in a sense a steam engine and diesel engine. It is a large engine. Keep your fingers crossed on that. That would be a major breakthrough I feel.

Mr. VOLKMER. That engine would only be used for industrial purposes?

Mr. HARVEY. Only industrial. These are very, very large diesels. This is not an automotive propulsion system. The two-cycle engine is called a cathedral engine, because it literally looks like a cathedral. It is 90 feet high by 90 feet long, 2 cycle with a piston diameter of 3 feet. These are big engines.

Mr. VOLKMER. And you don't know the result of what happened in the combustion chamber?

Mr. HARVEY. Not yet. We have burned coal oil slurry, burned that for about 200 hours, I think, and found very little wear inside of that engine. It has the advantage of having the piston separately lubricated from the crank shaft.

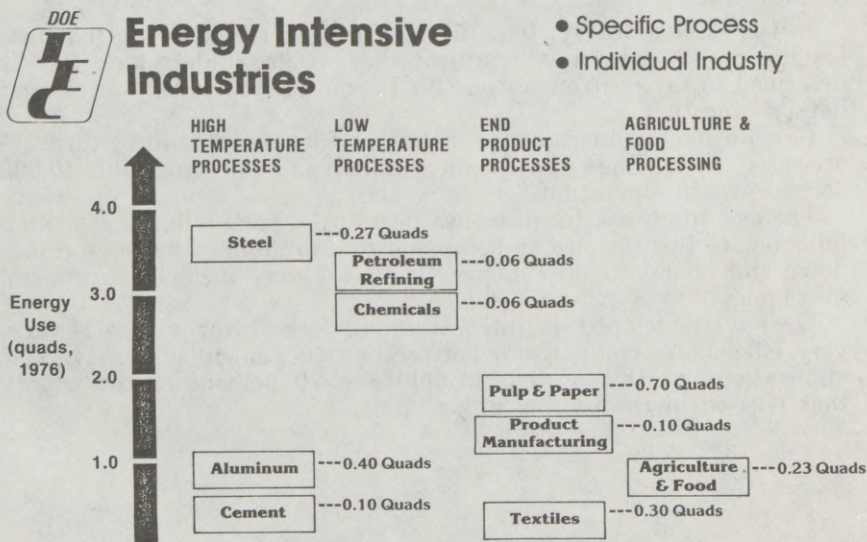


FIGURE 14

Now, let me talk for a moment about energy intensive processes. The vertical thrust of our program, figure 14 shows the most energy intensive industrial processes in the country. Steel, aluminum, cement, the high temperature processes, glass should be in that list along with petroleum refining, chemical, pulp and paper product manufacturing and agriculture and food process and textiles.

I don't intend to go through these in any detail, but rather would like to highlight a few of the programs we have.

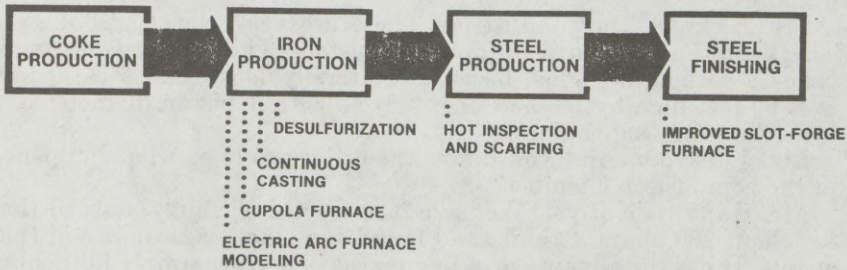
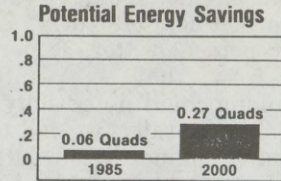
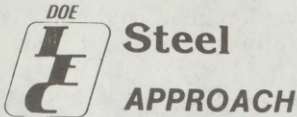


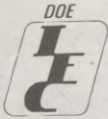
FIGURE 15

In the steel industry, [fig. 15] each one of the little dotted lines leading up to a sector is a project that we are undertaking that is described in my written testimony. If you want details, you can get details from that.

I would like to mention the slot forge furnace. Slot forge furnaces are used throughout the forging industry. Something like 10,000 forges are in operation.

The slot forge is a furnace that heats up a steel billet that a man pulls out of this furnace and slaps on to a forge and the forge comes down and pounds it into shapes. These are very inefficient furnaces, averaging 6 to 8 percent efficiency.

We have developed an integrated slot forge furnace that is very, very efficient in comparison, better than 50 percent efficiency. New applications of this system would save 70 percent of the energy that is used in the forging industry.



Aluminum APPROACH

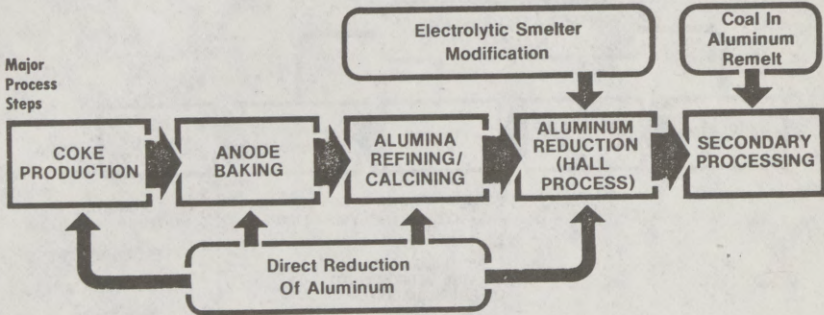
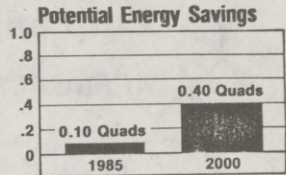


FIGURE 16

Figure 16 shows work in the aluminum industry.

Mr. VOLKMER. Before you start, let me ask you a question; maybe the details are in here, as to, again, capital cost as against recovery cost of 70 percent efficiency, as far as the manufacturer is concerned and the industry is going to look to that?

Mr. HARVEY. Yes, sir.

Mr. VOLKMER. The capital cost is going to be greater with interest and everything?

Mr. HARVEY. This would have a pay-back that is attractive. It does cost quite a bit more money than the slot forgers are used to paying. They typically build their own furnace, and this furnace would cost on the order of \$100,000.

Another thing we have done is build a retrofit package that would allow them to retrofit his own furnace using innovations developed in this integrated furnace. He could spend \$20,000 and have very good return on his investment. He would be able to save on the investment.

Mr. VOLKMER. It is attractive for him as far as just monetarily?

Mr. HARVEY. In terms of how much capital he has got to put out. It is much more attractive.

In the aluminum industry, we are working on several interesting projects. I won't go into detail on that today. We will have a witness this afternoon, on a program I consider to be a very revolutionary process for the production of aluminum, direct reduction of aluminum, a system that uses technology very similar to a blast furnace. Dr. Jarrett will describe that process to you.



Pulp and Paper APPROACH

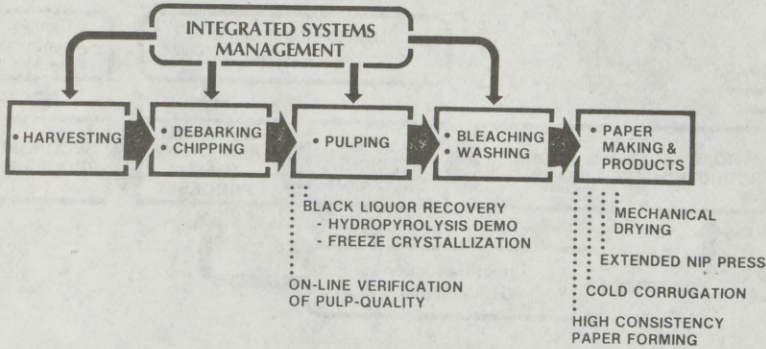
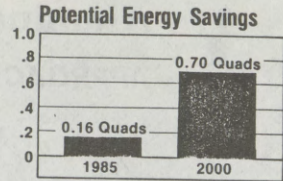


FIGURE 17

In the pulp and paper industry [fig. 17] again, we have an expert witness who will testify today on a very revolutionary process for the treatment of black liquor derived from the Kraft process. This has tremendous potential in the paper industry. It could make a paper mill a net exporter of energy as against a consumer of energy, again assuming success.

There is one interesting thing about this project I would like to mention that has to do with the way St. Regis developed and then formed a consortium of paper companies to come to the Government for cost shared funding.

St. Regis could not do this program on their own. They formed a corporation called Hydrolysis Corp. in which they got four other major corporations, paper corporations to invest money. This Hydrolysis Corp. would be the contracting entity with which we deal in developing this new process. They put in about 50 percent of the total value of the full-scale demonstration of this technology. This is an interesting concept.



Textiles APPROACH

Potential Energy Savings

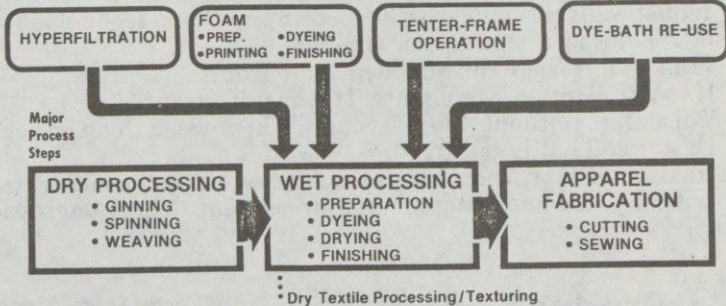
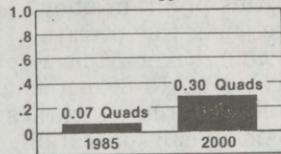


FIGURE 18

In the textile industry, [fig. 18] I am going to have to talk a little bit. We have a super technology that is revolutionary and applicable to existing process streams. This is a retrofit technology that is truly revolutionary. It has to do with the foam treating of textiles. In the conventional textile process line, dyeing is performed with about 20 parts water to 1 part dye. The material is then dried through strict thermal drying. Then it is often printed with water and dried again and then it is finished, 20 parts water and 1 part polymer and dried again. Finishing is the operation that gives the textile fabric wash and wear characteristics or rain resistance, and so forth.

These are very energy intensive processes. Thermal processes in textiles use about 60 percent of the total energy consumed. With United Merchants we developed a process that replaces the water with foam, actually like shaving cream foam, and reduces the amount of water that has to be dried and discharged from the process, very, very drastically, to less than eight parts water, and we found some ancillary benefits.

In the finishing operation, we have demonstrated in heavy fabrics, as much as 80 percent of the natural gas used in finishing can be eliminated and, at the same time with the same machines increase the production by a factor of four. It is pretty significant.

Mr. VOLKMER. You mean because of less drying?

Mr. HARVEY. Less amount of drying.

Mr. VOLKMER. And you can move it faster.

Mr. HARVEY. You can move it faster. Precisely right.

In the printing operation, there are energy savings also. We found another interesting ancillary benefit, as shown in this terry cloth [sample]. You can see the print is very well finely defined on this cloth. Something that you can't get with wet printing. This is another

[sample] example of the foam printing of textiles. We have only been in this program about 18 months and, there are 12 corporations that are using this process.

Dan River Mills is putting it into their corduroy lines. They are saving up to 80 percent of the finishing fuel. We processed over 250 million yards of textiles using this process. If we can succeed in the foam dyeing operation, we will hopefully capture the carpet market as well and we could reduce the energy consumed by the entire textile industry by as much as 30 percent if these technologies are successful. That is a significant amount.

Mr. VOLKMER. Where did the idea come from?

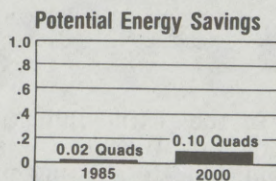
Mr. HARVEY. United Merchants. It was not invented by us.

Mr. VOLKMER. Without you, it wouldn't have been done either?

Mr. HARVEY. That is right.

As a matter of fact, their vice president wrote me a letter stating this specifically. I have entered this already into the Congressional Record.

DOE
**Product
Manufacturing
APPROACH**



Major
Sector
Categories

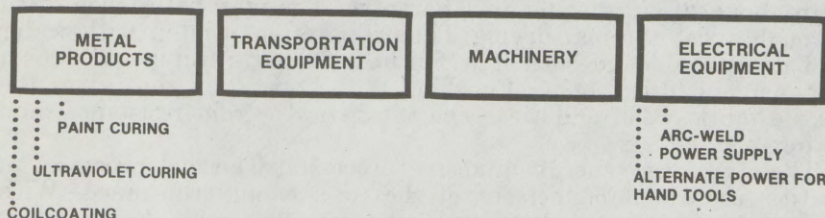


FIGURE 19

It is very interesting, exciting technology.

In product manufacturing, we have [fig. 19] other interesting technologies that I won't describe today. There is one, in paint curing, I suspect you may have heard about this. In the coil coating industry, the steel and aluminum sheet, called coils, are wrapped up into 20 ton coils. They are unrolled, painted, and put into a 250-foot long five zone oven where the solvents are drive off from the paint and the paint is cured on the surface, the sheet is then rolled back up again and sold to people like aluminum blind manufacturers and appliance manufacturers, and so forth.

The elevators, for example, in the DOE building are coil coated steel. They can make a simulated wood grain surface on this kind of thing.

Well, the drying process is extremely energy intensive because they discharge the solvents into the atmosphere. In order to comply with environmental regulations, they had to put a gas incinerator into the stack to burn up these solvents.

We developed a process using the solvents primarily as the fuel for the furnace. It is a zone incinerator that takes the solvents back to the burner and we have demonstrated a reduction of 80 percent of the natural gas consumed.

This has now been ordered by 12 firms.

Mr. VOLKMER. You said 80 percent.

Mr. HARVEY. Eighty percent of the energy consumed in coil coating and 12 firms have these systems on order or are using them.

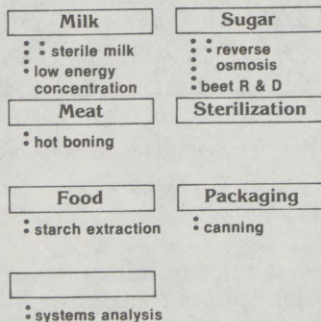
I am taking too long. I apologize for that.

Mr. VOLKMER. It is very interesting.

Mr. HARVEY. We have actually saved thus far about $3\frac{1}{2}$ trillion Btu's. It is not going to save the world, but we are getting there.



Food Processing



Agriculture

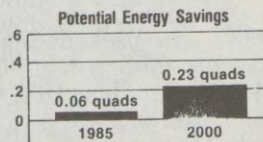
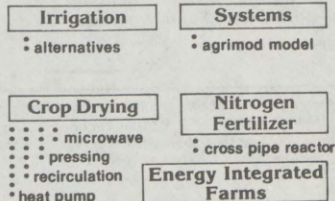


FIGURE 20

The energy integrated farm. In the food processing industry [fig. 20], there is one program that I want to mention that we are just starting.

We are examining the possibilities that could be used. Using manure, storing agricultural wastes, using solar energy, wind energy, and anerobic digestion, coupled with prime movers on the farm making electricity using the waste heat to heat the digester, and so forth. We are trying to make the farm totally energy independent. Thermodynamically it can be done. There is no question in my mind about that. Whether or not it can be made economically practical remains to be proven.

We have gone out with a PON—Program Opportunity Notice—on this. A PON is a procurement asking for ideas from the agricultural and engineering communities for ideas leading to actually developing and demonstrating an energy integrated farm. It is a very interesting process if indeed it can be done.

One of the things I am always asked is how effective are those programs from cost standards.

Cost-Effectiveness of the Federal Cost-Sharing RD&D Program**

Subprogram	Annual Savings (quad/year)		Average Private Cost (\$/10 ⁶ Btu)	Federal Benefit Cost Ratio*
	1985	2000		
Waste Energy Utilization	1.18	2.86	0.603	1772
Alternative Materials Utilization	0.03	0.98	0.468	1019
High Temperature Processes	0.51	2.65	0.234	477
End Product and Low Temperature Processes	0.63	2.16	0.357	1023
Agricultural and Food Processes	0.34	0.99	1.312	247
Cogeneration	0.46	1.80	1.20	1800

* Present Worth of Cumulative National Energy Savings Expected Through 2000 Divided by Present Worth of the Required Federal Investment.

** Includes Qualified, Innovative Technologies Identified to Date by the Office of Industrial Programs Whether Presently Being Funded or Not

FIGURE 21

In figure 21 we show the annual savings in both the year 1985 and 2000, and broken down into major subprogram areas, the average cost per million Btu of these technologies ranges between 23 cents to \$1.20 per million Btu. Compare that with today's fuel prices. Natural gas is running close to \$2. Distillate oil is \$3. These are cost effective technologies if they are successful.

Now, if you actually added up the energy savings you would end up with more than the 1½ quads I predicted earlier in 1985 and the 5½ quads in the year 2000. Remember, I said initially these are high risk technologies. We anticipate some failure. We have to anticipate failure if we are investing in high risk technologies.

So we have discounted these numbers by about 40 percent in order to come up with our projected value of savings.

There is another interesting column on this table, the last column. This represents the dollar value of energy saved per dollar of Federal investment.

In other words, in the waste energy utilization program, we are anticipating 1,700 dollars' worth of energy saved per year for each dollar of Federal investment. Pretty good return on the Federal investment.

COMPARISON OF FUEL COSTS WITH COSTS OF CONSERVATION USING NEW TECHNOLOGY

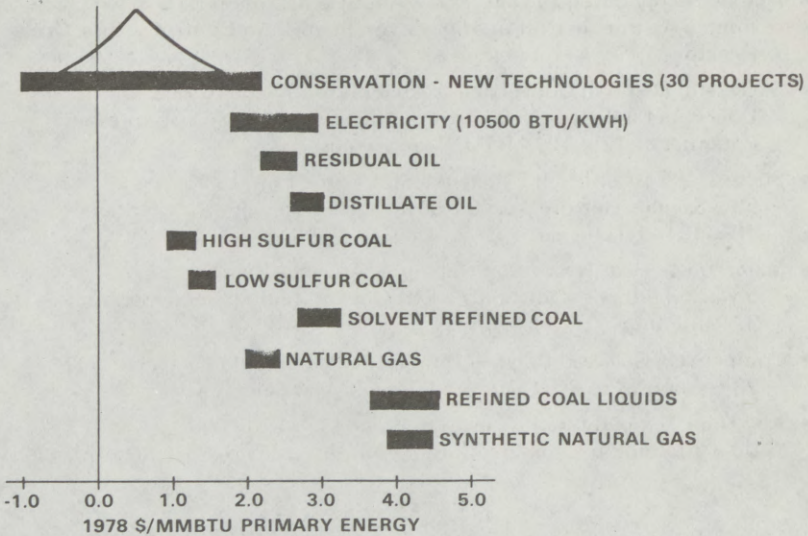


FIGURE 22

Figure 22 shows some of the same kind of information, relative to other fuels.

The top bar on this represents the span of 30 projects that we have under way. We have an average cost per million Btu of maybe 60 to 70 cents. Comparing that to other fuels today, you can see that they are all considerably more expensive.

So these are going to be cost effective technologies if, indeed, they are successful.

The last figure I will show has to do with the key accomplishments [fig. 23].

Key Accomplishments to Date

- Actual Energy Saved to Date: About 2.5 Trillion BTU's
 - Fumes-As-Fuel in Coil Coating Air/Fuel Ratio Control Pipe Cross Reactor
- Successful Demo in Converting Waste Polypropylene to Fuel Oil
 - Low Federal Cost — Near Term — High Private Interest Expressed
 - Potential of 12×10^{12} BTU/Year Savings
- Successful Test on High Efficiency Slot Forge Furnace
 - 50% Savings/Retrofits 70% Savings/Replacement Potential of 70×10^{12} BTU/Year
- Major Waste Heat Recovery Program in Advance Phases
 - 5 Recuperators One at 85% Eff. One at 2650 °F and Operating 3 Heat Pumps
- Competitively Selected Cogeneration Demo Program Established
 - 23 Responses to PON Formal Review and Selection
- Key High Temperature Processes in Progress
 - Coal/Aluminum Remelt Cathode Improv Direct Reduction

FIGURE 23

I don't know if I need to go into it in great detail since I have discussed essentially all of these programs, or they will be discussed later this afternoon with some of the other witnesses.

I thank you for your attention and time.

I think that in conclusion, it is essential that the Federal Government form a partnership with industry in the development of this revolutionary technology.

Mr. VOLKMER. Thank you very much.

I will hear from Mr. Sant, director, Energy Productivity Center, Mellon Institute.

[The biography and prepared statement of Mr. Roger Sant follows:]

BIOGRAPHICAL SKETCH

ROGER W. SANT

Roger W. Sant is the Director of the Energy Productivity Policy Center, Carnegie-Mellon Institute of Research. The Center was formed in August, 1977, for the purpose of evaluating different energy conservation policy alternatives. He also serves as a consultant to various organizations on energy matters.

From just after the Arab oil embargo until May, 1976, he was the Assistant Administrator for Energy Conservation and Environment in the Federal Energy Administration. He was the FEA's top official for energy conservation and was a key participant in developing the Ford Administration's energy policies.

Prior to entering Government service, Mr. Sant, a California native, was Vice President with Saga Corporation, and a lecturer at the Stanford University Graduate School of Business.

Mr. Sant received a B.S. from Brigham Young University, and an M.B.A., with distinction, from Harvard Graduate School of Business Administration.

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Remarks of Roger W. Sant
Director

Industrial Energy Conservation Potential
Problems & Policy
Committee on Science and Technology
Subcommittee on Energy Development & Applications
Richard L. Ottinger
Chairman

I am pleased to have the opportunity to testify on the subject of Industrial Energy Conservation. It is most gratifying to note the increased interest in the subject of Energy Conservation in general. The recent shift towards perceiving energy conservation as a process of substituting technology for energy use is a major advance. Although there are still many people, apparently including the President, who treat conservation as a cut back in benefits through reducing the level of energy services that are provided, many more people are now recognizing the tremendous opportunities conservation provides to the American economy from high technology input, management expertise and new product marketing.

It now appears that, despite our sense of confusion, a fundamental change in the relationship between energy and economic growth has taken place since the embargo - largely due to higher costs of energy. Fortunately, the nature of change has less to do with sacrifice of standards of living than with increased efficiency in energy use.

In 1973, for each dollar of GNP we consumed 63,000 BTU's of energy. In 1978 - just five years later - for each dollar of GNP, we consumed 56,000 BTU's, a decline of more than 10 percent. In other words, we are sustaining an equivalent level of economic productivity with 10 percent less energy. It is too early to predict to what extent this recent trend will continue because the 1978 ratio of BTU consumption to dollars of GNP was at the lowest level of our historic

experience.

More significantly, improved efficiency in the industrial sector has dramatically exceeded our early expectations. During the five year period 1973 - 78, industrial output in goods and services increased 12 percent, while industrial use of energy dropped by more than 10 percent - roughly a 22 percent overall improvement in industrial energy productivity. This trend has accelerated in 1979. As a consequence, industry's share of total U.S. energy consumption has declined from 40 to 36 percent, and its 1978 energy bill was \$15 billion less than it would have been at 1973 levels of energy efficiency.

In a study recently completed at the Energy Productivity Center that will be published September 20th*, we found that although these results are very impressive, particularly compared to much less impressive achievements in the buildings and transportation sectors, there appears to be substantial further opportunity, even at the prices of energy in effect in 1978. To illustrate the gap between what was and what might have been, we compared two cases in terms of demand for industrial energy services, energy consumption, and energy efficiency: the actual 1978 situation and hypothetical 1978 situation that would have resulted from providing those same energy services at the least cost to industrial consumers.

* Sant, Roger W., "The Least-Cost Energy Strategy" (Arlington, Virginia: Carnegie-Mellon University Press, 1979)

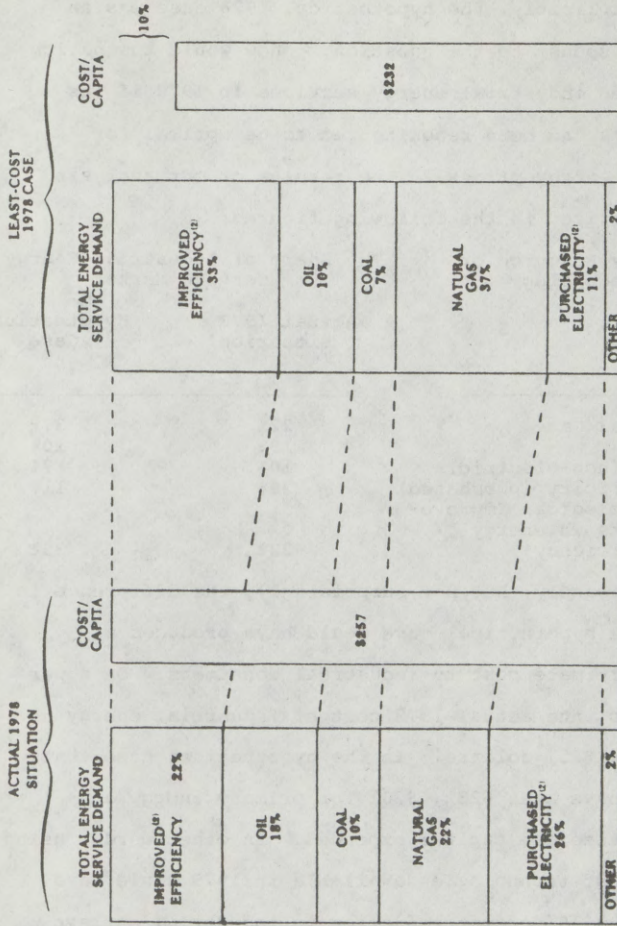
More explicitly, the hypothetical 1978 case was an estimated response to the question: "how would the nation have provided industrial energy services in 1978 if its capital stock had been reconfigured to be optimal for actual 1978 energy prices." The results of our analysis can be summarized in the following figures:

Energy Resource or Technology	Share of Industrial Energy Service Market	
	Actual 1978 Situation	Hypothetical Case
Natural Gas	22%	37%
Oil	18%	10%
Coal (non-electric)	10%	7%
Electricity (purchased)	26%	11%
Technological Improve- ments in energy efficiency*	22%	33%

Significantly, but not surprisingly, the difference in "mix" in the hypothetical case would have produced a different ultimate cost to industrial consumers. On a per capita basis, the actual 1978 cost of industrial energy services was \$257 dollars. In the hypothetical case that cost would have been \$232, \$201 for primary energy and \$31 to amortize the capital expended. In other words, using the least-cost technologies available in 1978 would have resulted in a 10 percent reduction in industrial outlays for 1978 energy services. These figures are summarized in a figure from the forthcoming publication of this data entitled Figure 2.

*Compared with 1973

FIGURE 2
INDUSTRY ENERGY SERVICE MARKET SHARES⁽¹⁾
OF VARIOUS TECHNOLOGIES



(1) The primary fuel equivalent of service demand was 28.2 quads, plus 7.9 quads of improved efficiency and 0.8 quads of biomass (calculated against a 1973 base), or a total of 36.9 quads.

(2) In terms of primary fuel.

As the preceding table suggests, the pattern of energy consumption in the hypothetical least-cost case would have been considerably different from the pattern of consumption that we actually experienced in 1978. The overall shares of the industrial energy service market captured by oil, coal, and purchased electricity would have been considerably smaller than they were, in fact 45 percent smaller for oil, 30 percent smaller for coal, and 58 percent smaller for purchased electricity. A happy side effect of this least-cost approach in the hypothetical case would have been a reduction in imported oil.

A significant portion of this reduced consumption would have resulted from improved efficiency. However, natural gas, which would have increased its market share in the hypothetical case would have been reallocated within various economic sectors. For example, gas consumption in the industrial sector would have risen from 22 percent to 37 percent, permitting a substantial reduction in consumption of oil from 18 percent to 10 percent. Much of this increased natural gas would have been made available from ever larger increases in efficiency in the building sector. A dramatic reduction of industrial purchased electricity from 26 percent to 11 percent would have resulted largely from the substitution of less costly and more efficient electricity cogenerated on site.

Although the potential reallocation of shares of the energy service market among different fuels is interesting, the most important point to emerge from this analysis is the extent to which, in response to a least-cost objective and strategy, technologies that improve energy efficiency might have captured shares of that market from fuels.

The results of a least-cost strategy would not have resulted in an identical mix in all sectors of the economy. In fact the mix in the industrial, buildings, and transportation sectors would have varied considerably as shown in figures 1,3 and 4. For example the gain in share of the market captured by improved efficiency in the hypothetical case would have been considerably less in the industrial sector than in the buildings and transportation sectors, due largely to the fact that industry was able to react more quickly to energy price increases after 1973 and had therefore, taken greater advantage of opportunities for improved efficiency by 1978.

Although dozens of technologies would account for the additional 11 percent market share for increased industrial energy efficiency in our hypothetical case, those which would have had the greatest impact in the industrial sector are indicated

FIGURE 1
ENERGY SERVICE MARKET SHARES ⁽¹⁾ OF
VARIOUS TECHNOLOGIES

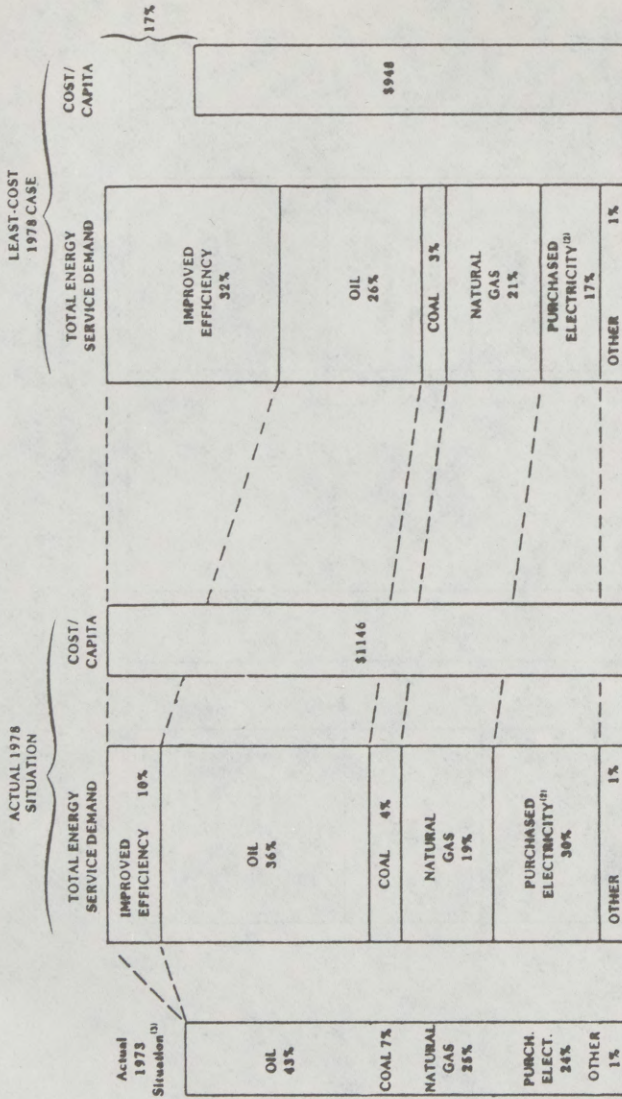
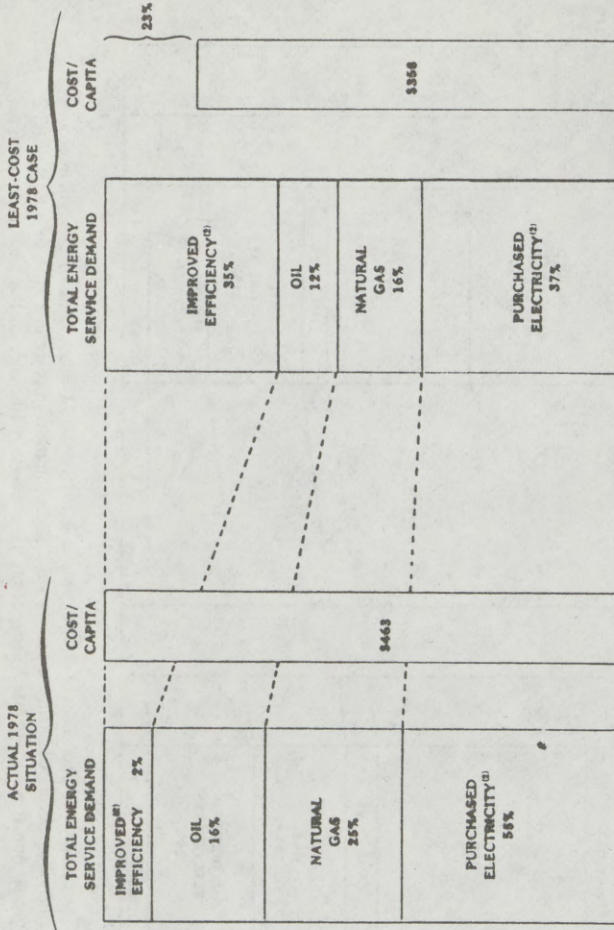
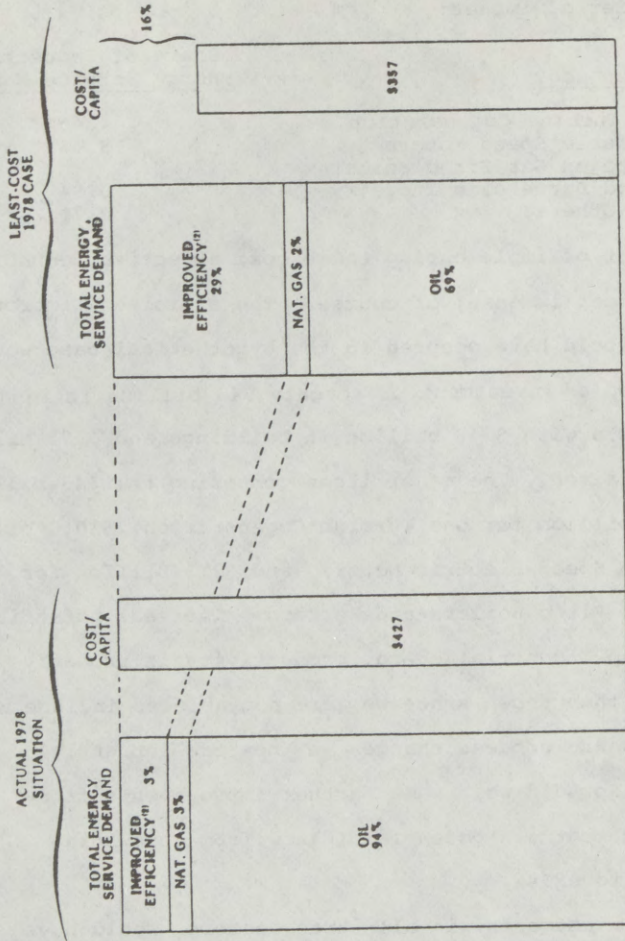


FIGURE 3
BUILDINGS ENERGY SERVICE MARKET SHARES ⁽¹⁾ OF VARIOUS
TECHNOLOGIES



- (1) The primary fuel equivalent of service demand was 29.3 quads, plus 0.7 quads of improved efficiency (calculated against a 1973 base), or a total of 30.0 quads.
- (2) In terms of primary fuel.

FIGURE 4
TRANSPORTATION ENERGY SERVICE MARKET SHARES⁽¹⁾
OF VARIOUS TECHNOLOGIES



(1) The primary fuel equivalent of service demand was 20.6 quads, plus 0.6 quads of improved efficiency, or a total of 21.2 quads.

(2) In terms of primary fuel.

below in order of impact:

<u>Technology</u>	<u>Share of Industrial Energy Service Market</u>
Gas Turbine Cogeneration	4.4%
Variable Speed Motors	3.1%
Improved Gas Fired Boilers and Burners in Industry	0.8%
All Others	2.7%

The cost of implementing these cost effective technologies would have been immense, of course. The efficiency improvements that would have occurred in the hypothetical case would have required an investment of roughly \$43 billion in industry. This contrasts with \$148 billion in buildings and \$173 billion in transportation. The major items composing the \$43 billion were \$13.6 billion for Gas Turbine Cogeneration, \$10.0 billion for Variable Speed Electric Motors, and \$2.3 billion for Improved Gas Fired Boilers and Burners. The real potential for increased industrial energy productivity is probably much higher than shown since we were not able to include many technologies and process changes we know are currently available. Nor did we assume further improvements from energy management - a potential I know from consulting experiences to exist.

These investments, in all three sectors, would have reduced fuel consumption by 18.5 quadrillion BTU's in 1978. Thus the average cost of this displaced fuel would have been \$2.14 per million BTU's or \$12.41 per barrel of oil equivalent. Such investments in least-cost technologies would have replaced even greater investments in energy production and imports than were actually required in past

years. The reduced fuel use that would have resulted from these improvements would have involved, almost entirely, imported oil and utility generated electricity. At a capital cost of \$1200 per kilowatt for electricity and actual prices paid for imported oil, these improvements would have precluded the need for investment of \$240 billion in power plants and \$161 billion in imported oil, a total of \$401 billion. So although investment to achieve a least-cost objective would have cost a lot less than the power plant investment and imported oil bills that were in fact paid in preceding years.

The purpose of this analysis was not to suggest what exactly could have occurred in 1978 under a least-cost strategy. Because rising energy prices have only been a reality for about five years, it would have been unreasonable to have expected that we could have achieved the optimum least-cost mix of the hypothetical case in so short a time. In addition, our analysis was based on actual 1978 fuel prices which might have been considerably different had competitive conditions prevailed during the preceding decade. The dynamics of a fully competitive market are wonderfully difficult to predict. For instance if the demand for oil had been as low as in the hypothetical case, the World or OPEC oil price would not have been as high as it actually was. Similarly the price of electricity would have been lower if the demand had been reduced to the level of the hypothetical case.

Furthermore the analysis should be considered as preliminary and tentative. A number of factors could lead one to question the results. For example the conclusions assume the existence of a perfect economic market and such a market will never exist. Non-economic behavioral and institutional factors would have diluted our hypothetical results. One of the purposes of our continuing research is to learn more about such factors and how they can be influenced. In addition, the costs of the efficiency technologies might well have been higher than those assumed in the study because those costs might have risen if demand had expanded to the extent assumed in the analysis. On the other hand, we have only begun our research effort to identify technologies which can reduce the costs of energy services, and there are many opportunities which are not yet included in our data base.

The chief purpose of this analysis is to demonstrate how far we have veered away from the lowest cost technologies - and to demonstrate that other, more productive directions are among our current options. It indicates that industrial consumers paid roughly 10 percent more for energy services in 1978 than, theoretically, they needed to pay. Overall consumers paid roughly 17 percent more of energy services than they needed to pay. Achieving results comparable to those suggested in our hypothetical case would obviously take some years, but our analysis does indicate the direction

in which we could begin to move to realize some of the benefits of a least-cost strategy.

Interestingly, the results of our analysis also indicates how some of our policy initiatives are now working against the achievement of the lowest cost to the consumer:

- Heavy government research and development emphasis has been focused on increasing utility supplied electricity, despite the fact in straight cost competition, electricity would lose market share.
- Regulations have forced industrial conversion to coal, as a means of reducing imports, despite the fact that at 1978 fuel prices our analysis shows that it was not in the industrial users economic interest to do so. This also took capital away from energy efficiency investments.
- Artificially low prices for natural gas have created excess demand; this is resulted in over use in the buildings sector because of an insured supply to high priority customers and under-use in industrial sector because the supply was not available. The Natural Gas Policy Act has increased that distortion by passing on the price of higher

cost gas to industry only thereby encouraging continuing over use in buildings.

- The present popularity of a massive government program to produce synthetic fuels well beyond the testing of commercial feasibility is a further example of our propensity to enact measures that work against achieving the least cost for the consumer.

Overall, I believe this analysis indicates that the most useful federal policy would be one that encourages the maximum number of competing elements. It also suggests that narrow goals such as reducing imports are clearly counter-productive to achieving the broader goal of minimizing the cost of energy services to consumers. I believe we have become so accustomed to expecting the government to do something about the energy problem that as private citizens we have failed to react to it as a major opportunity for individual action. This has given government an undue role in energy that has led to further aggravation of the problem.

These conclusions in turn suggest some specific areas that should be analyzed in determining further industrial policy initiatives. Among the questions that should be raised are the following:

- (1) Should we allow traditional sellers of energy to

become sellers of energy services? The most natural providers of energy services are the public utilities. If a gas utility, for instance, were allowed to be a seller of all energy services, not just a seller of natural gas, it could compete with the electric utilities in providing the total energy service requirements for an industrial plant. In addition to gas, the utility could provide cost effective building modifications, efficiency improvements to furnaces and boilers, and particularly technologies such as gas turbine cogeneration. Many of these improvements could be provided through subcontractors. The costs of such improvements could be billed to industrial customers over their lifetime just as gas is now billed. For example, gas turbines could be provided to customers for on-site generation of electricity and process or space heat, and again billed or charged over the lifetime of the services provided. Competition could be provided by other utilities and manufacturers to insure the lowest cost opportunities.

By focusing on consumer cost of service, the business of providing energy could be transformed from an over regulated, somewhat monopolistic activity of selling electricity, oil or natural gas into an exciting competitive enterprise of selling energy services. It could also offer utilities a chance to maintain or increase their market share in the face of a possible decline in their traditional energy products.

(2) Should we move to deregulate all activities of the oil, gas, and electric industries except the transmission and idstribution of electricity in the oil and gas pipelines?

As the data we have examined indicates there is no reason to consider the oil, gas and electric industries as inherently monopolistic. Competition exists in abundance amongst these fuels and from efficient technologies and their continued regulation only subsidizes and protects them from each other and from new competitors. Regulation of oil and gas prices is only supportable if there is no competition, so those who are still opposing relaxation of controls must be shown that competition for oil and gas in delivering energy services to the american public does in fact exist.

Similarly, as the data on market shares demonstrates, there is abundant competition - in the form of industrial cogeneration - for electricity generated by large central utilities. These competing technologies can be offered by private companies, gas utilities or perhaps financial institutions. That being the case, there may be no reason to regulate the existing power plants as monopolies. They could compete in the energy services market along with these other technologies in supplying the lowest cost services to the consumer.

(3) Should government sponsored research and development be directed towards different technologies?

Government subsidized research and development of promising low cost energy and energy service technologies may have definite contributions to make but they should be focused mainly on lowering consumer service costs, not just reducing imports, and include an expanded share of the budget to develop energy efficiency as indicated by our results.

* * * * *

As suggested earlier, the overall potential for increasing energy productivity and reducing current consumer costs is substantial. The 22 percent improvement in U.S. industrial energy productivity since 1974 is just the beginning; long-term results will be much greater. The evidence we have provided demonstrates that there is ample competition to hold costs to manageable levels for the required level of energy services. The exciting news is that energy productivity provides an expanding opportunity, not a last resort.

A wave of optimism - and commitment - is beginning to emerge from many quarters: these changes are possible, desirable and necessary. Perspectives have and will continue to change rapidly. When coupled with ingenuity, new technology and improved management, these changes can be powerful enough to master the energy problem. In fact, seen in this perspective, the problem is transformed into an opportunity - increased employment, new markets, an enhanced environment, a more secure energy future and most important, less onerous levels of energy service costs. We are definitely not stuck with our old attitudes about energy and energy conservation. I believe our analysis to date shows we can move to higher levels of productivity through a more competitive, consumer-oriented energy policy.

STATEMENT OF ROGER W. SANT, DIRECTOR, ENERGY PRODUCTIVITY CENTER, MELLON INSTITUTE

Mr. SANT. Thank you, Mr. Volkmer.

I am going to concentrate on the policy side of this issue and tell you some of the results we have gotten in a recent analysis, and then conclude with some policy recommendations that I think are fairly important.

I would first like to emphasize that I think Mr. Harvey makes a great point. Industry has already made tremendous strides in increasing energy productivity, not only since 1973, but for a long time before that.

In fact our figures are much higher than Mr. Harvey's in the sense that we find since 1973 there has been a 22 percent improvement in energy productivity in industry, which translates into roughly a \$15 billion saving in costs in 1978.

Those numbers are increasing this year from what we can tell; in fact at an accelerated pace from what they were for the last 5 years.

What I would like to do is excise large parts of my prepared testimony and just hit some highlights—some things that are interesting—so I won't follow the text exactly.

The interesting thing about industry is how well it has done to improve energy productivity relative to other sectors in the economy.

Overall, we get roughly a 10-percent improvement in energy efficiency since 1973 for all sectors of the economy. Industry with 22-percent, compares rather favorably with building, at around 2-percent. Therefore, some major strides have been made in industry relative not only to buildings but certainly to transportation as well.

In a study we recently completed at the Energy Productivity Center that will be published on September 20 we found that although these industry results are very impressive, particularly compared to those less impressive achievements in the other sectors, there appears to be a substantial further opportunity even at the prices of energy we experienced in 1978.

To illustrate the gap between what was and what could have been, we compared two cases in terms of the demand for industrial energy services—services being steam, process heat, electrolytic functions, machine drive, et cetera. We compared the actual 1978 situation with a hypothetical 1978 situation that would have resulted from providing the same energy services with the lowest cost technologies available.

In other words, we said, "What if we forgot that we are trying to save fuel, or that we are trying to reduce imports?" All we will try to do is reduce the cost of the energy services that industry now requires.

We got some rather encouraging results.

First of all, we found that if we were using those energy technologies that are least costly to consumers, natural gas in industry would have increased from 22 percent to 37 percent of the energy service market. Therefore, there is a large unmet demand for natural gas in industry.

Oil, on the other hand, would have dropped from 18 percent to 10 percent, obviously reducing imports, even though that was not our objective. Contrary to our national policy, coal would have dropped from 10 percent to 7 percent of the market. Purchased electricity from utilities would have dropped drastically from 26 percent to 11

percent. And efficiency would have increased its share of the market from 22 percent to 33 percent. Overall, those are rather marked differences in the mix of technologies that would have been used for industrial energy services versus those that were actually used.

Not surprisingly, the difference in this mix would have also produced a difference of roughly 10 percent in the overall cost of industrial energy services, some \$5 to \$6 billion less than the \$56 billion that was actually paid in 1978.

In other words, using strictly the objective of least-cost to minimize the cost of energy services—we found some rather exciting results that tell us, we think, that we have a major opportunity within the total energy policy picture to reconcile previously conflicting objectives.

If we compare the industrial results with those of buildings, again, we find that the potential for increasing the energy efficiency in buildings is much greater than industry, not because the theoretical potential is much greater but because the progress has been so slow in buildings to date. With only a 2-percent improvement in efficiency since 1973, we really have a much greater opportunity to improve the efficiency of existing buildings than we do with industry.

We found that the technologies that competed most effectively in the industrial sector had to deal with cogeneration, variable speed motors, improved gas fired boilers and furnaces, and then a large miscellaneous category.

We found that gas turbine cogeneration competed better than other cogeneration technologies. In spite of our professed interest in saving gas, again indicating that our fuel use priorities are leading us in the wrong direction.

The large increase in natural gas consumption indicated for industry didn't come as a surprise. The surprise was that this industrial gas would be made available if we were able to achieve the efficiency in the building sector that seems to be available. For the first time in my experience, we combined the building sector and industry sector in one analysis to examine the interaction between the two. We found that there is so much interaction that attempts to regulate or prioritize fuel use in the individual sectors may be very counterproductive.

It looks like the investments in efficiency in all three sectors are so cost effective even at 1978 prices, we have an immense opportunity to improve efficiency without even talking about marginal cost pricing or higher energy prices in general.

In fact, the energy reductions we found were so large that one hardly knows what energy prices would be if world oil demand and electricity consumption was reduced by the amounts we found from applying a least cost objective.

The only fuel that maintained its share of the energy service market in the least-cost case was natural gas, and it actually increased a little bit. But coal and oil declined and purchased electricity particularly declined, because it was replaced by so much cogeneration.

The purpose of what we did was not to suggest exactly what could have occurred or to make anybody wrong for what did occur in 1978. It was, rather, to look directly at the available opportunities to respond to the rising energy prices that have been a reality for the last 5 or 6 years. It would have been unreasonable to expect all of these changes to actually have occurred by 1978.

In fact, the least-cost mix of technologies is something that might have taken as much as 10 or 15 years to accomplish.

The chief purpose of what we were trying to do is suggest how far we have veered away from the least cost objective, and to demonstrate that other more productive directions are among our more current options.

The largest opportunities are those that increase efficiency. And overall, it indicates that the industrial consumer paid roughly 10 percent more for energy services in 1978 than theoretically they needed to pay, overall consumers paid roughly 17 percent more for energy services than they needed to pay.

The results of this analysis also point to some fairly major defects in Government policy up to this point.

For instance, most of the Government research and development money has been focused on increasing utility supplied electricity. Yet utility supplied electricity—in straight cost competition—is the worst competitor.

Second: We found that regulations that force industrial conversion to coal as a means of reducing imports were clearly not in the industrial users' economic interest. In fact, to do so took capital away from more productive energy investments in the efficiency area.

Third: The artificially low prices for natural gas have created obvious shortages in the industrial sector and resulted in overuse in the building sector. Because of an insured supply to priority users in the building sector, gas in industry is really priced as a supplemental commodity.

The Natural Gas Policy Act is increasing this distortion by passing on the incremental price to industrial users. I will come back to this in a moment.

Finally: The present popularity of a massive Government program to produce synthetic fuels goes way beyond anything we can imagine in terms of trying to achieve the lowest cost of industrial energy services.

Overall, I think this analysis indicates that the most useful Federal policy would be one that encourages the maximum number of competing elements without trying to manage those elements.

It also suggests that narrow goals, such as reducing imports, are clearly counterproductive to achieving a broader goal of minimizing the cost of energy services to consumers. And yet, minimizing cost seems to accomplish the goal of achieving reduced imports as well.

These conclusions, in turn, suggest some specific recommendations which I would like to make to accelerate industrial energy productivity.

First: Would be to repeal the fuel use provisions of the National Energy Act as being excessively costly, diverting capital away from efficiency, and not allowing people to use the most creative ingenuity in the costs they are now facing.

Second: It appears necessary to throw out the incremental pricing provisions of the National Gas Policy Act. It creates overuse in the building sector and makes less gas available in the industrial sector. Thus it reduces the opportunity for improved efficiency in the industrial sector. Because so many of the efficient technologies use gas.

Third: I believe that it is time for us to consider the opportunity of deregulating electric power generation. It appears that there is so

much competition available to provide electric power from technologies, such as cogeneration and all of the onsite and smaller technologies, that it is no longer necessary to consider large electric power generation as a monopoly.

Therefore, the possibility of deregulating the power generation side of the electric utility industry might be an incredibly useful opportunity to stimulate the competitiveness of cogeneration and many other less expensive technologies.

Finally, going along with Mr. Harvey's presentation in a very enthusiastic way, it seems to me our results call for a massive shift of Federal R. & D. spending toward the efficiency technologies that Mr. Harvey has outlined. Certainly these are the only technologies that, in mass, can compete with imported oil prices or, in fact, any of the alternative energy prices we are talking about.

I believe, Mr. Chairman, that those four things would do more than anything that we have talked about before. Certainly they represent a change in my opinion about the things that we should be doing to stimulate industrial energy conservation at this point.

Thank you very much.

Mr. OTTINGER. Thank you.

Can somebody advise me where we are in the proceedings at this point?

Let's hear from you, Mr. Reid.

[The biography and prepared statement of Mr. Robert O. Reid follows:]

BIOGRAPHICAL SKETCH: ROBERT O. REID

Mr. Reid is Executive Vice President of Energy and Environmental Analysis, Inc. (EEA). His areas of expertise include industrial energy conservation and demand, the economic impact of government regulatory policy and quantitative decision analysis. He is the author of over 100 technical reports, articles, and other publications. He has been active in the field of industrial energy conservation since 1974 and continues to be one of the principle consultants to the Federal government.

Prior to joining EEA in 1974 he was Assistant Director to the Office of Policy Analysis, U.S. Environmental Protection Agency. He holds a Ph.D. in economics from Georgetown University.

PREPARED TESTIMONY
ON
INDUSTRIAL ENERGY CONSERVATION POTENTIAL,
PROBLEMS AND POLICIES

BEFORE
THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

BY
ROBERT O. REID
EXECUTIVE VICE PRESIDENT
ENERGY AND ENVIRONMENTAL ANALYSIS, INC.

September 11, 1979

INDUSTRIAL ENERGY CONSERVATION POTENTIAL, PROBLEMS, AND POLICIES

I appreciate the opportunity to address this distinguished committee. I have been active in the area of industrial energy conservation for the past six years, dating back to the inception of the Voluntary Industrial Energy Conservation Program and the first major study performed under the sponsorship of the Federal government on the potential for energy conservation in the manufacturing sector.

Perhaps the spokespersons for energy conservation, and specifically those for industrial energy conservation, simply have been less articulate than other groups seeking to help resolve the energy malaise we now find ourselves in. If that is the case, it is unfortunate. Our studies and all supporting evidence indicate that the potential for vast improvements, which I will attempt to document later in my testimony, exists within the industrial sector and is much greater than the conservation potential in any other sector of the economy. Recent evidence from the first disruption of oil supplies and subsequent price increases supports this view. I would certainly rank the potential for industrial energy conservation to be at least equivalent to what can reasonably be accomplished through the synfuels program and much greater than that which can be accomplished through the application of solar technologies by the year 2000. More importantly, industrial conservation potential can be achieved at a much lower real cost to the American economy and can result in significant environmental benefits.

This brings me to another point which I think is important to highlight. When we talk of energy conservation, we have to think in terms broader than Btu reductions per unit of output. In addition to increasing the productivity of our energy resources, we must reserve scarce fuels for uses in which other substitutes are not available. For example the industrial sector utilizes roughly one-half of the natural gas consumed in the United States. Much of this natural gas is combusted in units in which other fuels, namely residual fuel oil and coal, could be used. If a significant portion of this gas was made available to the residential and commercial sectors, it could be used to displace middle distillates which, in turn, would be made more available for use in diesel and jet fuel or for upgrading to gasoline.

Getting back to my original point, I believe it is inappropriate to deal with the issue of energy conservation independent of the impact on fuel dependence. Programs and policies which ignore these fuel substitution issues could create perverse incentives resulting in the substitution of

scarce fuels for fuels which are either abundant domestically or, as in the case of residual fuel oil, represent fuels which can be used only in limited applications. We also cannot afford to analyze policies and programs in the narrow context of one sector of the economy. Actions taken to effect changes in industrial fuel balances and requirements will impact the availability and opportunities in other sectors of the economy.

POTENTIAL*

The potential for energy conservation within the industrial sector, as I stated previously, is enormous. It is also true that the decision-making apparatus exists within the industrial sector to insure that this potential is realized. However, the opportunities to conserve energy and the level at which decisions are required are by no means uniform. Thus, in thinking about opportunities to conserve energy and ways of influencing decisions, I have always found it helpful to deal with various categories.

First, there is housekeeping. This differs very little from what we all have been trying to accomplish for cost saving reasons in our homes. More selective lighting, thermostat settings, shutting down as opposed to idling process equipment, improved insulation, and other housekeeping activities have been largely responsible for the 12 to 15 percent overall decrease in energy consumption since 1974 as compared with historical trends. I believe that for all but the less energy intensive industries most of these opportunities have been exploited. The goal here will be to protect against recidivism and to encourage such actions in the less energy intensive, nonprimary goods industries.

The second category is retrofit of existing equipment. These actions can be capital intensive and involve extremely high ancillary costs. I just completed a study which implied that, above ambient temperatures, stack gases vented to the atmosphere in the industrial sector contain over 6.9 quads of energy. There are, however, severe limitations on how much of this energy can be recovered. Among the constraints are:

- Technology limitations
- Corrosivity of the gas stream
- Space limitations
- Implications for downtime of process equipment.

*For a more complete discussion see Energy Conservation and Public Policy, edited by John Sawhill, Chapter 5 "Technological Options for Improving Energy Efficiency in Industry and Agriculture," Robert O. Reid, Melvin H. Chiogioji.

We took a rough stab at estimating waste heat recovery potential using conventional technologies and relatively conservative economic assumptions and came up with a range of .6 to 1.0 quads of recoverable waste heat.

The enormous difference between what we considered to be economical to recover and the actual amount of energy vented to the atmosphere is indicative of both the state of our knowledge and the challenges before us.

The third area covers process modifications, improvements, and changes. These actions I characterize as fundamental alterations of production processes as they now exist. There is hardly an industry that has not done some experimentation in this area. By far the greatest opportunities for energy conservation are in this category. But these opportunities are far from mature and involve significant risks which only a few industries and, indeed, corporations can afford to accept. This is especially true when you consider that, even at today's prices, energy represents less than 10 percent of value added and for the sake of cutting this cost element by, for example, 50 percent you are sometimes risking 20 times the cost in invested capital. It is therefore not surprising that industry is very cautious of proceeding down these paths. The unforeseen obstacles and pitfalls are too numerous to elaborate.

The last category is product substitution. This is the bread and butter of the manufacturing sector and one option to which they seem to be responding. I do not believe that this is a productive area for investigation but it is one that since the 1950's has accounted for roughly one-third of the reduction in energy consumption per unit of industrial output.

Studies performed by my firm and others imply that it is not unrealistic to believe that the growth rate of industrial energy consumption could be reduced to approximately one-third of its historical relationship to industrial output. We already have seen a significant reduction in industrial energy consumption since 1974. Although the statistics vary, it appears that industrial energy productivity has improved anywhere from 12 to 15 percent since 1974, translating into a 2.6 to 3.3 quad reduction in industrial energy use. In terms of barrels of oil equivalent, these figures would equate to 1.2 to 1.5 MMBD.

Additional studies undertaken by the Energy Research and Development Administration and, most recently, the Department of Energy have focused on industrial fuel requirements in 1985 and 2000. These studies are particularly relevant because they reflect the current National Energy Plan.

These studies estimate that, through the application of new and existing technology, as much as five to 10 quads of conventional energy sources could be displaced by the year 2000. Exhibit 1 categorizes these opportunities.

I believe that these studies are conservative representations of the true opportunities which exist within the industrial sector. Studies I have performed and those of my colleagues would imply that we can sustain a three to four percent real growth rate in industrial output at no greater than a one percent per annual growth rate in energy consumption and simultaneously decrease reliance on oil and gas as combustion sources. The questions are how can this be accomplished and at what price? I think I can shed some light on the first question but can only give you a partial appreciation for the second.

RECOMMENDATION

I have separated my recommendations into three time dimensions, i.e., short-run, medium term, and long run.

In the short-run, price is the key. We continue to price fuels below replacement costs which, violates some of the most fundamental rules of economics. If you expect the price system to work you must allow resources to be allocated on the basis of market determined prices. The current inefficiency and indeed a great deal of the opportunity to conserve energy in the near term is a result of improper price signals. I am struck by the comment of one energy coordinator for a major oil company who was bemoaning the fact that refineries under his supervision built in 1950 reflected better energy conservation practices than plants built in the 1970's. We no longer can afford to provide artificial price signals which fail to reflect the true opportunity cost of energy to the nation. All consumers of energy including the industrial sector must base their decisions on realistic pricing assumptions.

I think that if oil prices are deregulated and the incremental pricing provisions of the Natural Gas Policy Act are implemented we will be a lot closer to this objective by 1981 or 1982. Industries will see prices at or near the fuel price cap in this time frame and, so long as oil is unregulated, we will finally see a reasonable pricing regime in the industrial sector. I would therefore argue to let the existing mechanisms take hold and not maintain the promise of government subsidization through further intervention.

My second recommendation relates to actions which can pay off in the medium term. My recommendations are in two parts. First, the industrial sector is in vast need of modernization. With the cost of capital approaching 15 to 17 percent on an after-tax basis, few industries can afford to pursue major modernization programs. I do not know what the

EXHIBIT 1

MARKET PENETRATION ESTIMATES FOR ADVANCED
ENERGY CONSERVING TECHNOLOGIES

<u>Product Category</u>	<u>MOPPS*</u>		<u>ISTUM**⁺</u>	
	<u>1985</u>	<u>2000</u>	<u>1985</u>	<u>2000</u>
Energy Saving Technologies				
• Process Changes	.636	2.046	.175	.694
• Waste Heat	<u>1.592</u>	<u>3.369</u>	<u>.240</u>	<u>.682</u>
Subtotal	2.228	5.415	.416	1.376
Energy Using Technologies				
• Industrial Waste Fuels	.959	2.632	.911	2.034
• Advanced Cogeneration	<u>.521</u>	<u>2.402</u>	<u>.121</u>	<u>1.693</u>
Subtotal	1.480	5.034	1.032	3.727
	<u> </u>	<u> </u>	<u> </u>	<u> </u>
Total All Conservation Technologies	3.708	10.449	1.448	5.103

*Energy Research and Development Administration, The Market Oriented Program Planning Study, Industrial Sector Working Group (MOPPS), March, 1978.

**Included are 40 percent of the projects being funded by the Division of Industrial Programs which could be fully documented within the timing and level of effort provided.

⁺U.S. Department of Energy, Office of Energy Technology, The Industrial Sector Technology Use Model (ISTUM), prepared by Energy and Environmental Analysis, Inc. (EEA), June, 1978.

cost has been in terms of inflation of maintaining antiquated production capacity, but I can assure you it is significant. Modernization is important to energy conservation because many of the existing technological opportunities will only occur through this avenue. The actions needed here must come through revisions of the tax code. Providing for more rapid depreciation of existing equipment, valuation of capital assets at replacement cost as opposed to book value, and corporate tax reductions are options that should be considered.

My second recommendation in this area would be that energy conservation, in the broader sense which I defined, needs to be stimulated. I would strongly encourage an extension of the business investment tax credit for energy conservation and alternative fuel investments contained in the Energy Tax Act of 1979. I would also argue for a liberal interpretation of qualifying parameters under the tax credit. For example, limiting the credit strictly to purchased equipment in many instances would only cover one-third to one-half the full cost of the system. Our data on waste heat recovery equipment would imply that a factor of two to three times the equipment cost is the installed and operating costs of these systems. A tax credit which ignores the actual cost would severely limit its importance as an economic incentive.

My final recommendation relates to those actions which involve long and uncertain payback periods. These actions cover a broad range of RD&D strategies. The existing Federally subsidized RD&D program is inadequately funded, too restrictive in its principle focus (probably as a result of the first point), and lacks the necessary tools to accomplish its goals.

Let's look at the facts. In 1978 the industrial sector consumed roughly 22 quads of energy on a net energy basis and 27 quads of energy if fuels used to generate electricity are included. At an average cost of \$2.50/MMBtu the industry spent between \$60 and \$70 billion dollars on energy last year. Research and development expenditures subsidized by the Federal government, on the other hand, amounted to something less than \$50 million or less than one-tenth of one percent.

I have heard the argument many times that if an option is a promising investment, the industrial sector should be pursuing it on its own. This is a difficult argument to overcome because RD&D expenditures are usually proprietary and therefore not generally within the purview of the Federal government. However, I have and will continue to argue against this view.

The vast bulk of industry's RD&D investments go towards product improvements or new product development. I think if you queried many major corporations you would find that most cost saving types of investment are introduced by architectural and engineering contractors who

work them into the design of new plants. Many of these changes are adaptations of changes occurring in the design of related facilities and are not the result of research and development programs.

Second, RD&D expenditures traditionally only pay off if you are pursuing a full scale manufacturing and marketing opportunity. Studies by the NSF and others imply that only one out of 10 new ideas get past basic research and only one out of 10 ideas funded are ever commercialized. There is little incentive for an end user to support or financially participate in the development of a new technology unless they are thinking about full scale licensing or entering a new line of business. In general I believe the incentives for the end user are small relative to the fixed costs associated with related RD&D activities.

Third, the investments we do hear about usually comprise large scale process changes. Direct reduction of aluminum and continuous casting of steel are two which are most frequently discussed. Energy conservation is indeed one of the reasons to pursue these investments, but it is not necessarily the only reason or the most important. In general many incentives, e.g., improved labor and capital productivity, materials substitution, and lower operating costs, have to occur simultaneously for these large scale projects to get off the ground. Even if these incentives are successful, the rate at which they are adopted can involve decades.

I personally believe there is a major role for the Federal government to play in this arena and we are deluding ourselves if we think that higher prices and the profit motive will capture the full range of these opportunities.

I submit that a three phased program is required. The first portion of the program would be to fund basic research. For example, a great deal needs to be learned about the combustion properties of coal in nonboiler applications and material problems associated with the treatment of particulate laden hot gas streams, just to name two areas. Doug Harvey I'll bet can give you a full list of programs in this area. I might set aside 10 percent of the budget for this purpose.

The second part might look a great deal like the existing cost sharing R&D program but with a much expanded base. To pick an arbitrary number, if one percent of fuel costs to the industrial sector was set aside each year to fund R&D efforts, the program would be 10 times as large as the existing program. As an aside, the precedent for this type of program already has been established through surcharges on natural gas and electricity which fund the Gas Research Institute and the Electric Power Research Institute. I see no lack of justification for establishing an Industrial Energy Consumers Research Institute. If such an RD&D program was created, criteria would have to be established for

obtaining funds; I would argue that opportunities should be biased toward near term, low risk options which offer substantial medium term benefits once deployed. I would bias the program toward opportunities to conserve scarce fuels and increase coal utilization.

The final element of this program would be to encourage more rapid introduction and adoption of process technologies that entail high risks or result in forced obsolescence of existing plants and equipment. The analogy already has been made with regard to the synfuel program so I do not feel restricted from using that same analogy in this case. During the war the government in partnership with industry helped build the infrastructure necessary to provide the implements of war. Many of these facilities were later sold to corporations. A similar partnership may be required at this juncture. The government could either accept the full risk of introducing these technologies by financing the construction and then selling the operating plant back to industry, hopefully at a net profit, or could undertake a more limited indemnification program. I personally favor the second option because it accomplishes the same objective at a lower initial, although not necessarily long term, cost to the Treasury.

To summarize I believe that industrial energy consumption can be reduced far below historical trends. If we could sustain a three percent annual growth in industrial output, no more than a one percent per annum growth in energy consumption would be required. Simultaneously, I think that with the right price incentives this could be accomplished at a net reduction in the consumption of oil and natural gas. By the way, the difference between a one and three percent growth rate in energy consumption is roughly 16 quadrillion Btu's in 2000 or equivalent to the annual output of 150 synfuel plants, each with a production of 50,000 bbl/day.

Actions necessary to accomplish these objectives include:

- Replacement cost pricing of oil and natural gas which, if implemented in their present form, will be accomplished through existing legislation
- Tax incentives to encourage modernization of existing capital stock and additional incentives to encourage investments in energy conserving technologies and desired fuel switching opportunities
- Enhanced research and development expenditures to include basic and applied research and development and indemnification programs to accelerate the rate of introduction of high risk but energy efficient process change options.

Thank you for giving me this opportunity to express my views. I would be happy to answer any questions or provide additional information.

STATEMENT OF ROBERT O. REID, EXECUTIVE VICE PRESIDENT,
ENERGY & ENVIRONMENT ANALYSIS CORP.

Mr. REID. I appreciate the opportunity to address this committee today. I have been active in the area of industrial energy conservation for the past 6 years, dating back to the inception of the voluntary industrial energy conservation program and the first major study performed under the sponsorship of the Federal Government on the potential for energy conservation in the manufacturing sector.

My remarks today will be much more directed to policy issues than to the technology issues that Mr. Harvey addressed.

When I received the invitation to testify, I was struck by the statement that industrial energy conservation had never been a subject of Science Committee hearings before. Part of this may be that the spokespersons for energy conservation, and specifically those for industrial energy conservation, simply have been less articulate than those of other groups seeking to help resolve the energy malaise we now find ourselves in.

If that is the case, it is unfortunate. Our studies and all supporting evidence, as pointed out by the two witnesses that preceded me, indicate that the potential for vast improvements exists within the industrial sector and that this potential is much greater than the conservation potential in any other sector of the economy.

Evidence from the recent disruption of oil supplies and subsequent price increases supports this view. I would certainly rank the potential for industrial energy conservation to be at least equivalent to what can be reasonably accomplished through the synfuels program, and much greater than that which can be accomplished through the application of solar technologies by the year 2000. More importantly, industrial conservation potential can be achieved at a much lower real cost to the American economy and can also result in significant environmental benefits.

This brings me to another point which I think is important to highlight.

When we speak of energy conservation, we have to think in broader terms than Btu reductions per unit of output. In addition to increasing the productivity of our energy resources, we must reserve scarce fuels for uses in which other substitutes are not available. For example, the industrial sector utilizes roughly one-half of the natural gas consumed in the United States. Much of this natural gas is combusted in units which could use other fuels, namely residual fuel oil and coal. If a significant portion of this gas was made available to the residential and commercial sectors, it could be used to displace middle distillates which, in turn, would be made more available for use in diesel and jet fuel or for upgrading gasoline.

Getting back to my original point, I believe it is inappropriate to deal with the issue of energy conservation independent of the impact on fuel dependence. Programs and policies which ignore these fuel substitution issues could create perverse incentives, resulting in substituting scarce fuels for fuels which are either domestically abundant or, as in the case of residual fuel oil, can be used in only limited applications. We also cannot afford to analyze policies and programs in the narrow context of one sector of the economy. Actions

taken to effect changes in industrial fuel balances and requirements will impact the availability and opportunities in other sectors of the economy.

Speaking specifically on the potential, as I stated previously, I think it is enormous, and it is also true that, in the industrial sector, a decisionmaking apparatus exists to insure that this potential is realized. However, the opportunities to conserve energy are quite varied and nonuniform within the industrial sector. Therefore, you need a broad gaged program in order to deal with them. I also find it very helpful myself to deal with categories of opportunities as opposed to lumping them all under one particular heading.

First: There is housekeeping, and maybe my views are a little bit different from the previous witness. I think that much of the conservation we have seen accomplished during the 1970's has been a result of housekeeping activities. Some of these involved easy retrofits where the capital cost was insignificant or small for the return on investment. According to my statistics, I think these activities have accounted for a 12- to 15-percent reduction in energy use since 1974 when compared with historical trends. I believe that, for all but the less energy intensive industries, most of these opportunities have been exploited. The future goal is, therefore, to protect against recidivism and to encourage similar actions in the less energy intensive, nonprimary goods industries.

The second area deals with retrofitting existing equipment. These actions can be capital intensive and involve extremely high ancillary costs. I just completed a study which implied that, above ambient temperatures, stack gases vented to the atmosphere in the industrial sector contain over 6.9 quads of energy. However, there are severely significant limitations in our ability to recover this energy, technical limitations such as Doug was talking about. There are burner type limitations, there are space limitations which seem to be a very significant problem for existing companies that have built up over a number of years, and process equipment downtime implications for many retrofit applications. Downtime is just really an unacceptable option for many industrial establishments.

Taking this potential of 6.9 quads, we took what I consider to be a rough stab and estimated what could be economically recovered, using current technology and a fairly conservative set of economic assumptions. We came up with a range of 0.6 to 1 quad of recoverable waste heat from the 6.9 quad potential.

The enormous difference between what we considered economical to recover and the actual amount of energy vented to the atmosphere is indicative of both the state of our knowledge and the challenges before us.

The third area covers process modifications, improvements, and changes, the revolutionary technologies that Mr. Harvey referred to. These actions I characterize as fundamental alterations of production processes as they now exist. There is hardly an industry that has not done some experimentation in this area. By far the greatest opportunities for energy conservation are in this category, but these opportunities are far from mature and involve significant risks which only a few industries and, indeed, corporations can afford to accept. This is especially true when you consider that, even at today's prices,

energy represents less than 10 percent of value added and, for the sake of cutting this cost element by, for example, 50 percent, you are sometimes risking 20 times the cost in invested capital. It is, therefore, not surprising that industry is very cautious in proceeding down these paths. The unforeseen obstacles and pitfalls are too numerous to specify.

The last category is product substitution. This is the bread and butter of the manufacturing sector and one option to which they seem to be responding. I do not believe that this is a particularly productive area for investigation, but it is one that, since the 1950's, has accounted for roughly one-third of the reduction in energy consumption per unit of industrial output.

Studies performed by my firm, and others, imply that it is not unrealistic to believe that the growth rate of industrial energy consumption could be reduced to approximately one-third of its historical relationship to industrial output. We already have seen a significant reduction in industrial energy consumption since 1974. Although the statistics vary, it appears that industrial energy productivity has improved anywhere from 12 to 15 percent since 1974, translating into a 2.6- to 3.3-quad reduction in industrial energy use. In terms of barrels of oil equivalent, these figures would equate to 1.2 to 1.5 million barrels per day. I would say that is a very significant reduction, but is just the tip of the iceberg in terms of what we can actually accomplish.

Additional studies undertaken by the Energy Research and development Administration and, most recently, the Department of Energy have focused on industrial fuel requirements in 1985 and 2000. These studies are particularly relevant because they reflect the current National Energy Plan, or what portions of it are currently on the books.

These studies estimate that, through the application of new and existing technology, as much as 5 to 10 quads of conventional energy sources could be displaced by the year 2000. Exhibit I categorizes these opportunities.

I believe that these studies are a conservative representation of the true opportunities which exist within the industrial sector. Studies I have performed, as well as those of my colleagues, would imply that we can sustain a 3- to 4-percent real growth rate in industrial output with no more than a 1-percent per year growth rate in energy consumption, and simultaneously decrease reliance on oil and gas as combustion sources. The questions are now, can this be accomplished, and at what price? I think I can shed some light on the first question, but can only give you a partial appreciation for the second.

I have separated my recommendations into three time dimensions, those in the short run, medium term, and long run.

In the short-run, price is the key. We continue to price fuels below replacement costs which violates some of the most fundamental rules of economics. If you expect the price system to work you must allow resources to be allocated on the basis of market determined prices. The current inefficiency, and indeed a great deal of the opportunity to conserve energy in the near term, is a result of improper price signals. I am struck by the comment of one energy coordinator for a major oil company who was bemoaning the fact that refineries under his supervision built in 1950 reflected better energy conservation

practices than plants built in the 1970's. We no longer can afford to provide artificial price signals which fail to reflect the true opportunity cost of energy to the Nation. All consumers of energy, including the industrial sector, must base their decisions on realistic pricing assumptions.

I think that if oil prices are deregulated and the incremental pricing provisions of the Natural Gas Policy Act are implemented, we will be a lot closer to this objective by 1981 or 1982. Industries will see prices at or near the fuel price cap in this timeframe and, so long as oil is unregulated, we will finally see a reasonable pricing regime in the industrial sector. I would, therefore, argue to let the existing mechanisms take hold and not maintain the promise of Government subsidization through further intervention in the price manipulation.

My second recommendation relates to actions which can pay off in the medium-term. My recommendations are in two parts. First, the industrial sector is in vast need of modernization. With the cost of capital approaching 15 to 17 percent on an after-tax-basis, few industries can afford to pursue major modernization programs. I do not know what the cost has been in terms of inflation or in maintaining antiquated production capacity, but I can assure you it is significant. Modernization is important to energy conservation because many of the existing technological opportunities will only occur through this avenue. The actions needed here must come through revisions of the tax code. Providing for more rapid depreciation of existing equipment, valuation of capital assets at replacement cost as opposed to book value, and corporate tax reductions are options that should be considered.

My second recommendation in this area would be that energy conservation in the broader sense, which I defined, needs to be stimulated.

I would strongly encourage an extension of the business investment tax credit for energy conservation and alternative fuel investments contained in the Energy Tax Act of 1979. I would also argue for a liberal interpretation of qualifying parameters under the tax credit. For example, limiting the credit strictly to purchased equipment in many instances would only cover one-third to one-half the full cost of the system. Our data on waste heat recovery equipment implies that a factor of two to three times the actual equipment cost is the installed and operating costs for these systems. A tax credit which ignores the actual cost would severely limit its importance as an economic incentive.

My final recommendation relates to those actions which involve long and uncertain payback periods. These actions cover a broad range of R.D. & D. strategies. The existing Federally subsidized R.D. & D. program is inadequately funded, too restrictive in its principal focus—probably as a result of the first point—and lacks the necessary tools to accomplish its goals.

Let's look at the facts. In 1978 the industrial sector consumed roughly 22 quads of energy on a net energy basis and 27 quads of energy, including fuels used to generate electricity it consumed. At an average cost of \$2.50/MMBtu the industry spent between \$60 and \$70 billion on energy last year. Research and development expenditures subsidized by the Federal Government, on the other hand, amounted to something less than \$50 million, or less than one-tenth of 1 percent.

I have heard the argument many times that if an option is a promising investment, the industrial sector should be pursuing it on its own. This is a difficult argument to overcome because R.D. & D. expenditures are usually proprietary and are therefore not generally within the purview of the Federal Government. However, I have, and will continue to argue against this view.

First: The vast bulk of industry's R.D. & D. investments go toward product improvements or new product development. I think if you queried many major corporations you would find that most cost saving types of investment are introduced by architectural and engineering contractors who work them into the design of new plants. Many of these changes are adaptations of changes occurring in the design of related facilities and are not the result of research and development programs.

Second: R.D. & D. expenditures traditionally only pay off if you are pursuing a full scale manufacturing and marketing opportunity. Studies by the NSF and others imply that only 1 out of 10 new ideas gets past basic research and only 1 out of 10 ideas funded is ever commercialized. There is little incentive for an end user to support or financially participate in developing a new technology unless they are thinking about either full scale licensing or entering a new line of business. In general, I believe the incentives for the end user are small relative to the fixed costs associated with related R.D. & D. activities.

Third: The investments we do hear about usually comprise large scale process changes. Direct reduction of aluminum and continuous casting of steel are two which are most frequently discussed. Energy conservation is indeed one of the reasons to pursue these investments, but it is not necessarily the only reason, nor the most important. In general, many incentives, for example, improved labor and capital productivity, materials substitution, and lower operating costs, have to occur simultaneously for these large scale projects to get off the ground. Even if these incentives are successful, the rate at which they are adopted can involve decades.

I personally believe there is a major role for the Federal Government to play in this arena and we are deluding ourselves if we think that higher prices and the profit motive will capture the full range of these opportunities.

I submit that a three-phased program is required. The first portion of the program would be to fund basic research. For example, a great deal needs to be learned about the combustion properties of coal in nonboiler applications and material problems associated with the treatment of particulate laden hot gas streams. Doug can give you a whole range of other promising opportunities, I am sure. I might set aside 10 percent of the budget for this purpose.

The second part might look a great deal like the existing cost sharing R. & D. program but with a much expanded base. To pick an arbitrary number, if 1 percent of fuel costs to the industrial sector was set aside each year to fund R. & D. efforts, the program would be 10 times as large as the existing program. As an aside, the precedent for this type of program already has been established through the surcharges on natural gas and electricity which fund the Gas Research Institute and the Electric Power Research Institute. I see no lack of justification for establishing an Industrial Energy Consumers Research

Institute. If such an R.D. & D. program was created, criteria would have to be established for obtaining funds; I would argue that opportunities should be biased toward near term, low risk options which offer substantial medium-term benefits once deployed. I would bias the program toward opportunities to conserve scarce fuels and increase coal utilization.

The final element of this program would be to encourage more rapid introduction and adoption of process technologies that entail high risks or result in forced obsolescence of existing plants and equipment. The analogy already has been made regarding the synfuel program, so I do not feel restricted from using the same analogy in this case. During the war, the Government, in partnership with industry, helped build the infrastructure necessary to provide the implements of war. Many of these facilities were later sold to corporations. A similar partnership may be required at this juncture. The Government could either accept the full risk of introducing these technologies by financing the construction and then selling the operating plant back to industry, hopefully at a net profit, or could undertake a more limited indemnification program. I personally favor the second option because it accomplishes the same objective at a lower initial, although not necessarily long-term cost to the Treasury.

To summarize, I believe that industrial energy consumption can be reduced far below historical trends. If we could sustain a 3-percent annual growth rate in industrial output, no more than a 1-percent per annum growth in energy consumption would be required. Simultaneously, I think that with the right price incentives this could be accomplished at a net reduction in the consumption of oil and natural gas.

By the way, the difference between a 1-and 3-percent growth rate in energy consumption is roughly 16 quadrillion Btu's in 2000, or equivalent to the annual output of 150 synfuel plants, each with a production capacity of 50,000 bbl/d.

Action necessary to accomplish these objectives include:

One: Replacement cost pricing of oil and natural gas which, if implemented in their present form, will be accomplished through existing legislation.

Two: Tax incentives to encourage modernization of existing capital stock and additional incentives to encourage investments in energy conserving technologies and desired fuel switching opportunities.

Three: Enhanced research and development expenditures to include basic and applied research and development and indemnification programs to accelerate the rate of introduction of high risk, but energy efficient process change options.

Thank you for giving me this opportunity to express my views. I would be happy to answer any questions or provide additional information.

Mr. OTTINGER. Thank you very much, Mr. Reid.

We will hear next from Mr. Gomes, chief, financial analysis, Kaiser Aluminum.

[The biography and prepared statement of Mr. Clemente Gomes follows:]

CLEMENTE M. GOMES

Education: BS in Mathematics and BS in Mechanical Engineering from University of Michigan. MS and Ph.D. in Control Systems from University of California, Berkeley.

Work Experience: Joined Kaiser Aluminum in 1968. Held various positions including Manager of Operations Research Department; presently, Associate Director of Energy in charge of Planning, Control and Administration. Before joining Kaiser worked five years for Bechtel Corporation in the design of Refinery and Power Plants.

TESTIMONY OF DR. CLEMENTE M. GOMES
 ASSOCIATE DIRECTOR OF ENERGY
 KAISER ALUMINUM & CHEMICAL CORPORATION
 BEFORE THE
 HOUSE ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE
 OF THE
 HOUSE SCIENCE & TECHNOLOGY COMMITTEE
 SEPTEMBER 11, 1979

MR. CHAIRMAN, I AM CLEMENTE M. GOMES, ASSOCIATE DIRECTOR OF ENERGY FOR KAISER ALUMINUM AND CHEMICAL CORPORATION. TO MY LEFT I HAVE MR. DONALD V. MOOREHEAD, PARTNER IN THE LAW FIRM OF SUTHERLAND, ASBILL & BRENNAN AND TO MY RIGHT IS MY COLLEAGUE MR. RICHARD B. POOL, ALSO AN ASSOCIATE DIRECTOR OF ENERGY FOR KAISER ALUMINUM. THESE GENTLEMEN WILL ASSIST ME IN ANSWERING QUESTIONS. I APPRECIATE THIS OPPORTUNITY TO APPEAR BEFORE THIS SUBCOMMITTEE AND TO SHARE WITH YOU AND YOUR COLLEAGUES OUR THOUGHTS ON INDUSTRIAL ENERGY CONSERVATION.

LET ME SAY AT THE OUTSET THAT OUR INTEREST IN THIS SUBJECT OF ENERGY CONSERVATION IS NOT NEW AND IT IS FAR FROM ACADEMIC. KAISER ALUMINUM & CHEMICAL CORPORATION OPERATES 71 MAJOR MANUFACTURING FACILITIES IN 30 STATES. WE CONSUME MORE THAN 200 TRILLION BTUS OF ENERGY EACH YEAR, WHICH PLACES US AMONG THE TOP 25 ENERGY CONSUMING COMPANIES IN THE COUNTRY. THE MAJOR FORM OF ENERGY WHICH WE CONSUME IS ELECTRICITY GENERATED FROM NATURAL GAS, OIL, COAL, AND HYDROELECTRIC POWER.

WE HAVE ACTIVELY STUDIED THE SUBJECT OF INDUSTRIAL ENERGY CONSERVATION INCENTIVES FOR MORE THAN FIVE YEARS AND HAVE DEVELOPED A PROPOSAL FOR INCENTIVES TO STIMULATE INDUSTRIAL ENERGY CONSERVATION PROJECTS. I AM SUBMITTING FOR THE RECORD A DETAILED DESCRIPTION OF OUR PROPOSAL AND I WILL COMMENT BRIEFLY ON ITS MAJOR FEATURES DURING THE COURSE OF MY TESTIMONY THIS MORNING. INITIALLY, HOWEVER, I WANT TO FOCUS ON TWO POINTS. FIRST, THE REASONS WE BELIEVE THAT ENERGY CONSERVATION MUST BE A CRITICAL PART OF ANY EFFECTIVE SHORT TERM STRATEGY FOR ENERGY INDEPENDENCE. SECOND, WHY INCENTIVES ARE NEEDED NOW TO STIMULATE ENERGY CONSERVATION PROJECTS.

THE UNITED STATES NOW CONFRONTS AN ENERGY PROBLEM THAT IS BECOMING MORE SEVERE EACH DAY. WE MUST NOW DEVISE AND IMPLEMENT STRATEGIES TO SOLVE OUR ENERGY PROBLEM IN WAYS THAT WILL NOT HAVE ADVERSE ECONOMIC IMPLICATIONS IN TERMS OF EMPLOYMENT, PRODUCTIVE CAPACITY, AND OTHERWISE. IN THE SHORT TERM, THAT IS OVER THE NEXT DECADE, OUR STRATEGY OPTIONS ARE FEW IN NUMBER. WIDESPREAD PRODUCTION OF SYNTHETIC FUELS, SOLAR ENERGY AND OTHER ALTERNATIVE ENERGY SOURCES REMAINS AT LEAST A DECADE AWAY, AND THE ROLE TO BE PLAYED BY NUCLEAR POWER REMAINS UNCERTAIN, PARTICULARLY IN THE SHORT TERM. GOVERNMENTAL ENCOURAGEMENT OF EFFORTS TO DEVELOP ALTERNATIVE ENERGY RESOURCES IS NEEDED, BUT THIS IS A LONG-TERM STRATEGY FOR THE 1990'S AND BEYOND.

IN THE SHORT TERM, TO DECREASE OUR DEPENDENCE UPON IMPORTED ENERGY REQUIRES EITHER INCREASED DOMESTIC PRODUCTION OF OIL AND GAS OR STIMULATION OF CONSERVATION OR BOTH. INCREASED PRODUCTION IS IMPORTANT, BUT IT IS NOT A SUBSTITUTE FOR THE MORE EFFICIENT USE OF OUR ENERGY RESOURCES. IN OUR JUDGMENT, THE CASE FOR CONSERVATION IS SELF-EVIDENT SIMPLY BECAUSE THE OTHER SHORT TERM OPTIONS ARE SO FEW.

OUR STUDIES INDICATE THAT THERE IS A SIGNIFICANT POTENTIAL FOR INDUSTRIAL ENERGY CONSERVATION AND THAT THE REALIZATION OF A SIGNIFICANT PORTION OF THESE CONSERVATION SAVINGS COULD BE ACCELERATED WITH CAREFULLY TAILORED INCENTIVES.

EXHIBIT 1.

THIS CONSERVATION POTENTIAL IS ILLUSTRATED IN EXHIBIT 1. THE FIRST LEVEL OF CONSERVATION SAVINGS - ABOUT 10% - INVOLVES MODEST CAPITAL REQUIREMENTS AND COMPARATIVELY MINIMUM NEW TECHNOLOGY. WITH INCREASES IN ENERGY PRICES THESE FIRST LEVEL PROJECTS HAVE INCREASINGLY BECOME COST EFFECTIVE. IN THE ALUMINUM INDUSTRY, AND WE BELIEVE IN OTHER INDUSTRIES AS WELL, THESE FIRST LEVEL CONSERVATION SAVINGS HAVE BEEN AND ARE BEING REALIZED.

OUR STUDIES ALSO INDICATE THAT IN THE ENERGY INTENSIVE PROCESS INDUSTRIES SUCH AS OURS, THERE IS ANOTHER 15-20% CONSERVATION POTENTIAL WHICH COULD BE OBTAINED WITH EXISTING TECHNOLOGY BUT WHICH REQUIRE SUBSTANTIAL CAPITAL INVESTMENTS. THESE PROJECTS, WHICH ARE REPRESENTED BY THE SHADED AREA IN EXHIBIT 1, WILL BE IMPLEMENTED SOMETIME IN THE FUTURE BUT THEY ARE NOT BEING UNDERTAKEN TODAY. IN OUR JUDGMENT, THE MAIN REASON WHY THESE PROJECTS ARE NOT PROCEEDING TODAY IS BECAUSE OF THE LARGE CAPITAL REQUIREMENTS NEEDED TO IMPLEMENT THEM AND IN MANY CASES, THEY ARE NOT COST EFFECTIVE TO INDUSTRY, I.E. THE RETURN ON INVESTMENT IS NOT ADEQUATE.

THERE IS A THIRD ZONE ABOVE THE SHADED AREA WHICH REPRESENTS ADDITIONAL LONG TERM CONSERVATION POTENTIAL WHICH IS DEPENDENT UPON THE OUTCOME OF RESEARCH AND DEVELOPMENT EFFORTS TO DEVELOP NEW TECHNOLOGIES. THESE RESEARCH AND DEVELOPMENT EFFORTS ARE VERY IMPORTANT AND MUST ALSO BE STIMULATED, BUT CONSERVATION SAVINGS IN THIS AREA ARE NOT LIKELY TO BE OBTAINABLE IN THE SHORT TERM.

THUS, IF WE ARE TO REALIZE ADDITIONAL INDUSTRIAL ENERGY CONSERVATION SAVINGS OVER THE PERIOD OF THE NEXT DECADE, OUR FOCUS MUST BE UPON THOSE "SECOND LEVEL" PROJECTS REPRESENTED BY THE SHADED AREA IN EXHIBIT 1. THESE ARE PROJECTS WHICH HAVE RELATIVELY LOW RISK SINCE THEY DO NOT INVOLVE ANY MAJOR NEW TECHNOLOGY. HOWEVER, AS I HAVE INDICATED, THE CAPITAL REQUIRED BY THESE PROJECTS IS OFTEN SO LARGE THAT THEY ARE NOT NOW COST EFFECTIVE TO INDUSTRY. THESE PROJECTS WILL BE COST EFFECTIVE IN TIME, BUT NOT IN THE SHORT TERM. OUR STUDIES HAVE LED US TO CONCLUDE THAT PROPERLY TAILORED INCENTIVES CAN REACH THESE "SECOND LEVEL" PROJECTS AND HARNESS THE SIGNIFICANT ENERGY CONSERVATION POTENTIAL THEY REPRESENT.

NEXT, I WOULD LIKE TO DISCUSS BRIEFLY WHY WE HAVE CONCLUDED THAT FROM THE NATION'S STANDPOINT, INCENTIVES ARE A MORE DESIRABLE ROUTE TO HARNESS THIS ENERGY CONSERVATION RATHER THAN THROUGH MANDATORY APPROACHES INCLUDING ARTIFICIAL INCREASES IN ENERGY PRICES. IN OUR JUDGMENT, THERE ARE AT LEAST FOUR IMPORTANT REASONS AGAINST MANDATORY APPROACHES. FIRST, OUR STUDIES SHOW THAT, IN MANY INSTANCES, MANDATORY CONSERVATION ORDERS WOULD FORCE INDUSTRY TO SHUTDOWN VALUABLE DOMESTIC INDUSTRIAL CAPACITY, THUS, COMPOUNDING THE PROBLEMS OF UNEMPLOYMENT AND BALANCE OF PAYMENTS. SECOND, WE BELIEVE THAT MANDATORY CONSERVATION IS DISCRIMINATORY, SINCE IT PLACES A HIGHER BURDEN ON ENERGY INTENSIVE INDUSTRIES SUCH AS OURS. THIRD, MANDATORY CONSERVATION WILL FORCE INDUSTRY TO UNDERTAKE MANY UNECONOMICAL PROJECTS, THUS WORSENING THE ALREADY SERIOUS CAPITAL FORMATION PROBLEM. AND LASTLY, IN MANY CASES, MANDATORY CONSERVATION WOULD FORCE IMPLEMENTATION OF PROJECTS WHICH ARE NOT COST EFFECTIVE FROM THE NATION'S STANDPOINT, I.E. THE INCREMENTAL COST OF PRODUCING ENERGY BY MEANS OF CONSERVATION WOULD BE HIGHER THAN PRODUCING THE SAME ENERGY BY MEANS OF ALTERNATE SOURCES - CERTAINLY AN UNDESIRABLE SITUATION! I WILL BE DISCUSSING

FURTHER THIS CONCEPT OF "COST EFFECTIVE TO THE NATION" LATER IN MY TESTIMONY.
MR. CHAIRMAN, FOR THESE REASONS WE BELIEVE THAT INCENTIVES FOR CONSERVATION PROJECTS MAY BE THE COUNTRY'S BEST SHORT RANGE STRATEGY TO HARNESS THIS SIGNIFICANT POTENTIAL FOR ENERGY SAVINGS.

EXHIBIT 2.

I WOULD LIKE NOW TO SHARE WITH YOU SOME ACTUAL ENERGY CONSERVATION OPPORTUNITIES THAT EXIST IN OUR COMPANY. THESE ARE PROJECTS WHICH ARE COST EFFECTIVE FROM THE NATIONAL STANDPOINT SINCE THE ENERGY SAVINGS THEY REPRESENT CAN BE OBTAINED FOR SMALLER COST THAN WOULD BE REQUIRED TO PRODUCE EQUIVALENT AMOUNTS OF ENERGY FROM ALTERNATE SOURCES; HOWEVER, IN MANY CASES THEY ARE NOT GOING AHEAD BECAUSE OF POOR ECONOMICS TO INDUSTRY. FOR INSTANCE, LET US TAKE A LOOK AT PROJECT 3 WHICH PRODUCES A 22% SAVINGS IN ELECTRIC ENERGY. THE CAPITAL REQUIRED TO IMPLEMENT THIS PROJECT IS \$360 MILLION: A VERY LARGE AMOUNT OF MONEY FOR A COMPANY LIKE KAISER. THE RETURN ON INVESTMENT IS 6.9%, WHICH IS MUCH BELOW OUR HURDLE RATE OF 15% AT THE MINIMUM. THE CONSERVATION PRICE, SHOWN IN THE SECOND TO LAST COLUMN, IS 20 DOLLARS PER BARREL OF OIL EQUIVALENT. THIS IS THE COMPUTED COST OF PRODUCING THE ENERGY SAVINGS AND THEREFORE, CAN BE COMPARED DIRECTLY WITH THE COST OF PRODUCING EQUIVALENT ENERGY THROUGH ALTERNATE SOURCES. THE COMPUTATIONS OF CONSERVATION PRICE ARE EXPLAINED IN DETAIL IN THE MATERIAL WE HAVE SUBMITTED FOR THE RECORD. THE THRESHOLD BARREL OF OIL EQUIVALENT PRICE, WHICH IS SHOWN IN THE LAST COLUMN, IS THE COST OF PRODUCING AN ALTERNATE SOURCE OF ENERGY; IN THIS CASE, ELECTRICITY. WE ESTIMATE THIS COST AT 30 DOLLARS PER BARREL OF OIL EQUIVALENT OR 50 MILLS PER KILOWATT HOUR, WHICH IS THE MARGINAL COST OF PRODUCING ELECTRICITY VIA COAL OR NUCLEAR.

AS YOU CAN SEE, THE RETURN ON INVESTMENT IS TOO LOW FOR US TO IMPLEMENT THIS PROJECT. HOWEVER, THE ENERGY SAVED IS COST EFFECTIVE BECAUSE IT IS CHEAPER THAN PRODUCING EQUIVALENT ENERGY VIA ALTERNATE SOURCES. CONVERSELY, PROJECT NO. 4

SHOWN IN THE EXHIBIT IS COST EFFECTIVE TO INDUSTRY, SINCE IT HAS A RETURN ON INVESTMENT OF 40.3%. IT IS ALSO COST EFFECTIVE TO THE NATION, SINCE THE CONSERVATION PRICE IS 2.78, MUCH BELOW THE THRESHOLD PRICE OF 32 DOLLARS PER BARREL OF OIL EQUIVALENT. THIS PROJECT SHOULD NOT GET INCENTIVES, IN FACT, THIS PROJECT HAS BEEN IMPLEMENTED. THIS CONCEPT CAN BEST BE ILLUSTRATED, PERHAPS, BY THE NEXT EXHIBIT.

EXHIBIT 3.

HERE WE HAVE PLOTTED PROJECTS 1 THROUGH 4. THE HORIZONTAL AXIS SHOWS THE RETURN ON INVESTMENT AND THE VERTICAL AXIS SHOWS THE COMPUTED CONSERVATION PRICE. I WANT TO REPEAT THAT THIS IS COST EXPRESSED IN BARREL OF OIL EQUIVALENT OF CONSERVING THE ENERGY. AS YOU WILL NOTE, THE PROJECTS GENERALLY FALL ON A CURVE OF THE TYPE SHOWN ON THIS EXHIBIT. PROJECTS THAT HAVE MORE THAN 15% RETURN, DOWN IN THE LOWER AREA, ARE ECONOMICAL FOR INDUSTRY SINCE THEY HAVE ADEQUATE RETURNS AND, THEREFORE, DO NOT NEED ANY INCENTIVES TO PROCEED. PROJECTS ABOVE THE THRESHOLD PRICE, SHOWN HERE AS 30 DOLLARS, ARE THOSE WHICH ARE NOT ECONOMICAL FROM A NATIONAL STANDPOINT. IN OTHER WORDS, ENERGY SAVED BY THESE PROJECTS IS MORE EXPENSIVE THAN ALTERNATE SOURCES. THE PROJECTS IN THE SHADED AREA ARE PROJECTS WHICH SHOULD PROCEED FROM A NATIONAL STANDPOINT SINCE THESE PROJECTS ARE ECONOMICAL FOR THE COUNTRY BUT ARE NOT PROCEEDING BECAUSE THEY ARE UNECONOMICAL FOR INDUSTRY. THESE ARE THE ONLY PROJECTS THAT SHOULD RECEIVE INCENTIVES. OUR INCENTIVE PROPOSAL IS DESIGNED TO STIMULATE THE PROJECTS LOCATED IN THE SHADED AREA OF THIS EXHIBIT. IF A REASONABLE PORTION OF THESE PROJECTS CAN BE UNDERTAKEN, THE ENERGY SAVINGS COULD BE SUBSTANTIAL. OUR STUDIES SUGGEST THAT THE INCENTIVES WE PROPOSE HAVE THE POTENTIAL FOR CONSERVING UP TO 2.5 MILLION BARRELS OF OIL EQUIVALENT PER DAY. THIS IS MORE THAN A QUARTER OF OUR TOTAL IMPORTS OF TODAY. THUS, EVEN IF ONLY HALF OF THESE POTENTIAL SAVINGS ARE REALIZED, WE WILL HAVE

MADE SIGNIFICANT PROGRESS TOWARDS REDUCING OUR DEPENDENCE UPON IMPORTED ENERGY AND WE WILL HAVE DONE SO WITHOUT JEOPARDIZING LOSS OF VALUABLE INDUSTRIAL DOMESTIC CAPACITY, LOSS OF JOBS, AND DETRIMENTAL IMPACT ON OUR BALANCE OF PAYMENTS. OUR INCENTIVES PROPOSAL IS EXPLAINED IN DETAIL, INCLUDING SOLUTIONS FOR SOME COMPLEX IMPLEMENTATION PROBLEMS, IN THE MATERIAL THAT WE HAVE SUBMITTED FOR THE RECORD. I WILL DISCUSS HERE ONLY ITS ESSENTIAL FEATURES WHICH ARE QUITE SIMPLE AND ARE SHOWN IN THE NEXT EXHIBIT.

EXHIBIT 4.

CONSERVATION PROJECTS WOULD BE ELIGIBLE FOR INCENTIVES ONLY IF THE ENERGY SAVED BY THESE PROJECTS IS FIRST COST EFFECTIVE TO THE NATION. USING THE METHODOLOGY THAT WE HAVE DEVELOPED, WE CAN COMPUTE THE LIFE CYCLE COST EXPRESSED IN BARREL OF OIL EQUIVALENT OF PRODUCING THIS CONSERVATION ENERGY. THE COST OF PRODUCING THIS CONSERVATION ENERGY (DEFINED AS CONSERVATION PRICE) CAN BE THEN DIRECTLY COMPARED WITH THE COST OF PRODUCING EQUIVALENT ENERGY FROM ALTERNATE SOURCES. SO LONG AS THE COST FOR PRODUCING AN EQUIVALENT AMOUNT OF ENERGY FROM ALTERNATE SOURCES EXCEEDS THE COST OF PRODUCING ENERGY THROUGH CONSERVATION, THE CONSERVATION PROJECT IS COST EFFECTIVE TO THE NATION. SECOND, PROJECTS ARE ELIGIBLE FOR INCENTIVES ONLY IF THE ENERGY CONSERVED IS NOT COST EFFECTIVE TO INDUSTRY. IF THE PROJECT'S RETURN ON INVESTMENT EQUALS OR EXCEEDS A DESIGNATED TARGET RETURN, THE PROJECT WILL BE CONSIDERED COST EFFECTIVE TO INDUSTRY AND THEREFORE, WOULD NOT BE ELIGIBLE FOR INCENTIVES. LASTLY, WE PROPOSE 0-30% ADDITIONAL INVESTMENT TAX CREDITS. THE INCENTIVE WILL BE EQUAL TO THE AMOUNT NECESSARY TO PRODUCE A REAL RATE OF RETURN ON INVESTMENT EQUAL TO A DESIGNATED MINIMUM TARGET RATE OF RETURN SPECIFIED BY CONGRESS. WE CONTEMPLATE A TARGET RATE OF EQUAL TO AT LEAST 15%.

OUR POSITION PAPER DESCRIBES IN DETAIL THE METHOD FOR COMPUTING THE AMOUNT OF INCENTIVES AND THE CONSERVATION PRICE.

EXHIBIT 5.

THE IMPACT OF SUCH AN INCENTIVE PROPOSAL IS EXPLAINED IN THIS EXHIBIT. ONLY PROJECTS IN THE SHADED AREA WOULD BE ELIGIBLE FOR INCENTIVES. THESE PROJECTS WILL RECEIVE INCENTIVES BUT NO MORE THAN REQUIRED TO GIVE A SPECIFIED TARGET RATE OF RETURN, IN THIS CASE 15%, I.E. THE PROJECTS ON THE DOTTED LINE WOULD BE MOVED TO THE VERTICAL SOLID LINE THAT CORRESPONDS TO A 15% RETURN.

EXHIBIT 6.

IN SUMMARY, I WOULD LIKE TO REITERATE THE FOLLOWING POINTS:

1. A LARGE POTENTIAL EXISTS TO INCREASE ENERGY SUPPLY BY INDUSTRIAL CONSERVATION.
2. THIS POTENTIAL CAN BE REALIZED IN A RELATIVELY SHORT TIME.
3. A SIGNIFICANT AMOUNT OF COST EFFECTIVE ENERGY SAVINGS TO THE NATION IS NOT BEING CONSERVED DUE TO CAPITAL LIMITATIONS AND POOR ECONOMICS TO INDUSTRY.
4. INCENTIVES REPRESENT THE BEST MECHANISM TO CAPTURE SIGNIFICANT AMOUNTS OF ADDITIONAL ENERGY THROUGH INDUSTRIAL CONSERVATION.
5. WE HAVE SUBMITTED A PROPOSAL OF INCENTIVES FOR CONSERVATION FOR YOUR CONSIDERATION. THE PROPOSAL LIMITS INCENTIVES TO ONLY INDUSTRIAL PROJECTS THAT ARE ENERGY COST EFFECTIVE TO THE NATION AND WHICH NEED INCENTIVES TO PROCEED, THEREFORE, PROVIDING THE MAXIMUM ENERGY SAVINGS FOR EVERY DOLLAR OF INCENTIVES.

AGAIN, I APPRECIATE THE OPPORTUNITY TO APPEAR BEFORE THIS DISTINGUISHED COMMITTEE AND I THANK YOU.

EXHIBIT 1

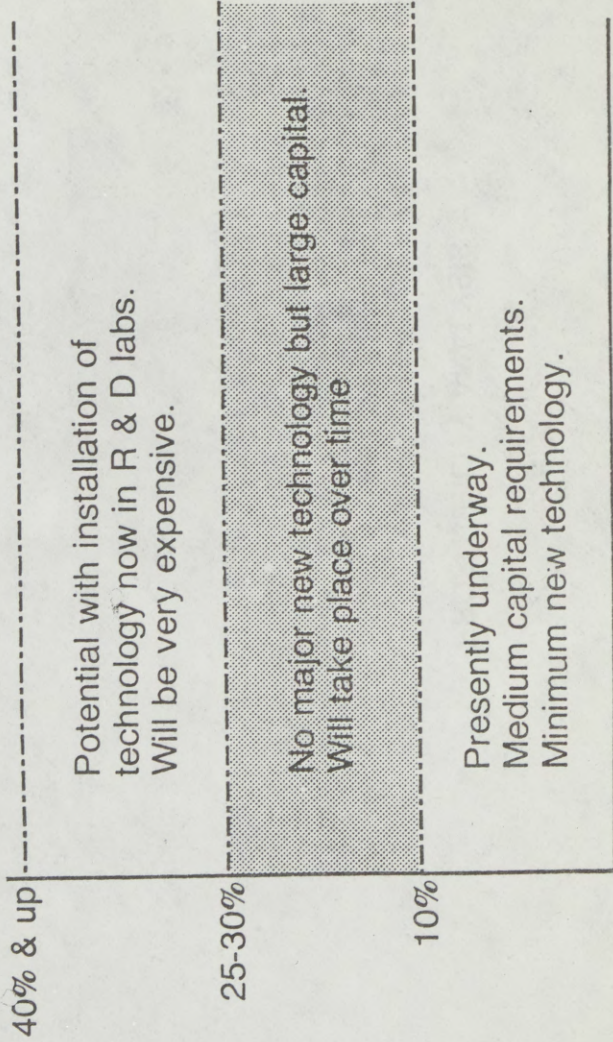
**INDUSTRIAL ENERGY
CONSERVATION POTENTIAL**

EXHIBIT 2

PROFITABILITY ANALYSIS

	Fuel Saved		Capital MM Dollars	ROI %	Conservation Price		Threshold Price \$/BOE
	%	Type			\$/BOE		
		No. 2					
Project 1	15.4	Fuel oil	4.3	14.9	14.34		28.0
Project 2	30.0	Gas	31.4	6.1	27.03		32.0
Project 3	22.0	Effect	360.0	6.9	20.0		30.0
Project 4	15.0	Gas	1.0	40.3	2.78		32.0

EXHIBIT 3 **COST/EFFECTIVENESS AND RETURN ON INVESTMENT**

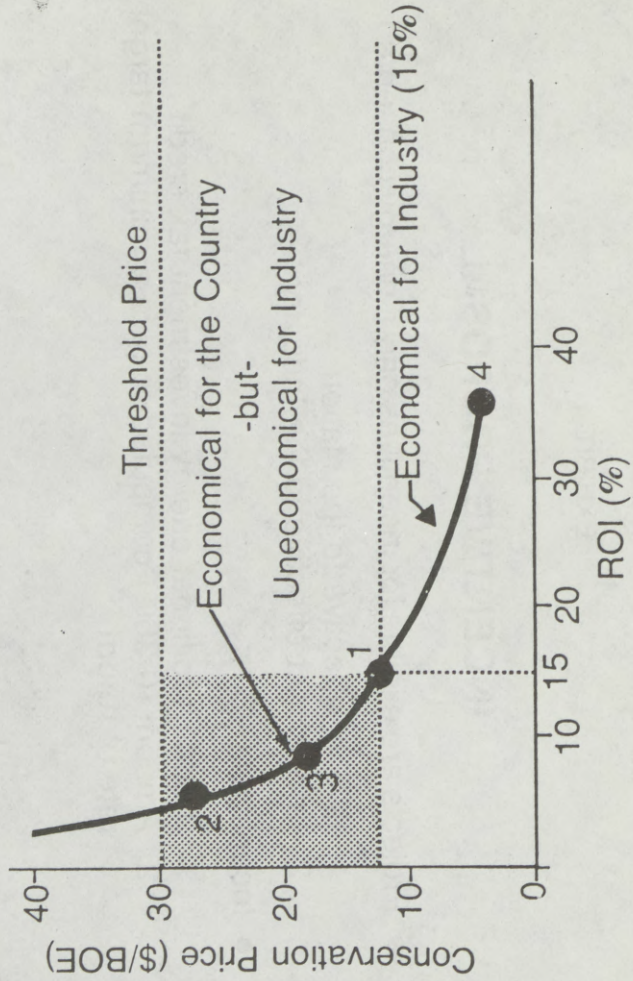


EXHIBIT 4

INCENTIVE PROPOSAL

- Projects are eligible for incentives only if energy conserved.
 1. **Is** cost effective to the Nation
 2. **Is not** cost effective to the Industry
- Incentives
 1. 0-30% Additional energy investment tax credit
 2. Amount (0-30%) computed to give a minimum target rate of return

EXHIBIT 5

IMPACT OF IMPLEMENTATION OF INCENTIVES

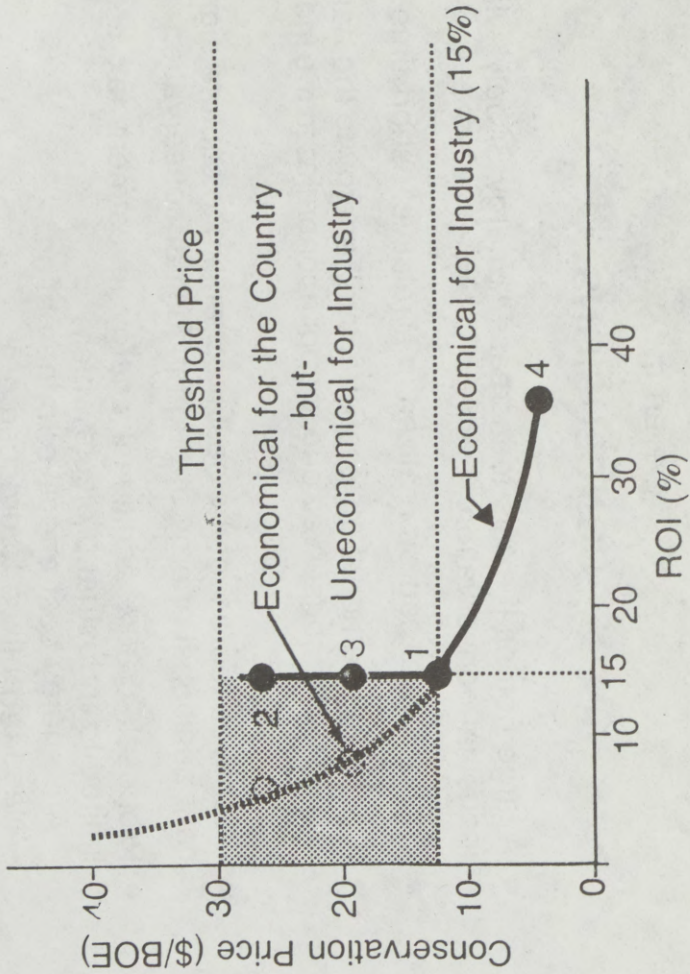


EXHIBIT 6

CONCLUSIONS

- A large potential exists to increase "Energy Supply" via industrial conservation.
- This potential can be realized in a relatively short time.
- A significant amount of "cost effective" energy to the nation is **NOT** being conserved due to poor economics to the industry.
- Incentives represent the best mechanism to capture significant additional energy through industrial conservation.
- Proposal: 0-30% additional energy investment tax credit limited to industrial projects which:
 - Are energy cost effective to the nation
 - Need incentives to proceed

STATEMENT OF CLEMENTE GOMES, CHIEF, FINANCIAL ANALYSIS,
KAISER ALUMINUM

Mr. GOMES. I am Clemente M. Gomes, associate director of energy, for Kaiser Aluminum & Chemical Corp.

First of all, I would like to apologize for my voice. I am just coming out of a bout of laryngitis and hopefully I can finish my testimony without too many problems.

By the way, running the Vu-Graph will be my associate Mr. Richard Pool, also associate director of energy for Kaiser.

I would like to say at the outset that our interest in the subject of energy conservation is not new and it is far from academic.

Kaiser Aluminum & Chemical Corp. operates 17 major manufacturing facilities in 30 States. We consume more than 200 trillion Btu's of energy each year, which places us among the top 25 energy consuming companies in the country.

The major form of energy which we consume is electricity generated from natural gas, oil, coal, and hydroelectric power. We have actively studied the subject of industrial energy conservation incentives for more than 5 years and have developed a proposal for incentives to stimulate industrial conservation projects.

I am submitting for the record a detailed description of our proposal and I will comment briefly on its major features during the course of my testimony this morning. Initially, however, I want to focus on two points.

First, the reasons we believe that energy conservation must be a critical part of any effective short-term strategy for energy independence; and second, why incentives are needed now to stimulate energy conservation projects.

The United States now confronts an energy problem that is becoming more severe each day. We must now devise and implement strategies to solve our energy problem in ways that will not have adverse economic implications in terms of employment, productive capacity, or otherwise. In the short term, that is over the next decade, our strategy options are few in number. Widespread production of synthetic fuels, solar energy and other alternative energy sources remains at least a decade away, and the role to be played by nuclear power remains uncertain, particularly in the short term. Governmental encouragement efforts to develop alternative energy resources is needed, but this is a long-term strategy for the 1990's and beyond.

In the short term, to decrease our dependence upon imported energy requires either increased domestic production of oil and gas or stimulation of conservation or both. Increased production is important, but it is not a substitute for the more efficient use of our energy resources. In our judgment, the case for conservation is self-evident simply because the other short-term options are so few. Our studies indicate that there is a significant potential for industrial energy conservation and that the realization of a significant portion of these conservation savings could be accelerated with carefully tailored incentives.

This conservation potential is illustrated in exhibit 1. The first level of conservation savings, about 10 percent, these are the savings

Mr. Reid mentioned in his testimony. They involve modest capital requirements and comparatively minimum new technology. With increases in energy prices these first-level projects have increasingly become cost effective. In the aluminum industry, and we believe in other industries as well, these first-level conservation savings have been and are being realized.

Our studies also indicate that in the energy intensive process industries such as ours, there is another 15 to 20 percent conservation potential which could be obtained with existing technology but which require substantial capital investments. These projects, which are represented by the shaded area in exhibit 1, will be implemented sometime in the future, but they are not being undertaken today. In our judgment, the main reason why these projects are not proceeding today is because of the large capital requirements needed to implement them and in many cases, they are not cost effective to industry, that is, the return on investment is not adequate.

There is a third zone above the shaded area which represents additional long-term conservation potential which is dependent upon the outcome of research and development efforts to develop new technologies. These research and development efforts are very important and must also be stimulated, but conservation savings in this area are not likely to be obtainable in the short term.

Thus, if we are to realize additional industrial energy conservation savings over the period of the next decade, our focus must be upon those "second level" projects represented by the shaded area in exhibit 1.

These are projects which have relatively low risk since they do not involve any major new technology. However, as I have indicated, the capital required by these projects is often so large that they are not now cost effective to industry. These projects will be cost effective in time, but not in the short term. Our studies have led us to conclude that properly tailored incentives can reach these "second level" projects and harness the significant energy conservation potential they represent.

We have concluded that from the Nation's standpoint, incentives are a more desirable route to harness this energy conservation rather than through mandatory approaches including artificial increases in energy prices.

In our judgment, there are at least four important reasons against mandatory approaches.

First: Our studies show that in many instances mandatory conservation orders would force industry to shut down valuable domestic industrial capacity, thus, compounding the problems of unemployment and balance of payments.

Second: We believe that mandatory conservation is discriminatory, since it places a higher burden on energy intensive industries such as ours.

Third: Mandatory conservation will force industry to undertake many uneconomical projects, thus worsening the already serious capital formation problem.

And last: In many cases, mandatory conservation would force implementation of projects which are not cost effective from the Nation's standpoint, that is the cost of producing energy by means of conservation would be higher than producing the same energy by means of alternate sources, certainly an undesirable situation.

I will be discussing further this concept of "cost effective to the Nation" later in my testimony.

Mr. Chairman, for these reasons we believe that incentives for conservation projects may be the country's best short-range strategy to harness this significant potential for energy savings.

I would like now to share with you some actual energy conservation opportunities that exist in our company.

These are projects which are cost effective from the national standpoint since the energy savings they represent can be obtained for smaller cost than would be required to produce equivalent amounts of energy from alternate sources.

However, in many cases, they are not going ahead because of poor economics to industry.

For instance, let us take a look at project 3 which produces a 22 percent savings in electric energy. The capital required to implement this project is \$360 million—a very large amount of money for a company like Kaiser.

The return on investment is 6.9 percent, which is much below our hurdle rate of 15 percent at the minimum. The conservation price, shown in the second to last column, is \$20 per barrel of oil equivalent. This is the computed cost of producing the energy savings and therefore, can be compared directly with the cost of producing equivalent energy through alternate sources. The computations of conservation price are explained in detail in the material we have submitted for the record. The threshold barrel of oil equivalent price, which is shown in the last column, is the cost of producing an alternate source of energy; in this case, electricity.

We estimate this cost at \$30 per barrel of oil equivalent or 50 mills per kilowatt hour, which is the marginal cost of producing electricity via coal or nuclear power.

As you can see, the return on investment is too low for us to implement this project. However, the energy saved is cost effective because it is cheaper than producing equivalent energy via alternate sources. Conversely, project No. 4 shown in the exhibit is cost effective to industry, since it has a return on investment of 40.3 percent. It is also cost effective to the Nation, since the conservation price is \$2.78, much below the threshold price of \$32 per barrel of oil equivalent. This project should not get incentives. In fact, this project has been implemented. This concept can best be illustrated, perhaps, by the next exhibit.

Here we have plotted projects 1 through 4. The horizontal axis shows the return on investment and the vertical axis shows the computed conservation price.

I want to repeat that this is cost expressed in barrel of oil equivalent of conserving the energy.

As you will note, the projects generally fall on a curve of the type shown on this exhibit. Projects that have more than 15 percent return, down in the lower area, are economical for industry since they have adequate returns and, therefore, do not need any incentives to proceed. Projects above the threshold price, shown here as \$30, are those which are not, I repeat, not, economical from a national standpoint.

In other words, energy saved by these projects is more expensive than alternate sources. The projects in the shaded area are projects which should proceed from a national standpoint since these projects

are economical for the country but are not proceeding because they are uneconomical for industry.

These are the only projects that should receive incentives. Our incentive proposal is designed to stimulate the projects located in the shaded area of this exhibit. If a reasonable portion of these projects can be undertaken, the energy savings could be substantial. Our studies suggest that the incentives we propose have the potential for conserving up to 2.5 million barrels of oil equivalent per day. This is more than one-quarter of our total imports of today.

Thus, even if only half of these potential savings are realized, we will have made significant progress toward reducing our dependence upon imported energy, and we will have done so without jeopardizing loss of valuable industrial domestic capacity, loss of jobs, and detrimental impact on our balance of payments.

Our incentives proposal is explained in detail, including solutions for some complex implementation problems, in the material that we have submitted for the record. I will discuss here only its essential features, which are quite simple and are shown in the next exhibit.

Conservation projects would be eligible for incentives only if the energy saved by these projects is first cost effective to the Nation. Using the methodology that we have developed, we can compute the life cycle cost expressed in barrel of oil equivalent of producing this conservation energy.

The cost of producing this conservation energy, defined as conservation price, can then be directly compared with the cost of producing equivalent energy from alternate sources. So long as the cost for producing an equivalent amount of energy from alternate sources exceeds the cost of producing energy through conservation, the conservation project is cost effective to the Nation.

Second: Projects are eligible for incentives only if the energy conserved is not cost effective to industry.

If the project's return on investment equals or exceeds a designated target return, the project will be considered cost effective to industry and, therefore, would not be eligible for incentives.

Last: We propose 0 to 30 percent additional investment tax credits. The incentive will be equal to the amount necessary to produce a real rate of return on investment equal to a designated minimum target rate of return specified by Congress. We contemplate a target rate equal to at least 15 percent.

Our position paper describes in detail the method for computing the amount of incentives and the conservation price.

The impact of such an incentive proposal is explained in this exhibit. Only projects in the shaded area would be eligible for incentives. These projects will receive incentives, but no more than required to give a specified target rate of return, in this case 15 percent; that is, the projects on the dotted line would be moved to the vertical solid line that corresponds to a 15-percent return.

In summary, I would like to reiterate the following points:

One: A large potential exists to increase energy supply by industrial conservation.

Two: This potential can be realized in a relatively short time.

Three: A significant amount of cost effective energy savings to the Nation is not being conserved, due to capital limitations and poor economics to the industry.

Four: Incentives represent the best mechanism to capture significant amounts of additional energy through industrial conservation.

Five: We have submitted a proposal of incentives for conservation for your consideration. The proposal limits incentives to only industrial projects that are energy cost effective to the Nation and which need incentives to proceed, therefore, providing the maximum energy savings for every dollar of incentives.

Again, I appreciate the opportunity to appear before this distinguished committee, and I thank you.

Mr. OTTINGER, Thank you very much for a very interesting testimony.

I will hear last from Mr. Sternlicht, technical director, Mechanical Technology, Inc. [MTI].

[The biographies and prepared statements of Dr. Beno Sternlicht and Mr. Donald Colosimo follow:]



**U.S. House of Representatives Hearings
Subcommittee on
Energy Development and Applications**

prepared by
Dr. Beno Sternlicht
and
Donald Colosimo

Mechanical Technology Incorporated
Latham, New York 12110

September 11, 1979

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About the AuthorsDr. Beno Sternlicht

Board Chairman and Technical Director, MTI; Ph.D., M.S., Columbia University; Honorary Doctor of Science and B.S.E.E., Union College. 28 years of industrial experience in various capacities of engineering and management. The first 11 years spent with the G.E. Company in the capacity of Specialist, Technical Director and Consulting Engineer. For the past 17 years, has been that of Technical Director, Co-founder and Chairman of the Board of MTI. 1966-70 served as President and 1970-73 as Board Chairman of VITA (Volunteers in Technical Assistance). 1978-79 served on the Presidential Domestic Policy Review Committee on Industrial Innovation. Author of numerous technical papers and books. Fellow of ASME and recipient of its Machine Design Award 1966. Holder of 11 patents. Listed in Engineers of Distinction, Leading Men in the United States of America, American Men of Science and Who's Who in Finance and Industry.

Donald Colosimo

Manager Business Planning, MTI; M.S., B.S. Massachusetts Institute of Technology; M.B.A. State University of New York with over 17 years of industrial experience in various engineering and management positions. Involvement in energy programs and policy range from manager of a state energy R&D program in Ohio, to manager of energy R&D for the American Gas Association, to manager of business planning for energy productivity technologies at MTI.

Testimony of Dr. Beno Sternlicht and Donald Colosimo

of

Mechanical Technology Incorporated, Latham, N.Y.

Before

Subcommittee on Energy Development and Applications

Committee on Science and Technology

U.S. House of Representatives

September 11, 1979

INTRODUCTION

Mr. Chairman and Members of the Committee:

I am Beno Sternlicht, Board Chairman, Technical Director, and cofounder of Mechanical Technology, Inc. (MTI), a high-technology corporation specializing in the development and production of energy conversion and utilization products. I am accompanied by Donald Colosimo, Manager of Business Planning at MTI. It is with great pleasure that we testify before you today on the government's role and policy on Industrial Energy Conservation. This is a subject with which we, at MTI, are deeply concerned and one which we feel particularly well suited to address. When MTI was founded in 1961, it was our objective to make our company THE model for the innovation and commercialization of high-technology electro-mechanical equipment. While MTI has developed and is developing products for the consumer and industrial markets, MTI only manufactures products for the industrial market. In trying to develop and commercialize advanced machinery products for the industrial market, MTI sought to use energy efficiency and reliability as the new product attributes. Thus, we have been strong advocates of the life-cycle cost philosophy. Energy efficiency was a product feature that MTI tried to promote even before the advent of the energy crisis. With the energy crisis, we have increased our efforts to develop and commercialize energy efficient machinery for the industrial market. Our comments today draw upon this experience of MTI in developing and commercializing products for Industrial Energy Conservation.

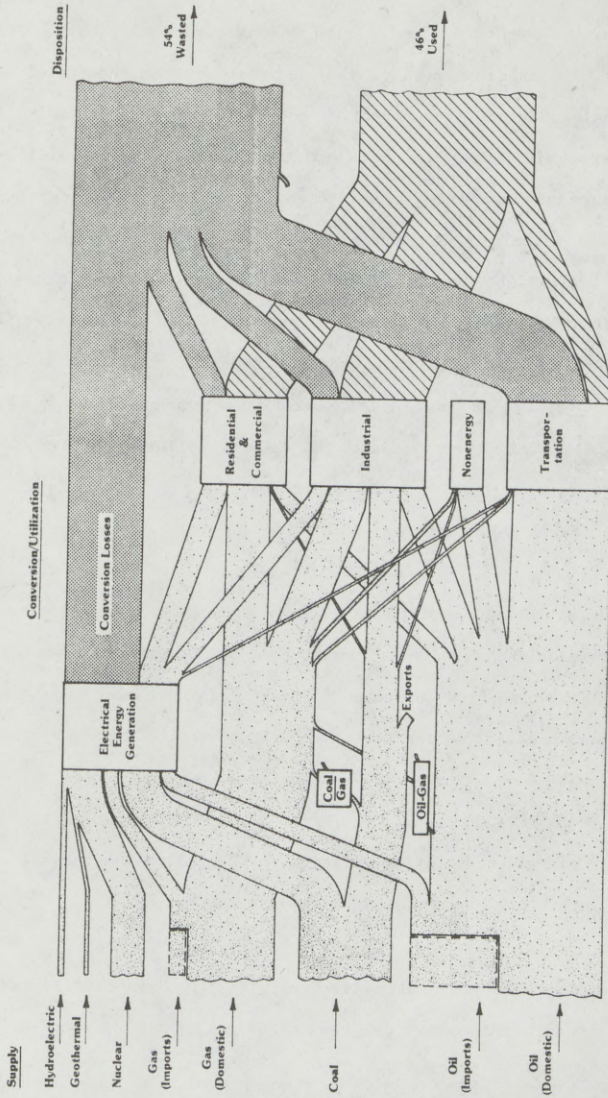
GENERAL OBSERVATIONS

Mr. Chairman, we have been blessed with a long period of plentiful energy at cheap prices. During this period, the vast bulk of the industrial equipment designs, housing design, transportation mode selection and general life style evolved. Energy efficiency was not important or cost effective. Therefore, today we have in place energy inefficient processes, machinery, buildings, appliances and vehicles. For example, we are driving automobiles which are nominally 15% efficient, we are heating our homes at 55% efficiency (or less with electric resistance heat), and our industries are characteristically 35% efficient. In addition to wasting energy, these practices also lead to environmental problems. The energy left over after conversion is present in a myriad of waste heat streams leading to thermal pollution. The use of more energy than necessary results in more particulates, SO_2 , CO_2 , NO_x and all the other environmental pollutants.

The wastefulness of our society is clearly indicated in a report issued in 1973 by the Joint Congressional Committee on Atomic Energy entitled "Understanding the National Energy Dilemma." Figure 1 is extracted from this report and shows that about 55% of the energy used is wasted. Obviously, the laws of thermodynamics will not permit 100% useful work, so some waste is necessary, but not as much as indicated. The waste indicated is actually understated since through energy productivity, with improved utilization technologies, the same useful work can be accomplished with less energy.

The need for improved utilization technologies has been clearly recognized; however, actions to encourage them have been lacking or ineffective. On many

Projected 1980 Energy Flow



Source: "Understanding the National Energy Dilemma"
A report of the Joint Committee on Atomic Energy, 1973

Figure 1

occasions, we have noted in the Federal government the lack of emphasis, commitment, policy and funding toward improved energy utilization technology development and utilization. Efficient energy utilization or "conservation" technology has been subjugated to the supply technologies. This is partly because the word "conservation" has evoked images of doing without and making sacrifices, while supply has been regarded as an insurance policy for continuation or improvement in our life-style. There seems to be, also, a pervading belief that the public will conserve through change in life-style, that industry can be forced into conservation measures through regulatory initiatives, or that our free enterprise system will lead naturally to the required technological end-use improvements. It appears that, for these reasons, the governmental authorities have concluded that the supply technologies must be largely federally supported and that the end-use technologies can be left largely to their own devices.

It is essential that Congress and the executive branch understand that energy conservation, through efficiency improvements and the development of new processes, can actually preserve or improve our life-style, and, very importantly, provide more time for a transition to the use of synfuels and renewable resources. Improvements in end-use conversion equipment efficiency are the lowest cost way to produce fuel availability; or in other words, it is less expensive to make a barrel of oil available by saving it with improved efficiency equipment than it is to produce a barrel with a synfuel plant.

Energy conservation should not mean "doing without" or "suffering". It is unfortunate that this meaning is the accepted meaning. In order to secure

popular support for true energy conservation, we will need to call it something else. The term "energy productivity" has been introduced recently. This term is very reflective of what we are trying to accomplish and does not have any negative connotations. Therefore, we will try to use the term energy productivity throughout the remainder of our testimony.

While energy productivity is important in all sectors of our economy, it is fitting that this subcommittee is placing particular emphasis on the problems of energy productivity in the industrial sector. The opportunities for conservation in the industrial sector are immense, both in relative and absolute terms. Relative to other industrial nations, the U.S. uses more energy per unit output as shown in Figure 2 for a comparison with Germany. There are three reasons for this difference. First, the European and Japanese industrial capital plant is newer. Having been destroyed during World War II, it was rebuilt with newer technology. Secondly, the cost of energy in the other industrialized nations has always been higher due both to the costs of the raw energy stocks and high taxes. The high costs of energy made energy productivity pay. Thirdly, their social attitudes are more attuned to practicing conservation. The U.S. has been conditioned to a throwaway economy. In an absolute sense, industry wastes a vast amount of energy. Figure 3 presents data from a recent study for DOE which shows that about 11 quads of heat are rejected from industrial processes. Obviously, industry is a prime target for energy productivity. The problem then, is how can this potential for energy productivity be realized.

Implicit in the fact that hearings are being held on industrial energy productivity and that there are industrial energy productivity programs in DOE is

**Energy Use Per Ton of Petroleum Products,
Steel and Paper for the
United States and West Germany — 1972**

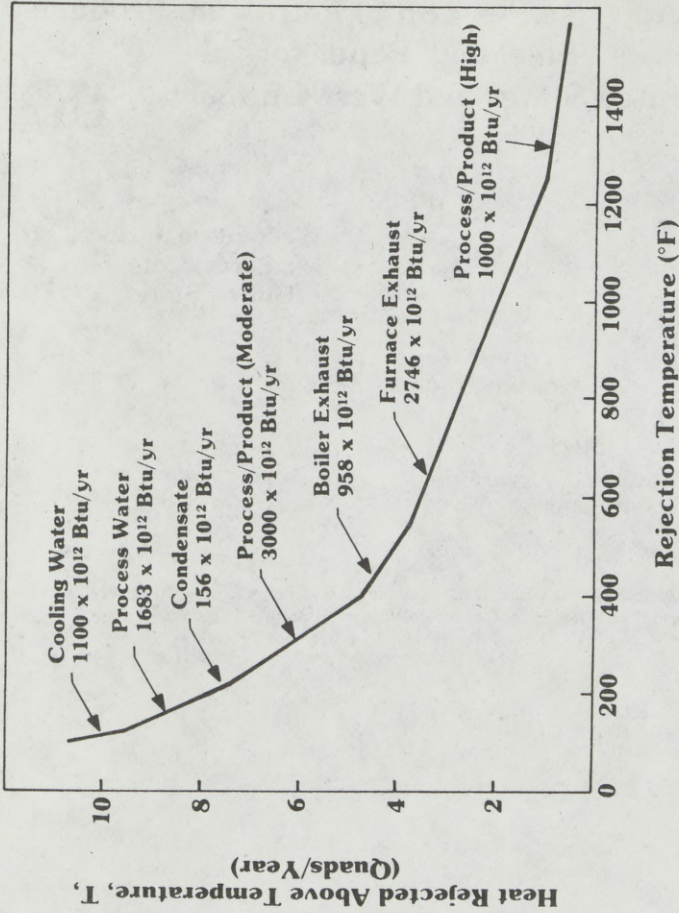
**West Germany as
Percent of
United States**

Petroleum Products	67%
Steel	68
Paper	57

Source: Geon, R.L. and White, R.K., "Comparison of Energy Consumed Between West Germany and the United States," Standard Research Institute, June 1975.

Figure 2

Distribution of Industrial Waste Heat Flows



Ref. "Industrial Applications Study" DOE Report HCP/T 2862-01, March 1978

Figure 3

the belief that government has a role in making industrial energy productivity a reality. In order to address the government's role, it is necessary to clearly define the objective. It is our understanding that the government's objective in energy R&D is to stimulate and accelerate the "commercialization" of revolutionary energy end-use equipment and supply technologies. In this way, we, as a nation, can continue to maintain and improve our standard of living without the excessive impact of foreign entities such as OPEC. The basic questions relating to this objective are:

- 1) Why is government involvement needed?
- 2) What can government do that is effective?

The three questions posed in Representative Ottinger's letter are really subsets to these two more basic questions as related to industrial energy productivity. In order to effectively respond to Representative Ottinger's questions, the more fundamental questions will be addressed in light of our perception of the government's objective.

The first step in responding is to distinguish among the various types of industrial energy productivity options. Next, it is necessary to understand the commercialization process and decision criteria that impact upon commercialization. Finally, it is necessary to relate the impact of current and proposed Federal policies on these decision processes as they relate to energy productivity. We will then be in a position to respond to the specific areas of concern today. All these points are covered in the written statement. In our verbal presentation, we will limit our comments primarily to the first and last points.

INDUSTRIAL ENERGY PRODUCTIVITY

Energy productivity in the industrial sector can be realized by entirely new processes, by improvements in components, and by energy cascading. New processes are easily understood. Improvements in components, while easily understood, are less obvious. Industrial machinery components such as motors, pumps, compressors, and steam turbines, all have room for basic design point efficiency improvements. In general, however, the larger the unit of equipment, the smaller the potential for efficiency improvement. This is due to the fact that efficiency in large machinery costs less per unit of gain than in small machinery, and, therefore, has been economic even with low energy costs. Energy cascading is an unfamiliar concept outside the scientific community. The basic premise for energy cascading is the matching of the quality (temperature) of available energy to the needs of the tasks at hand. The available energy can be either direct fuel energy or rejected, and normally wasted, energy from another task. Actually, energy cascading is a restatement of good engineering design practice based on the Second Law of Thermodynamics. Conventional engineering design practice only considers the quantity of heat required for a task, not its quality. While we are accustomed to seeing high system efficiencies expressed on the basis of conventional engineering practices, most processes are very inefficient when measured against energy cascading. A good example of this is a residential furnace. Under the conventional (First Law) definition, the gas furnace is 75% efficient; under the energy cascading (Second Law) definition, the gas furnace is only 5% efficient.

For a clearer illustration of the energy cascading concept, refer to Figure 4. On the left side of Figure 4 are listed five processes or cycles. Each

Illustration of Energy Cascading Concept

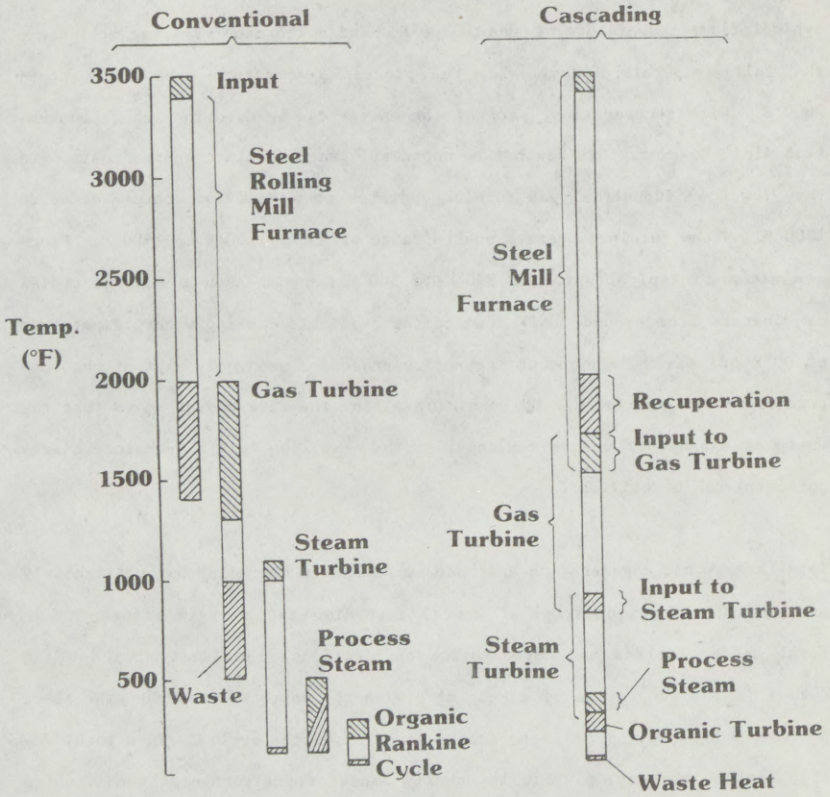


Figure 4

process uses heat at a higher temperature and rejects heat at a lower temperature. The maximum quality or temperature of heat that occurs is that of a typical flame temperature of about 3500°F. While the steel rolling mill needs the full temperature available, the process temperature exhaust is about 2000°F. With recuperation, part of the energy can be used to preheat combustion air. However, this has not been general practice since energy costs were very low. An industrial gas turbine operates at a peak temperature of up to 1800°F. Steam turbines operate over a range of about 1100°F to 1400°F. Process steam is typically in the 300°F to 500°F range. Organic Rankine cycles can operate from around 300°F down to the available cooling water temperature of 90°F or less. Each one of these five processes uses only part of the temperature range available. By combining all of the five processes so that the waste or exhaust of one is the input to the next, the full temperature-energy potential can be utilized.

Total energy and cogeneration are based upon energy cascading but utilize only part of the total potential of energy cascading as shown in Figure 5. In total energy systems and cogeneration applications, the first step (or top cycle) is the generation of electricity with the waste heat of the generation process being the input of the second step (or bottom cycle). In a total energy system, the bottom cycle is usually used for environmental conditioning (heating and cooling a building and heating water). In cogeneration applications, the bottom cycle is usually process steam for an industrial plant. While combining a few of the steps is more energy efficient than the separate steps, considerably more energy could be saved by fully applying the concept of energy cascading. Whereas energy cascading is the ultimate for energy productivity, it is difficult to find situations where energy cascading can be

Example of Partial Energy Cascaded Techniques

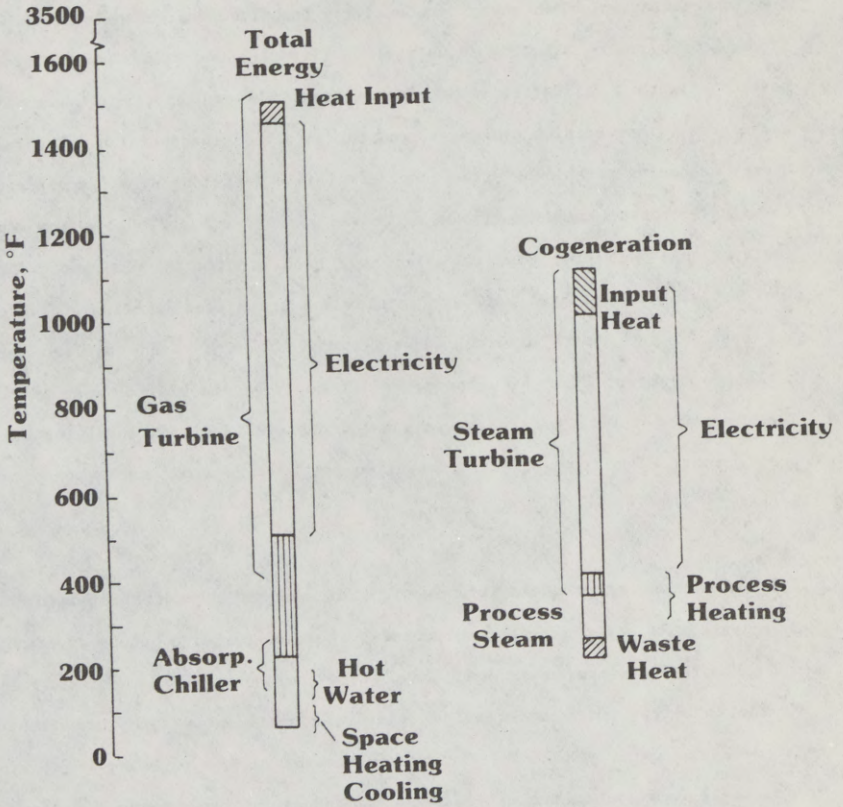


Figure 5

fully utilized in a single industrial process or even a single industrial plant. Partial cascading is readily possible, desirable and, now economic. The implementation of an energy productivity technique must be related to how it impacts upon the existing industrial facilities and decision making processes. Figure 6 illustrates the interactions between energy productivity techniques, the decision processes, and the impact of the decision. The full energy cascading techniques often involve multiple decisions by different sectors. The costs, commitments and perceived risks are high. There are many institutional barriers, most of which have been erected by the government. The problems in this area are very complex and are presently being addressed at least in regards to utility-industrial cogeneration. Since this area is not the subject of discussion today, no further comments will be made on it. The area of interest is the conventional industrial decision involving only one company. The types of implementation paths range from simple component retrofits to building whole new plants.

The easiest energy productivity technique is the replacement of inefficient components with more efficient components. Motors, pumps, compressors, fans, and steam turbines are common examples. These components offer the least risk to the industrial user and require relatively small amounts of investment. However, the gains realized from the replacement of a single component are very small relative to the other losses in industrial processes. Therefore, there is little interest in the development of more efficient components by the users. Also, since components are used by everyone, no single user company or industry has an incentive to support the development of something for other companies and industries. The suppliers of such equipment have little

Decisions Relating to Implementation of Industrial Energy Productivity Techniques

Type of Decision	Energy Productivity Technique	Comments
Conventional Industrial Decisions	Improved Components	Retrofits, low capital requirements, low risk
	Process Modifications	
	New Processes	Major capital investment, high risk
Integrated, Industrial-Societal Decisions	Cogeneration	Full energy cascading involves institutional barriers, high costs, long-term commitments, and perceived high risk
	Community Energy Integration	
	Industrial Energy Parks	

Figure 6

incentive to develop more efficient equipment since the returns of bringing out a revolutionary product are inadequate and the current products are selling very well. These points will be amplified further.

The next easiest energy productivity technique would be modification to the existing processes to make them more efficient. These process retrofits imply an add-on of some type of equipment. Recuperators, waste heat boilers, industrial heat pumps and Rankine bottoming cycles are examples of these techniques. While these techniques offer the potential of large savings per unit installation, they are more capital intensive and present higher risk since they are more integrated into the primary production process. The industrial users have no incentive to sponsor the development of these retrofit options. The potential manufacturers see very large development, demonstration and market introduction expenses. These expenses, combined with long developmental periods, produce inadequate returns along with a very high risk.

The final energy productivity technique is a revolutionary production process. Revolutionary production processes offer the potential for very large energy savings. However, the development costs are very large, the development risks are very high, and the implementation capital investment is very high. In general, the new processes are developed by the end user.

The problems associated with the development and commercialization of the three energy productivity techniques are slightly different. Their potential for energy savings is different, as is the timing of their impact. Figure 7 illustrates the timing and savings potentials for each technique. A very important consideration is that all three techniques are needed. Integrated

Timing and Relations of Industrial Energy Productivity Alternatives

Energy Productivity Alternative	Implementation Timing	Potential for Energy Savings	Needs and Relationships
Improved Components	Near- to Mid-Term	Moderate	Builds upon basic advances in mechanics, materials, aerodynamics and other technologies
Process Improvements	Near- to Mid-Term	High	Builds upon improved components and system integration
New Processes	Mid- to Long-Term	Highest	Builds upon improved components, proven process modifications and basic advances in process engineering

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Figure 7

processes are built up of subsystems and components. The advances in components will enhance and, possibly, make some of the retrofit process modifications and new processes economic. The new processes will directly incorporate heat exchange, heat pumps and bottoming cycles from the initial design. Government policy needs to account for the differences in the industrial energy productivity needs.

Discussions of energy productivity with government officials usually turn to the discussion of commercialization. Obviously, energy savings will not be realized until and unless the energy productivity technology is utilized. The quantity of energy savings is related to the energy savings potential inherent in the technology combined with the total energy consumed by the replaced technology and with how much and how fast the old technology is replaced by the new technology. Therefore, commercialization is important. However, commercialization is becoming an overused term and is a misunderstood term. With all the interest in commercialization, it is important to understand the term and the industrial decision processes related to commercialization.

According to Webster, commercialization means "to be profitable in a business way." The operative word is "profitable." Simply selling or offering to sell a product is not commercialization unless there is an amortization of and return on the total investment needed to bring the product to market. Further, the return on the investment must be greater than the return on risk-free investments like treasury bonds. Industry will not invest in the development and manufacture of a product unless there is a reasonable expectation for profit. This means that there must be an adequate number of buyers for the product at a price which will not only cover the cost of manufacture, but also

provide an economic return on the total investment. Government R&D policy partially recognizes the question of profitability by providing funds for the cooperative development of energy productivity and supply technologies. However, other aspects of government R&D policy tend to negate this, particularly in the area of patent rights.

Given a supplier or manufacturer, there must also be a customer. The buyer of a product buys it because it satisfies a real or perceived need at the lowest cost. For the individual consumer, many factors enter into the definition of the need including status, aesthetics, social custom, etc. However, whether the consumer is satisfying his need for an automobile by buying a Citation or a Mercedes, he wants to get it at the lowest price. If the product does not visibly impact the perceived status of the individual consumer, price is the prime determinant in the purchase. For industrial customers, life cycle costs are the prime determinant in the purchase if the product satisfies all the other specifications. There has been some recognition by the government of the fact that the value of energy savings to the customer does not justify the cost of new energy conservative products. Therefore, tax credits for solar equipment have been granted. Incentives for the industrial sector have been enacted in the form of added investment tax credits. Other industrial incentives are being proposed.

The key factor in the commercialization process is the existence of a product which satisfies a need for a customer. Without a product, the whole commercialization process ceases. The identification of revolutionary products in any field is risky. The probability that basic research will produce a product is low. If a product is identified, the payoff is very long range. For

example, one industrial process has taken over 100 years from the time it was first identified until it was in general use. A more typical time for identification to widespread commercial use for industrial products is 30 years. For these reasons, basic research is not vigorously funded by industry. Aside from a few programs in a few central laboratories of the very largest companies in the country, basic research is in the realm of academia and individual inventors.

The commercialization process involves four basic elements - a product concept, a manufacturer, a product-need match and a buyer. Since commercialization implies profitability, price enters the process relative to both the seller and buyer. The paths that flow among these various elements have major barriers, as shown in Figure 8, which must be hurdled. The various barriers in the commercialization paths are such that any single barrier can produce failure for the development. The form and content of the barriers between the basic elements are listed in Figure 9. Some of the barriers are amenable to government action, others may not be.

Starting with the concept-manufacturer linkage, there are a number of problems which may defy government action. First is the problem of the development of a product concept. As noted earlier, industry spends little on basic research. The findings of the Advisory Committee on Industrial Innovation suggest that industrial funding on any type of product development is being reduced due to the requirements of meeting various environmental, safety, or performance standards (see Attachment A). Thus, there is a major problem in the performance of basic research and revolutionary product developments. The next problem is the high risk of failure. Data on new product developments

Major Elements and Barriers to Commercialization

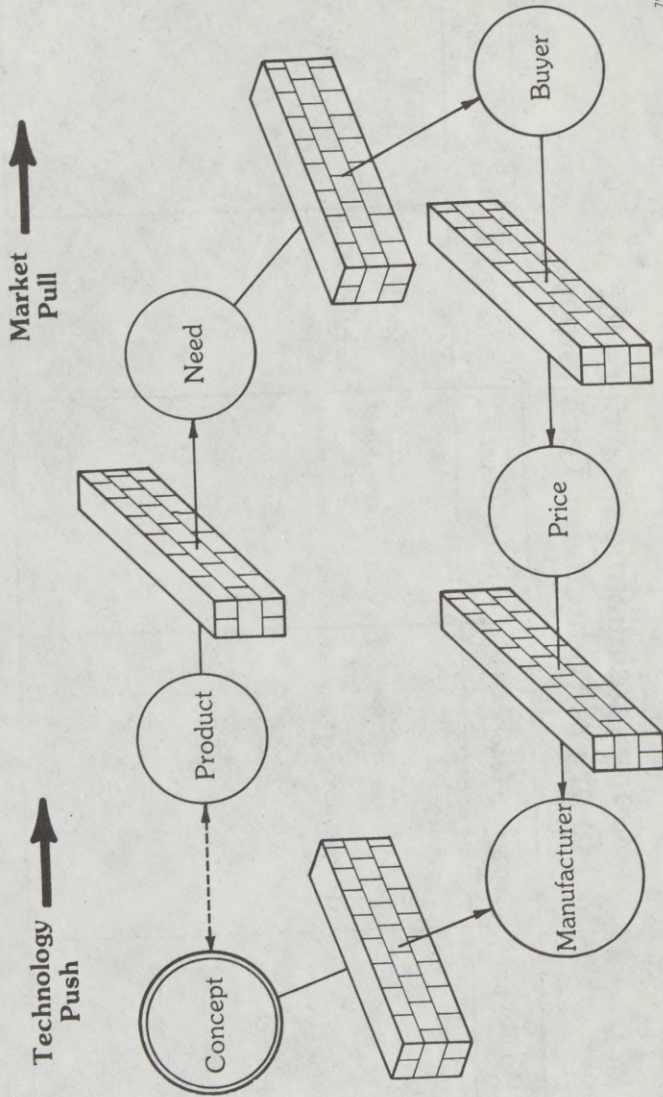


Figure 8

Commercialization Barriers for Energy Productivity Technology

Concept - Manufacturer	Concept - Product - Need	Need - Buyer	Price - Buyer	Price-Manufacturer
Development of Concept Risk NIH Attitude Current Products Current Investments Investment Time Span Earnings Impacts Business Condition	Technology Push Codes and Standards Demonstrated Performance Market Pull	Risk Corporate Incentives Current Investments Business Condition	Inadequate Return High Threshold Risk	Inadequate Return Risk

Figure 9

show that new products typically fail (Figure 10). While there is some uncertainty in the data, it is generally believed that less than 2% of all product concepts break even. Anything that increases uncertainty increases the perceived risk of failure. Unfortunately, governmental action and inaction has produced significant uncertainty. Given the fact that the manufacturers usually do not develop the concept, the developer of the concept must have a manufacturer accept the concept for it to be further developed. It is at this point that a major problem arises due to human nature. This problem is well known and called the NIH (Not-Invented-Here) attitude. Even though corporate engineering staffs are not making basic developments, there is an implication of failure in their acceptance of an idea from the outside. The next problems relate to current products and investments. If a company just brought out a new product, it has an investment that it would want to recover; or if a company just made an expansion of production capacity, it has an investment it would want to recover. In both these cases, the manufacturer's commitment to these investments and products will constrain his desires for a new product. The investment time span for the product development has an impact. This problem in industry is similar to the problem in government in that there is a strong incentive for short-term results. The President of the United States must appear before the electorate after four years and tell them what he has accomplished. A corporate president reports to his board of directors and stockholders each year. Investments in new products that have a payoff ten years in the future do not have the impact of an investment that has a smaller one-year payoff. This problem relates directly with the next problem. Any investment that results in a negative impact on reported corporate earnings over the short term receives very low grades. The final problem is the business condition of the company and the economy in general. It is well known

Product Idea: Failure and Expense Profiles

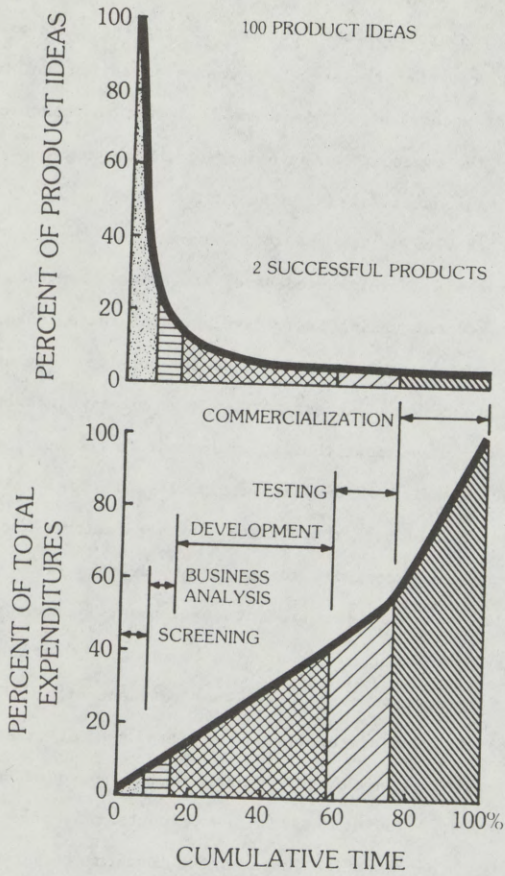


Figure 10

that some U.S. industries are very sick and are not in a position to innovate. Combine this with a recession economy and the result is a virtually insurmountable barrier to new product development.

The barrier between the concept-product and the need tends to be composed of primarily technical problems. The principal problem is the matching of the product concept and the market need. We are all familiar with the terms "technology push" and "market pull." Unfortunately, technology push is often a case of a technology in search of an application since the developer is insulated from the realities of the market. Also, the market pull often goes unsatisfied since those with the knowledge of the market need do not have the technical skills or resources to satisfy it. If there is a match between a product concept and a market need, there are a number of codes, standards and practices that must be satisfied. Unfortunately, codes and standards have been developed to protect against stupidity or to shield against failure. They are, therefore, very conservative and restrain innovation. Assuming all these problems are overcome, the product concept must be demonstrated. This performance demonstration can cause an extreme problem to the manufacturer for some products in some industries. For example, in many chemical and petroleum companies, a piece of equipment can not be purchased unless it has been in similar service for two years. This is a classic example of Catch-22.

There are a number of problems which impose a barrier between the need and the buyer. Until many buyers are willing to pay for a product to satisfy a need, there is no market. The distinction between a need and a market eludes many people and has resulted in many product and company failures. The key barrier is the risk associated with the use of the product. This ties in with the

codes and demonstrated performance. If there is little risk that the product will fail and, more importantly, will not impact production if it does fail, the product will be viewed favorably. The next problem is one of corporate incentives to plant managers and purchasing decision makers for buying energy productivity equipment. Evaluation by managers is based upon many criteria, including sales volume and profits. Energy productivity is not an explicit evaluation factor. If the manager can take his investment budget and use it to buy more production equipment, he will do that rather than increasing energy productivity. This decision is in his best interest, not necessarily in either his company's or the nation's. Another problem is the current investments made by the prospective buyer. If a new piece of machinery, process or plant has been installed, the decision to replace it will be very difficult. The final problem is the general business condition of the company and the economy.

The barriers between the price and buyer and the price and manufacturer are very similar and are basically economic. Before the buyer purchases a piece of equipment or invests in a new process, he asks the question as to what will be his return on the investment. This return is compared to other investment opportunities and corrected for the risk involved in the investment. Energy productivity falls into the lowest investment class and, thus, faces the highest return thresholds (see Figure 11). If there is any risk perceived associated with the investment, even higher returns will be demanded by the buyer. Since government action is viewed as an unknown and, therefore, a risk, the purchase of energy productivity technologies has been deferred. The manufacturer also wants to know if his investment will yield an acceptable return. Since any risk perceived with the investment will raise the rate return deemed

Investment Categories and Typical DCF Threshold

Investment Category	DCF Threshold
Mandatory (e.g., EPA, OSHA, Stay-in-Business)	None
Production Expansion	10% - 20%
New Products	15% - 25%
Discretionary Cost Saving	20% - 30%
Perceived Risky Discretionary	>30%

Figure 11

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acceptable, and since government actions have been viewed as creating an element of risk for the manufacturer, the commercialization of energy productivity technologies has been deferred. Some of the other barriers include economic factors. However, they tend to be attitudinal or subjective economic factors. The rate of return evaluations are very objective evaluations. The buyer looks at the after-tax impact of buying a piece of energy productivity equipment relative to the savings it will accrue to him relative to a standard piece of equipment. It is assumed that energy productivity equipment will cost the buyer more than the standard equipment. The investment and savings streams are illustrated in Figure 12. The manufacturer faces a similar type of investment analysis based upon his development and manufacturing capital investment requirements. This is illustrated in Figure 13. The buyer and manufacturer share one common input to their evaluations - the price of the product. If the price at which the buyer is willing to buy is not sufficient to provide a greater profit than the existing products, there is no incentive to the manufacturer to bring out the new product.

The key barrier to commercialization is profitability to the buyer and manufacturer. The dollar value of the energy productivity must make it profitable to the buyer to pay the price. The price and the number of buyers (total market) must make it profitable to the manufacturer to invest in the new product.

Typical Investment Profile for a Buyer of Energy Productivity Equipment

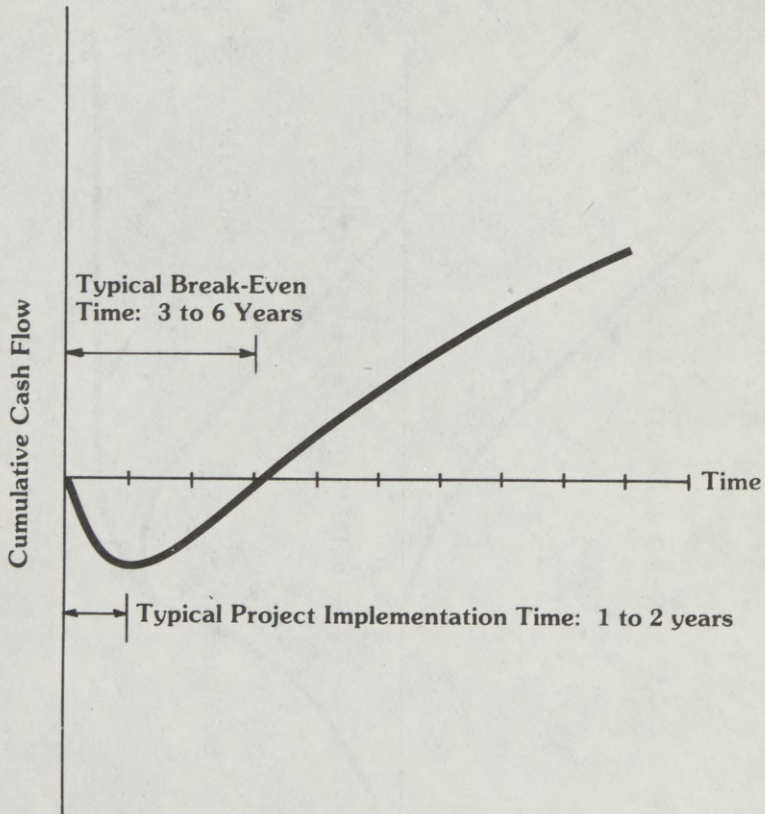


Figure 12

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Illustration of Financial Risk and Exposure for a Manufacturer of a New Product

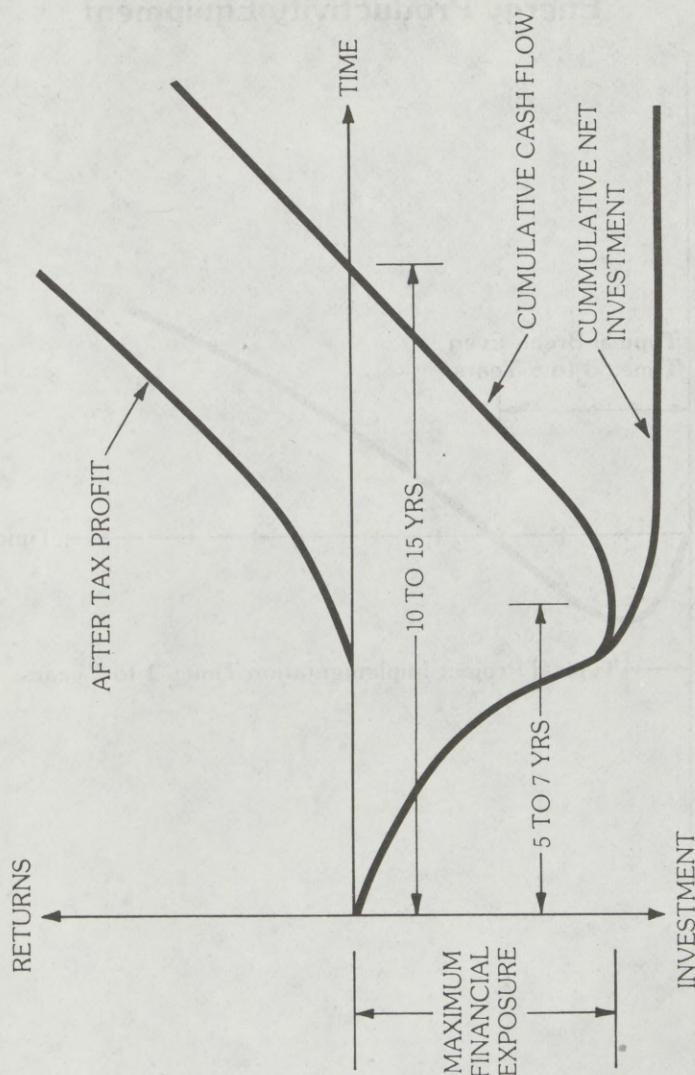


Figure 13

GOVERNMENT ACTIONS

The next topic for consideration is government actions. In this section, we will begin to explicitly address the points raised in Representative Ottinger's letter.

The key government action is the development of a clear and steady government policy regarding energy. U.S. policy regarding energy is viewed as erratic, at best, and nonexistent, at worst. The petroleum crunch during the past year is a typical example. The government tried to make everyone happy, or at least no one unhappy. Priority was given to building up stocks of heating oil, then to farmers, then to truckers, then to vacationing citizens, and now back to home heating oil. The citizens grumbled that when gasoline was a dollar a gallon there would be adequate gasoline. Amazingly, the gas lines disappeared when gas hit a dollar a gallon. The situation in natural gas is similar. Restrictions on the use of natural gas were imposed and the well-head price restrictions removed. Now amazingly, we have the "gas bubble." Industry was told to get off gas and use oil. Now, it is told to use gas. These erratic actions raise the perception of risk by industry in doing anything - even obeying the government since the government might change its mind next year or even next week. The other problem with these erratic actions is the fact that it increases the perception among the citizens that the energy crisis is nothing more than a big scam. Now, six years after the embargo, the U.S. still does not have a clear national energy policy. The existence of a U.S. energy policy will enhance the commercialization of energy productivity technologies in all sectors and energy supply technologies.

It is axiomatic that equipment to use energy efficiently is more expensive than equipment to use energy inefficiently. The difference in the price between energy-efficient equipment and inefficient equipment must be justified by the dollar value of the energy savings. If energy were cheap and getting cheaper, as it was in the U.S. through the 1960s, energy efficiency cannot be justified. To illustrate this fact, we have analyzed the investment decision by a potential buyer of a Rankine bottoming cycle for various electrical prices. The Rankine cycle will take waste heat and produce electricity. The generated electricity displaces purchased electricity and, thus, pays for the investment. An investment threshold of 15 to 20% would be considered the minimum acceptable. Since an electric charge of 3.5¢/kWh is very unusual, even today, for an industrial consumer, the investment in a Rankine bottoming cycle would not be attractive under the assumptions used in Figure 14, even though about 4500 megawatts of power could be generated from industrial waste heat with Rankine bottoming cycles. Figure 15 shows the impact of the inflation rate on the investment decision. If electric rates inflate at 8% per year (2% more than general inflation assumed in this analysis), the uneconomic investment becomes economic. It is important to recognize that it is not only current levels of energy prices but the expected future levels of energy prices that will impact upon the investment economics of the buyer of energy-productive equipment. The energy prices impact upon the investment economics of the manufacturer since the price the buyer is willing to pay affects the profitability of the manufacturer. Any action by government which controls or permits energy to be priced below its marginal cost to our nation reduces significantly the potential for energy productivity. The failure to use the energy price mechanism must then be offset by other types of incentives.

Effect of Energy Cost on the Discounted Cash Flow

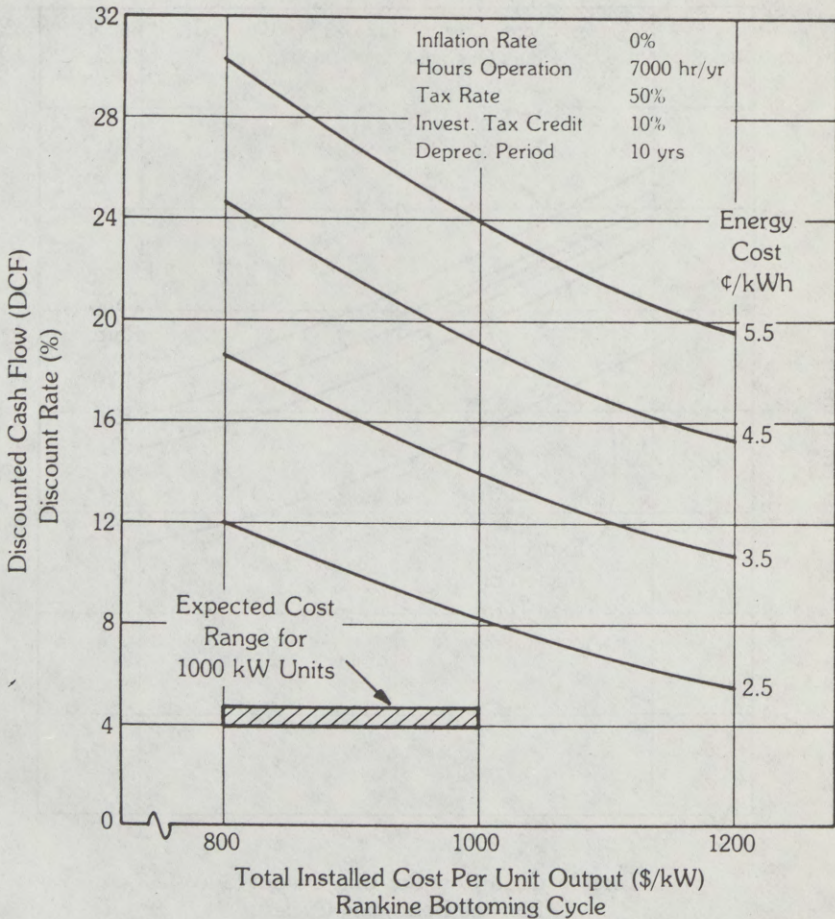


Figure 14

Effect of Energy Inflation Rate on the Discounted Cash Flow

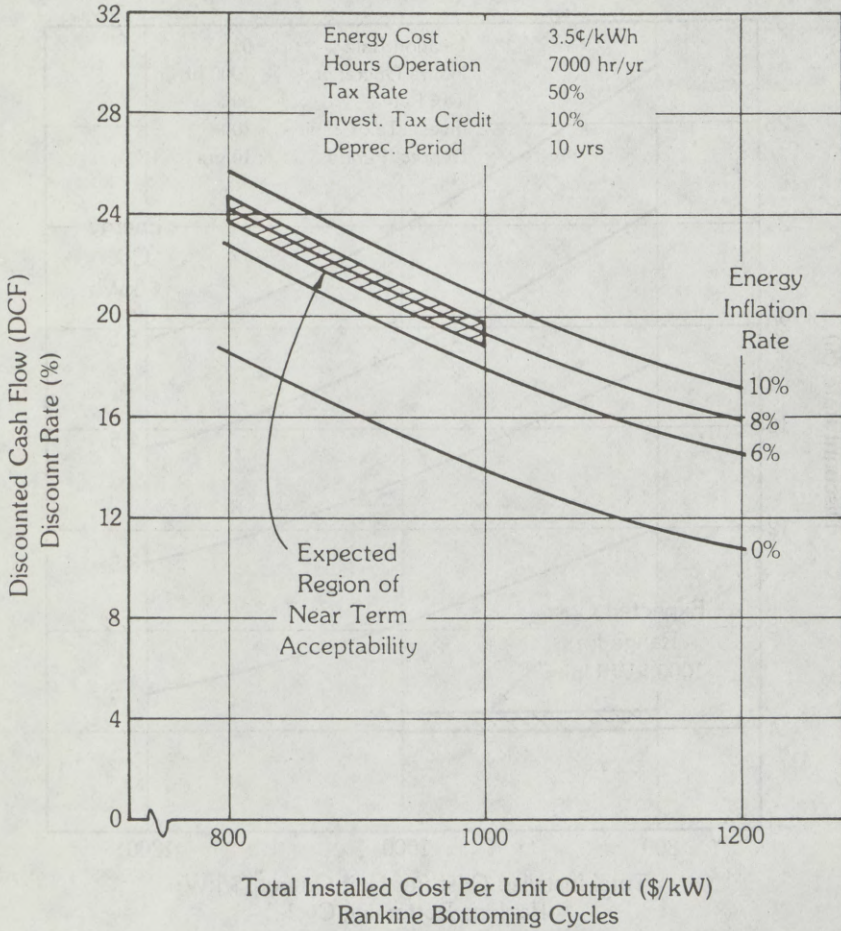


Figure 15

One key incentive the government can take is in the area of the development of demonstration of energy productivity technologies. We have viewed a number of problems with the energy R&D program and have previously expressed our opinions. (See the attached Bibliography.) First of all, the funding levels are totally inadequate. Figure 16 presents some funding projections for meaningful and significant programs in three energy productivity areas. The other problem is the variations in funding levels due to the annual appropriation cycles. The development of major energy productivity technologies in the consumer and industrial markets are multiyear programs. The programs cannot be turned on and off due to bureaucratic fumbblings. The problem is worse when government enters into cooperative development programs with industry and then cannot live up to its financial commitments. The cooperative government industry development programs could be a powerful tool to commercialize energy productivity technologies. However, governmental concerns and bureaucratic position justifications make government an exceptionally difficult partner. In addition to not being assured of meeting its financial commitments, the ancillary program management and contract requirements imposed by the government are a bureaucratic nightmare despite the efforts of the DOE program managers. An additional problem is the cost sharing percentages demanded by the government. If the investment makes economic sense to industry, government involvement is not needed. The higher the risk and the longer the time to full commercialization, the less likely the project would be economic to the industry. This implies that the government's role should be proportionately greater early in the development effort and lower at the end. However, the government generally demands a constant fixed percentage cost sharing over the entire agreement period. The timing of involvement and the overall average

Examples of Adequate Funding for the Development of Revolutionary Energy Productivity Technologies

	RD&D					Total Desirable Avg. \$M Year	Investment by each Corp. for Mfg. Facilities \$M
	Demonstrations			(5) Technology & New Concepts \$M Year			
	\$ Million System	\$ Million Year/System	No. of Systems		\$M Year		
"New" Automotive Power Plants	250	50	6 ⁽¹⁾	60	360	>> 500	
"New" Heat Pumps	10	3.3	4 ⁽²⁾	2.6	15.8	≈ 50	
Waste Heat Recovery (≤5 Mw ⁽⁴⁾)	10	5	5 ⁽³⁾	3	18	≈ 50	

(1) For thermal engines, the Stirling and gas turbine have been selected as viable future power plants. In addition, there are the electric and hybrid vehicle systems. To create competition, there should be a minimum of two candidates in each race. This brings the initial number to a minimum of eight. During the life of the program, it is likely that at least one of the systems will be eliminated. A minimum of six systems was assumed here.

(2) The energy source could be either electric or fossil fuel. In each there should be a minimum of two competitive systems. Therefore, four systems represent a minimum program.

(3) Variety of viable systems, waste stream, temperature levels and competition requires a minimum of five systems.

(4) Considerably larger budget will be required if the developments are conducted on systems which are larger than 5 Mw.

(5) Basic research, support technology and evaluation of new advanced high risk/high payoff concepts should be about 20 percent of the demonstration budget.

Figure 16

percentage of involvement should be flexible, based upon the risk of the program and the societal benefit. Another problem with cooperative government-industry programs is the government's position on patent rights. This position is fixed by law. Industry's motivation in cooperative programs is ultimate commercialization. This is the only way for industry to recover its money. The denial of exclusive proprietary position to developments from the program increases the risk to industry in achieving its return. These issues make it especially difficult for small corporations to deal with the Federal government. It is therefore not very surprising that innovations, which largely have come from small corporations, have greatly suffered in this climate.

A number of investment incentives have been enacted or proposed to allow for the fact that the price of energy to industry does not reflect cost of energy to society. The most explicit statement of this fact is the critical fuels rebate program proposed by Senators Kennedy and Durkin. The incentives that we wish to discuss are:

- a) Investment Tax Credit
- b) Depreciation Period
- c) Income Tax Rate
- d) Allowability of Energy Expenses as Tax Deductions
- e) Direct Subsidies
- f) Energy Rebates

The effects of investment tax credits (ITC), depreciation periods and income tax rates are shown in Figures 17 through 19, respectively. The impact of the

Effect of Investment Tax Credit Rate on the Discounted Cash Flow

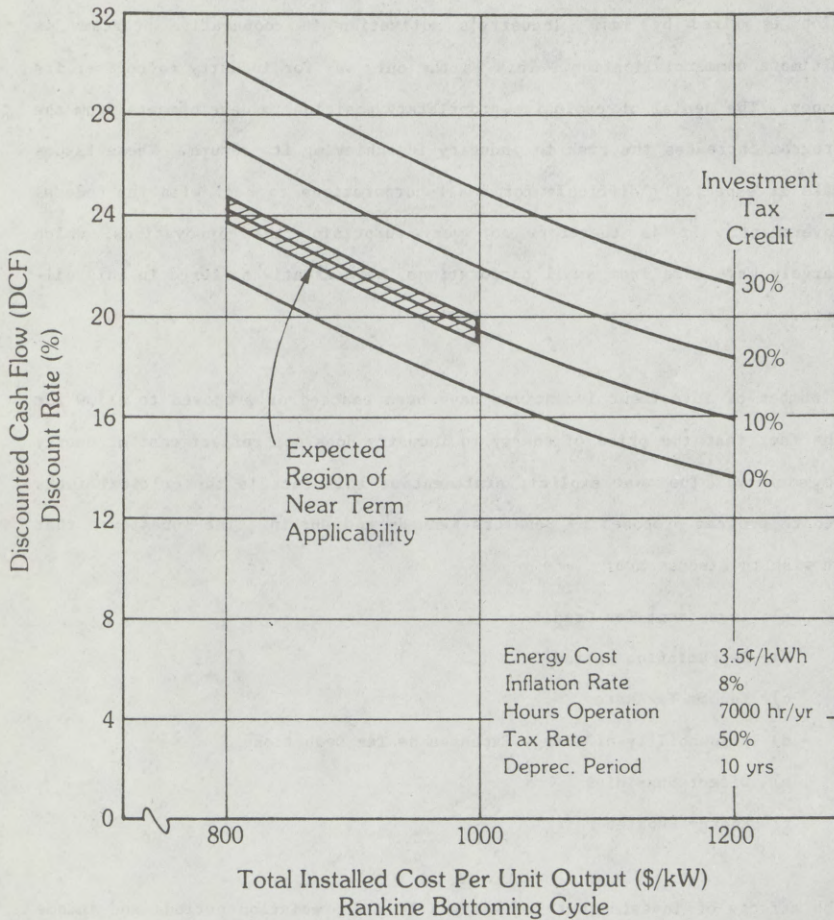


Figure 17

Effect of Depreciation Period on the Discounted Cash Flow

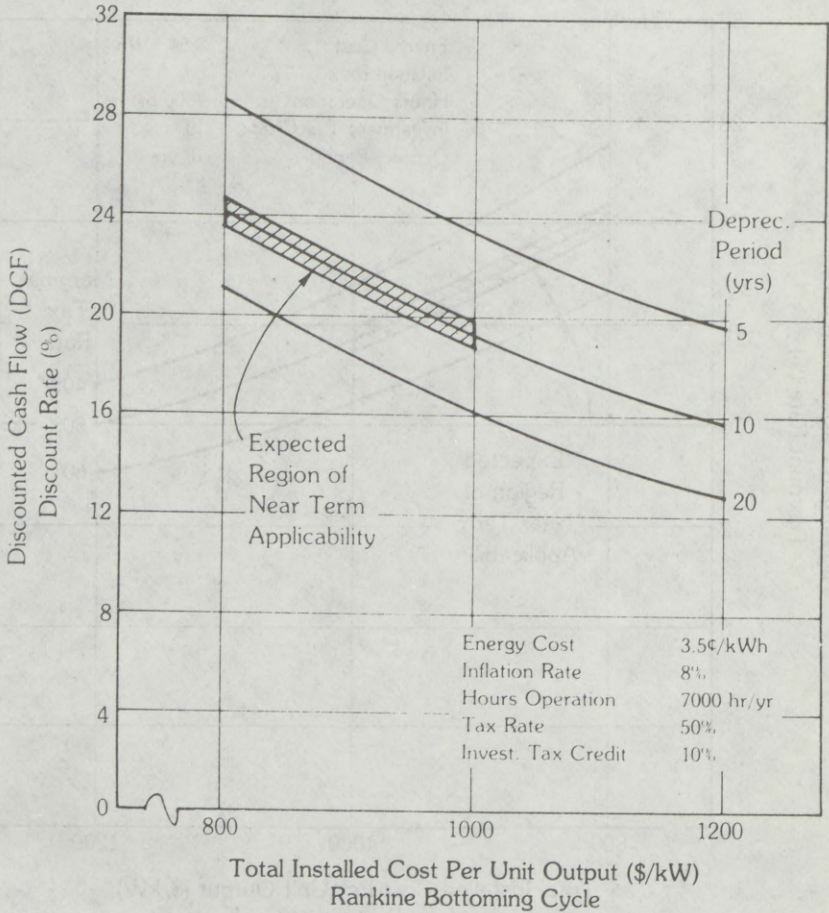


Figure 18

Effect of Marginal Tax Rate on the Discounted Cash Flow

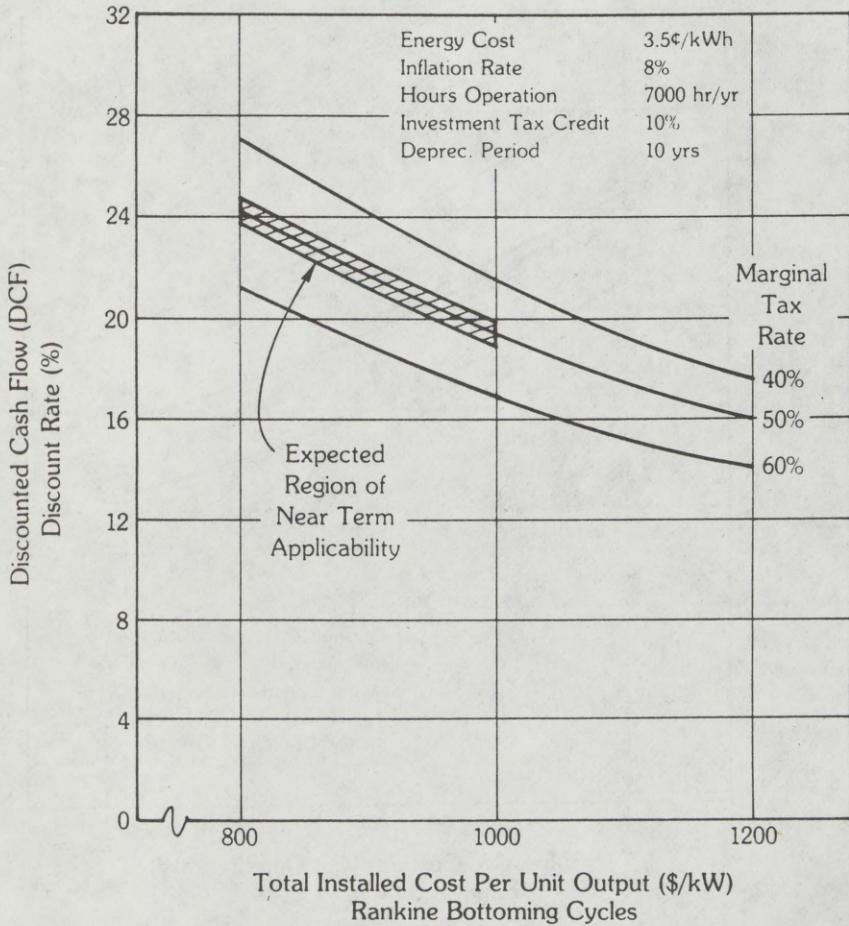
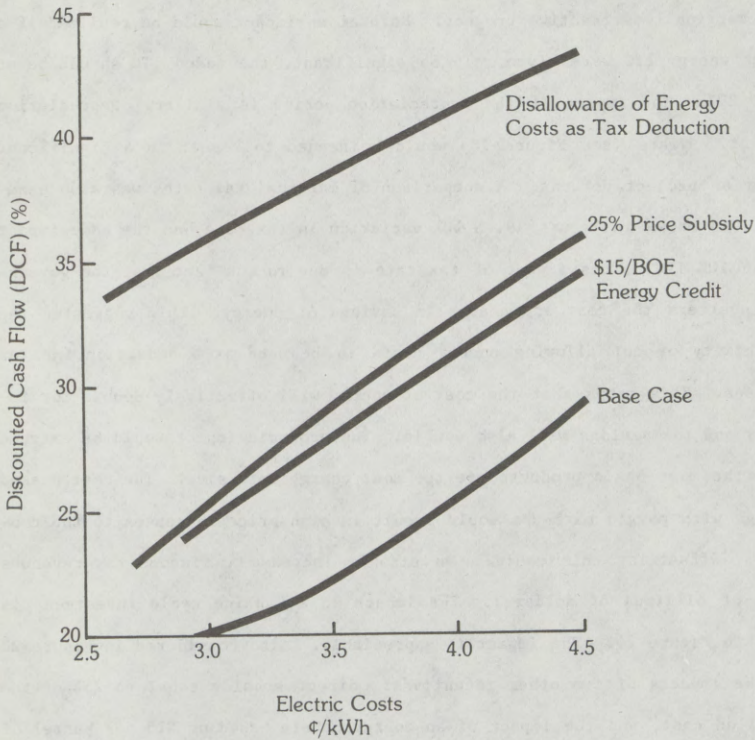


Figure 19

10% additional investment tax credit already enacted is minimal on the investment decision since it results in an increase of only 3 percentage points on the return for the investment. This moves a marginally unattractive project to a marginally attractive project. More of an impact would be realized if a higher energy ITC were given. To be significant, the added ITC should be at least 20%. The impact of the depreciation period is similar. Depreciation life of 5 years (see Figure 18) would be needed to result in a significant impact on project returns. A comparison of marginal tax rates was also examined. As shown in Figure 19, a 10% variation in tax rate has the same impact as the 10% ITC. This impact of tax rate is due to the fact that the government shelters the cost and shares in savings of energy. This suggested the possibility of not allowing energy costs to be used as a deduction for tax purposes. This means that the cost of energy will effectively double for industry and the savings will also double. The economic impact would be extreme since the most basic products are the most energy intensive. The cost passed through with margin mark-ups would result in high price increases to the consumer. Offsetting this could be a sizable increase in income tax revenues (tens of billions of dollars). The impact on a Rankine cycle investment is shown in Figure 20. The impact is appreciable. Also considered in Figure 20 are the impacts of two other incentives: direct subsidy equal to 25% of the installed cost, and the impact of an energy rebate based on \$15 per barrel of oil equivalent saved during the first year (assuming electricity would be valued at its fuel rate of 10,700 Btu/kWh). Either of these latter three approaches has an appreciable impact on the investment economics.

The incentives discussed so far have been incentives to the buyer. They are not incentives to the manufacturer. The incentives to the buyers are, however, an indirect incentive to the manufacturer since they remove some of the

Sensitivities of Owner Economics for a Rankine Bottoming Cycle to Various Incentives



Assumptions:

- 15-year project life
- 8000 hours annual operation
- Base system cost @ \$1100/kW
- 20% investment tax credit
- 12-year SOYD depreciation method
- 50% combined marginal tax rate
- \$30,000 O&M charge
- 3% local taxes and insurance

Figure 20

price pressures to allow a reasonable profit and enlarge the total market. Figure 21 illustrates this latter point. If the installed price of the Rankine bottoming cycle is effectively reduced to the buyer by 25%, the total economic market almost doubles. Attachments B and C present the cost and impact of a price subsidy for Rankine bottoming cycles and advanced energy-efficient components. The relative impact of government participation in the Rankine bottoming cycle development and demonstration can be significant as shown in Figure 22.

Incentives to the suppliers of synthetic fuels have been proposed in the form of loan guarantees, guaranteed purchases and price supports. It is not clear if loan guarantees will provide any additional incentives to manufacturers. However, loan guarantees would be desirable for the installer of a new process. In the case of large industrial processes, the distinction between the manufacturer and buyer disappears and a close similarity to the synfuel case develops.

The accounting treatment of existing plant and equipment that may have to be discarded to implement energy productivity technologies is a problem. The scrap value of the equipment will usually be lower than book value. The write-offs of the equipment may impact the economics of the decision due to the impact on earnings the year of the write-off. This may be alleviated by deferring the write-off until the energy savings are realized. The inflow of savings should more than offset any write-off. This will be a factor only for very sizable investments.

The final realm of government actions is in the area of regulation, for example, the energy efficiency improvement goals that have been enacted and the

Energy Conservation Potential from the Utilization of Industrial Waste Heat

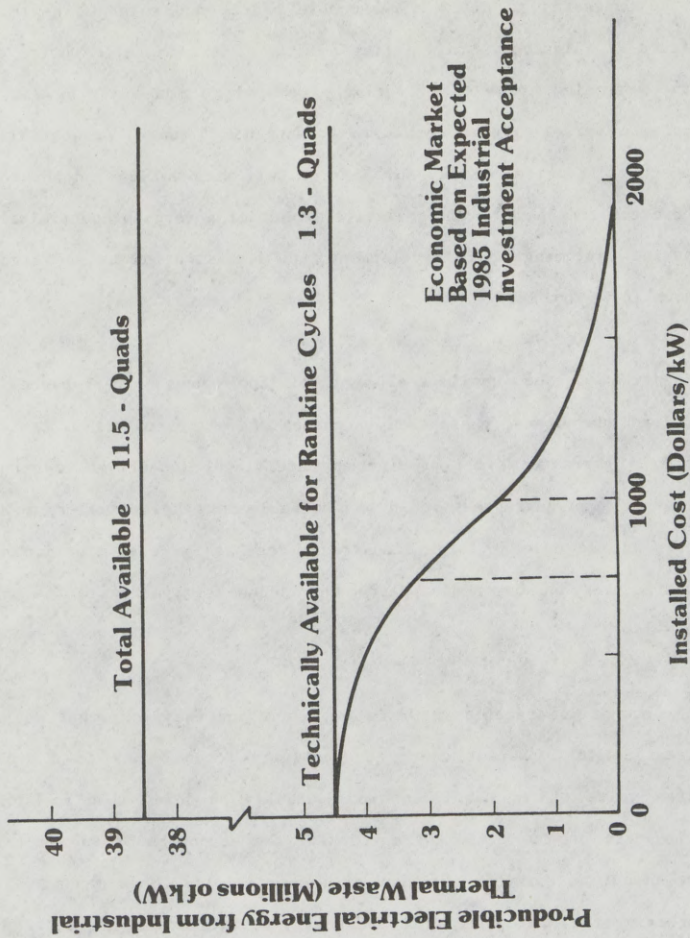


Figure 21

Energy Savings Potential of Rankine Bottoming Cycles As A Function of Government Actions

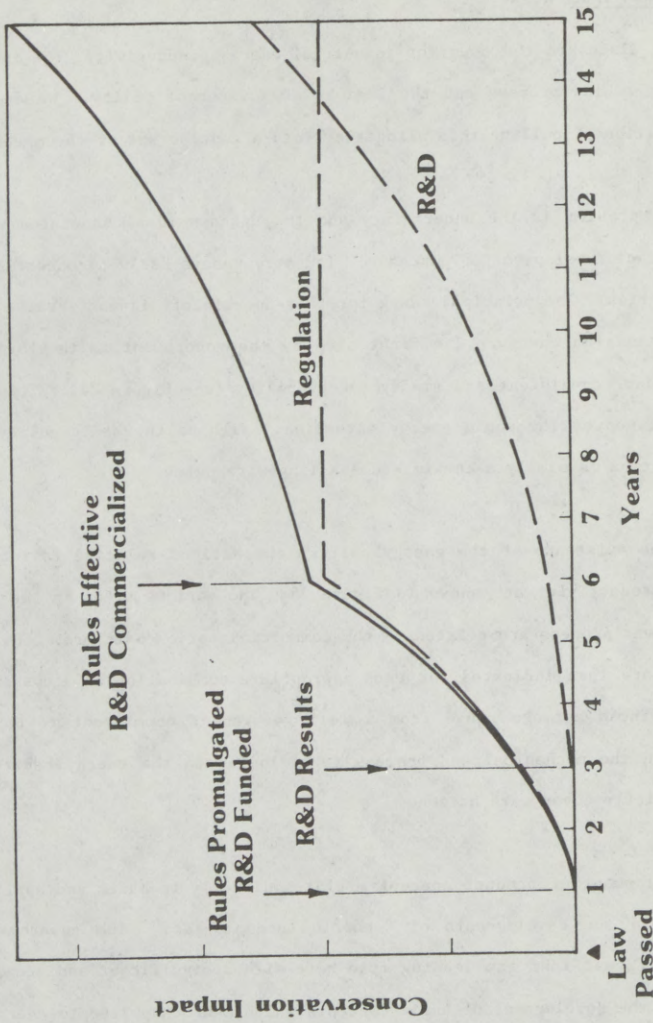
Year	No Government Action	Adequate Government RD&D Support	RD&D Support Plus Initial Subsidies*
1980	0	0	0
1981	0	0	150
1982	0	75	1670
1983	0	380	4700
1984	0	1140	9250
1985	0	2650	15320
Total	0	4,245	31,090

*To attain this savings, RD&D must be part of program.

Figure 22

proposed motor efficiency standards. For the industrial sector, product standards, energy consumption standards and energy reduction goals are not necessary if the other factors of price, development assistance and incentives are in place. Regulation tends to reinforce the "suffering" definition of energy conservation and often diverts skills and funds to meet short-term regulatory goals at the expense of long-term revolutionary improvements. This has been graphically displayed in a study carried out by the Oak Ridge National Laboratory showing the impact of proposed regulations for efficiency standards compared to new technologies. The implications of this study are illustrated in Figure 23. Regulations achieve early impact but, when fully implemented, show no additional gains. New technology impacts occur more slowly but continue to show impact.

Illustration of the Impact of Regulation and New Technology on Energy Conservation in a Given Consumption Sector



Ref: Hirst, E., "Future Energy Use in Residential and Commercial Buildings: Energy Conservation Economics," Oak Ridge National Laboratory, Sept. 1978.

Figure 23

RECOMMENDATIONS

We have discussed the need for industrial energy productivity, the industrial decision-making process and the impacts of government policy. We are now in the position of pulling this altogether into a concise set of recommendations.

The key problem is the uncertainty and the unknown risk associated with any new product development or purchase. Industry reacts badly to uncertainty and unknown risk. The principal cause for this uncertainty is the erratic government actions on energy. The first step by the government is the formulation of a clear, consistent and steady energy policy (see Figure 24). This is the sine qua non of the whole energy situation. Without the basic policy, every other action is simply a chewing-gum-bailing-wire patch.

Given the existence of the energy policy, the actions relative to industrial energy productivity are shown in Figure 25. The various steps in the product development process are related to the commercialization barriers. Government actions are then indicated for each appropriate combination of steps and barriers. These actions range from a full government commitment to basic research in the mechanical and process technologies to the energy rebates. We shall briefly cover each action.

The development of product concepts relates directly to basic and applied research and the developments of "generic technologies." The government, by necessity, must take the leading role here with a significant and steady program for the development of basic concepts which can be applied to energy productivity. These activities would be carried out primarily in academia, private research institutions, technology companies and government laboratories.

**Principal Government Action
in Energy Policy**

**A Clear, Consistent and Steady
Energy Policy Is Needed to
Remove Investment Uncertainties**

Figure 24

Government Actions in the Development and Commercialization of Industrial Energy Productivity Technologies

Commercialization Barriers	Product Development Process					
	Basic Research	Applied Research & Generic Technologies	Pilot Demonstrations	Commercial Sale Demonstrations	Introductory Offerings	Product Maturity
Concept Development	Unique Government Role	Principal Government Role	Government Role			
Matching Market Needs		Cooperative Programs With Low Industry Funding	Cooperative Programs With Moderate Industry Funding	Cooperative Programs With Moderate-to-High Industry Funding		
Reduce Manufacturer's Risk/Investment		Energy Studies, Rebates for Prospective Buyers	Cooperative Programs More Flexible Patent Policies		Loan Guarantees	
Reduce Buyer's Risk					Direct Subsidies Energy Savings Rebate Cooperative Programs	
Enhance Buyer's Economics					Investment Tax Credits Depreciation Periods Energy Savings Rebates Tax Policies	

Figure 25

The problems of matching product concepts with market needs can be addressed by cooperatively funded programs with industry, both manufacturers and users. The relative funding participation between government and industry should be reflective of the stage of the concept development, risk and commercialization time span. Another action by government is along the lines of the energy study rebates as proposed by Senators Kennedy and Durkin. Here, the energy studies would be more in the line of problem statements rather than investment analyses. That is, the user industries would take a specific problem, examine an energy productivity alternative, and identify the needed modifications in order to make it technically or economically acceptable. This problem statement could then be used by the manufacturers and technology developers. The national laboratories could play a very constructive role in this area.

The cooperative programs will reduce the risk and long lead time investments for industry. This combined with a more flexible patent policy to recognize industry's funding participation in funding the developments would provide a very meaningful incentive to the manufacturers.

Loan guarantees for manufacturing investments would be a very low priority incentive. Loan guarantees for buyers and operators of new industrial processes will be as necessary as as they are for synfuel developers.

In Figure 16, some general numbers were given for the funding requirements for the development of energy productivity technologies. We would like at this point to become very specific as to the future development funding requirements for Rankine bottoming cycles. These numbers are presented in Figure 26. If we use the rule of thumb evaluation criterion for federal support of one

**Suggested Funding Levels to Complete the
Development and Demonstration of Rankine Bottoming Cycles**

FY	Funding Appropriation
1980	6,000,000
1981	20,000,000
1982	20,000,000
1983	6,000,000
1984	3,000,000

Figure 26

dollar per barrel of oil equivalent saved per year, the 4500-megawatt potential of bottoming cycles should receive about \$300 million of funding. Significantly less is needed.

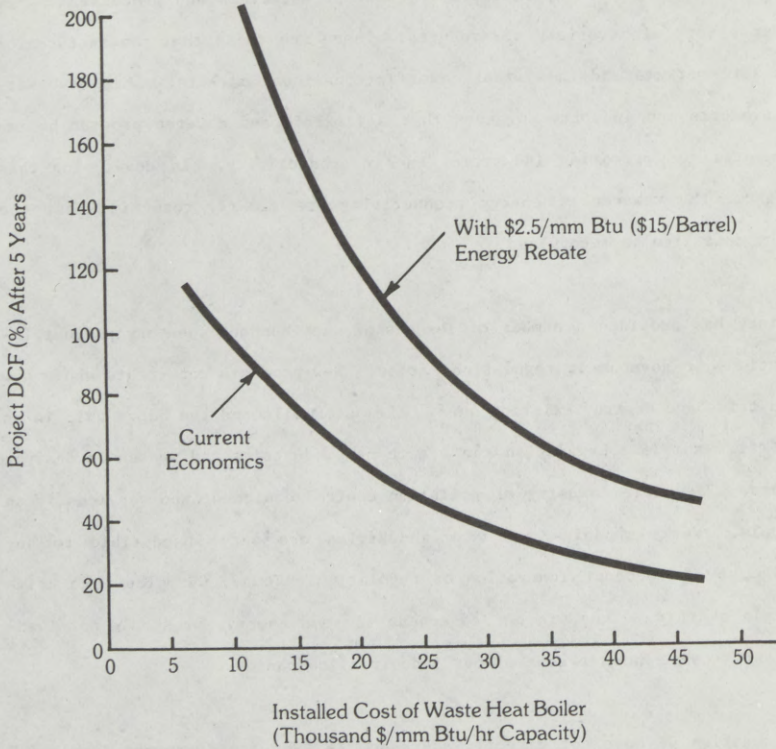
It is important to make the risks as low as possible to the buyer when the new product is being demonstrated in his plant. The risks are related not only to the possible failure of the new equipment but also the impact on production. Direct subsidies, energy studies rebates and cooperative programs are possible alternatives. The energy studies rebates are not much of a financial incentive but more of a psychological incentive. A detailed energy study will quantify the risks. The reduction of risks to the buyer in the commercial demonstration and product introduction steps is very close to giving a direct incentive to the manufacturer. In this case, the incentive has to go to the buyer since he has to make the decision.

The final incentives are those needed to offset the imbalance between the price of energy to industry and its value to society. The most effective incentive seems to be the energy rebate. However, there are numerous types of industrial investments. Even though the energy rebate seems most effective for the investments we examined, other incentives may be more effective for other investments. This has to be examined almost on a case by case basis.

It is important to note that not all incentives affect all investments equally. The investment ranges in scale from a simple motor retrofit to an entire process replacement. The investments range in maturity from products such as the Rankine bottoming cycle, which is in the commercial demonstration stage, to well-established products such as recuperators and waste heat boilers. The

incentives needed to make waste heat boilers more readily used are quite different than for the Rankine bottoming cycle. Figure 27 shows the current investment returns with and without the energy rebate. MTI is discussing with an industrial customer a waste heat boiler with an estimated installed cost of \$20,000 per million Btu's per hour of steam. This industrial customer should install the boiler even without incentives.

Effect of Energy Rebate On Waste Heat Boiler Owner Economics



Assumptions:

Displaced fuel at \$2.50/mm Btu
 8000 hours annual utilization
 20% investment tax credit
 50% combined marginal tax rate
 12-year SOYD depreciation
 \$15,000 O & M charge
 3% local taxes and insurance

Figure 27

Conclusion

Mr. Chairman, it is important for us to recognize that there is a very wide spectrum of industries - from the very small to the very large - that manufactures consumer products, industrial products, materials and processes. They cover a very wide variety of products. There are those that manufacture for domestic markets and those that cover international markets. This diversity of products and industry suggests that a flexible and diverse program be implemented for promoting industrial energy productivity. In developing this program, the rewards of energy productivity are clearly recognized but the risks must also be recognized.

History has provided a number of lessons of what happens when new product innovations or government regulations arise. New products can create whole new industries and destroy existing ones. The automobile and the buggy whip is an old time example. Regulation can create new industries and weaken or destroy others. The whole industry of pollution control equipment and services is an example. Weak companies and weak industries are very susceptible to any change, be it product innovation or regulation. Today, Chrysler is a prime example of this. Thus, in our eagerness to save energy, we should not inadvertently cause harm to some of our industrial companies.

One question we have not directly addressed is "Why is government involved?" Basically, there are two answers. One is that government is already involved and must extend its involvement to obtain a balanced result, which is in the long-term best interest to the public. The second is that the energy savings potential is so large and vital to the health of our economy that the government has a responsibility to insure that industry have available and practice energy productivity.

We find it very curious that the question of government's role in industrial energy conservation is raised so often. Each year, we and others supportive of energy conservation or productivity are forced to prepare lengthy program justifications, testify before Congress, and discuss the subject with high levels of DOE management and with the Office of Management and Budget. The topic is a \$40-million Industrial Conservation budget. The priority and fundings of minuscule portions of this minuscule program are questioned. However, an \$88-billion (or whatever it will turn out to be) federal synthetic fuel program is readily accepted. The money will be derived from wind-fall taxes on the "obscene" profits of the oil companies, and the oil companies will be the principal beneficiaries. We will spend billions on providing an admittedly more expensive fuel but spend next to nothing to use that fuel efficiently and cost effectively. While we are fully supportive of a synthetic fuel program, it needs to be tied to an energy productivity program. Otherwise, the type of illogical situation as illustrated in Figure 28 will occur.

It is clear that the federal government has a responsibility to the public to insure that we maintain a healthy national economy. In the energy area, this must be translated into both energy supply and energy productivity. There appears to be a commitment to energy supply in the form of synfuels. We cannot, however, afford to ignore other supply options. More importantly, we cannot afford to continue to ignore energy productivity in the U.S. industrial complex.

We hope that our comments today will help Congress in formulating a responsive position to accelerate industrial energy productivity.

This concludes our testimony. We would be pleased to respond to any questions.

The Impact of an Energy Policy that Stresses a Synfuel Program but Ignores the Conversion/Utilization of Energy

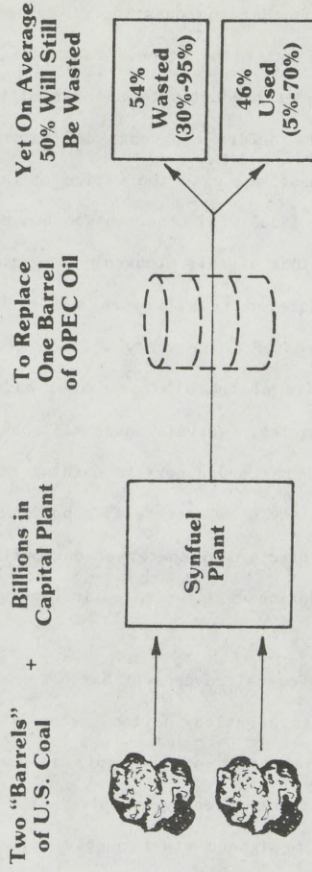


Figure 28

The Impact of an Energy Policy that Stresses a Synfuel Program but Ignores the Conversion/Utilization of Energy

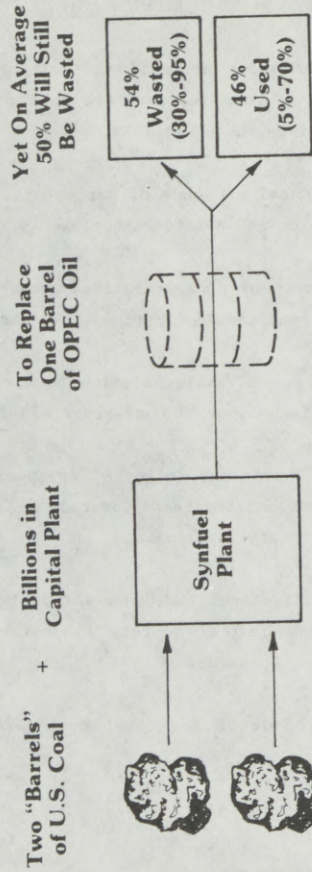


Figure 28

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ATTACHMENT A

INDUSTRIAL INNOVATIONREPORT OF AD HOC COMMITTEE ON DIRECT FEDERAL SUPPORT
OF RESEARCH AND DEVELOPMENT TO ENHANCE
INNOVATION IN THE PROCESS INDUSTRIESINTRODUCTION:

The subcommittee on Direct Federal Support in Research & Development, of the Advisory Committee on Industrial Innovation, draft report (dated December, 1978) makes a number of important observations and defines some valid needs. In particular, that of coupling the universities and industries more tightly so that all industry (specifically small business) could have easier access to and some direction of the innovative research that can be performed in the university environment.

Although there is no specific disagreement with the needs identified in the subcommittee's report, there is a strong feeling that the report is applicable primarily to the mass produced "product" portion of industry. The report does not appear to consider the needs and unique requirements of what may legitimately be termed the "process" portion of industry.

Based on this perception, a group of more than twenty process oriented industry representatives met for a full day to:

- a. review the draft report
- b. understand the general nature of the views expressed by the subcommittee membership
- c. determine if additional recommendations or suggested modifications to the draft report would be appropriate.

A list of those attending the ad hoc meeting is attached.

PROBLEMS AND CONCERNS

There has been a significant decrease in innovations within the U.S. While there are many theories for this decline, the most important reasons appear to

be associated with the high cost, high risk and uncertain payoffs due to a lack of demonstration and understanding of the new (innovative) processes.

In addition, there is the impact of increasing interest rates and there is a scarcity of investment capital in general and discretionary capital in particular. Much of the available capital is therefore directed to

- a. plant expansion
- b. product expansion
- c. meeting regulatory requirements.

This has the overall effect of severely limiting the amount of discretionary capital available for incorporation of new innovative techniques within the process industries.

These factors result in severe constraints and extremely limited industrial discretionary funding which can be used for Research, Development and Demonstration (R,D&D). However, it is this discretionary funding which is necessary for the development and demonstration of the new innovative processes and new energy supply and conservation techniques. Each discretionary investment must be subjected to a very rigorous risk analysis. The more risky the project, the lower the incentive for any significant investment. Often it is just the perceived risk that discourages the investment. Particularly if, the investment must span several years.

Basic research and advancements in generic technology which are very important to many industries and to industry in general are quite often insufficient to enhance or encourage innovations within the process industries. Due to the nature of the process industries, any new equipment must have a history of successful operation, with a demonstrated reliability and availability record. It must also have appropriate warranty provisions, and a known, verified maintenance schedule. This is essential whether the equipment is product output oriented or whether it is being considered as an energy conservation improvement. It should be noted that many of the largest energy consuming industries are process industries. Consequently, the process industries represent some of the most effective cost benefit targets and energy saving opportunities for Federal R&D efforts.

In summary, the group does not feel there is a shortage of good ideas (inventions) concerning new techniques which could be used to enhance the process industries. However, there is a stringent requirement for new techniques to be fully demonstrated before commercialization will, in fact, occur.

Although research in general is critically important and a source of innovative ideas, research can only be considered "the tip of the iceberg". To accelerate the innovation process through implementation and effective use by industry, requires appropriate Federal support of development and demonstration projects.

RECOMMENDATIONS:

I. Development and Demonstrations

The ad hoc group strongly feels that demonstrations with Federal support in the industrial environment are necessary to enhance the innovation process. The areas of synthetic fuels (inexhaustible sources), new materials, process efficiency improvements, energy conservation are all good examples of the strong need for demonstrations prior to effective commercialization.

It was the unanimous opinion of the ad hoc group that in today's business environment, Federal funds are needed to support these high-risk demonstrations. There is a need for flexible cost sharing guidelines in establishing demonstration projects so that the risks involved and the size of the innovating company are properly considered.

II. Improve Industry-Government Relationships

Again, the ad hoc group unanimously reflected the need to change the overall climate of government-industry relationships so that the innovation process is directly encouraged. The need for industry to enhance and more rapidly complete the innovation process must be understood and nurtured by the appropriate government agencies. It is essential that a more cooperative relationship be developed in lieu of the adversary one which now exists in many instances.

Removal of conflicting requirements, streamlining, simplifying and accelerating the proposal approval process were four of the specific recommendations made most frequently.

III. Innovation Enhancement Incentives

In addition to the above specific recommendations, the group, in general, felt that the following innovation process incentives should be thoroughly considered:

- a. Very rapid depreciation
- b. Substantial investment tax credits
- c. Exclusive use of patents for a limited time period
- d. Repayment of Federal R,D & D investment via royalty arrangements
- e. Opportunity to convert demonstration grant contracts to loans when the demonstration is successful and commercialization begins.

SUMMARY

Although the ad hoc group is generally supportive of the recommendations made by the Subcommittee on Direct Federal Support of Research and Development, it strongly feels that the above recommendations for direct Federal support of demonstrations must be added. To the ad hoc group, this is an essential link in the innovation process.

This group evidenced considerable reservation regarding the generic technology centers which have previously been recommended. Such centers may be needed and could possibly serve very useful functions. However, it was difficult for the ad hoc group to perceive how they would directly enhance or improve implementation and demonstration of innovations within the process industries. In the event that such centers are established, it is essential that their function be clearly defined and that any actual demonstrations be conducted in a real industrial environment. In addition they must be staffed with very high quality people and be formed only in association with a strong responsive industrial client (e.g. NACA/NASA - the Aviation Industry.)

FEDERAL SUPPORT OF R&D RELATING TO
INDUSTRIAL INNOVATION

March 8, 1979

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ATTACHMENT B

A Proposed Commercialization Incentive for Industrial Waste Heat Utilization

Approximately 11 quads of industrial waste heat are available in various forms. Figure B-1 presents the distribution of this industrial waste heat and the general form in which it is found. Since 1973, some utilization of industrial waste heat has been accomplished through the implementation of older, well-known technologies such as shell-and-tube heat exchangers and boiler economizers. Although industry should be commended for these efforts, the situation clearly shows the reticence of industrial product line and process managers to implement anything which is not well-known technology. This clearly points out the need for careful product development, demonstration and installation incentives for such equipment as advanced regenerators and recuperators, and organic and steam Rankine cycles.

Regenerators and recuperators are heat exchangers that can recover waste heat and deliver it to some other part of the operation. Advanced and more efficient high-, medium- and low-temperature regenerators and recuperators are needed in a variety of sizes for application to a wide variety of industrial processes. In each temperature range, the design and materials needs of the equipment change; at high temperatures, for instance, the capability of the heat exchanger materials to withstand heat is all-important, while at low temperatures, resistance to corrosion is paramount.

Success-oriented programs in recuperator and regenerator R&D should include continuing, competing hardware development efforts in each temperature range, supported by ongoing technology development efforts in materials and design

Distribution of Industrial Waste Heat Flows

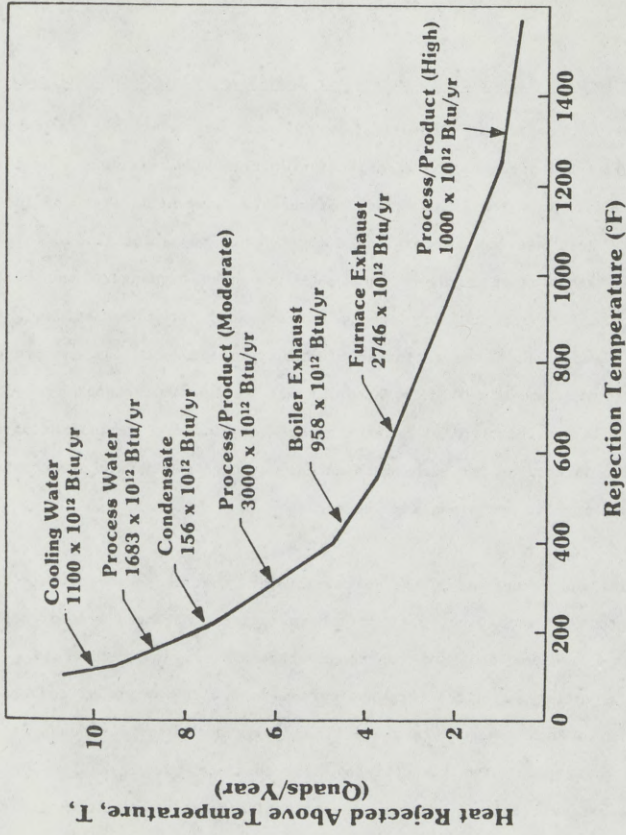


FIGURE B-1

Ref. "Industrial Applications Study" DOE Report HCP/T 2862-01, March 1978

analysis, aimed at significantly improving presently available equipment. The hardware contractors selected should be capable of maintaining ongoing working relationships with industrial furnace manufacturers and industrial process contractors to ensure implementation of the evolving waste heat utilization equipment.

Undertaking the suggested hardware programs and the needed technology support would require six contracts at annual levels of \$1.5M each to address needed hardware, with at least \$1M budgeted annually for a technology support effort. The Gas Research Institute, in a document entitled "A National Plan for Improved Efficiency in the Use of Natural Gas," recommends funding levels of \$10M in 1980 with \$15M in 1981 and 1982 to address recuperators, regenerators and heat transfer technology. We concur with the GRI assessment.

DOE is currently supporting the development of Rankine bottoming cycles to convert industrial waste heat into usable energy such as electricity or shaft horsepower. The technical energy saving potential of this market is 190,000 BOPDE, or about $\frac{1}{2}$ quad per year. The current economics of utilizing these systems is marginal due to the relatively low value of energy to industry and to the high equipment costs and risks associated with limited production equipment. An expenditure of \$303,000,000 to support the introduction of these units during the next six years will result in a cumulative savings of 26,852,000 BOE by 1985, with an additional savings of 12,670,000 BOE each year thereafter. This expenditure is based on providing the purchaser of a bottoming cycle a direct subsidy of \$300 per installed kilowatt of capacity. This expenditure could be in the form of an energy tax investment credit. The expenditure and incremental energy savings are as follows:

<u>FY</u>	<u>Expenditures</u> (\$ in Thousands)		<u>Incremental Energy Savings</u> (Barrels of Oil Equivalent)	
	<u>B/A</u>	<u>B/O</u>	<u>Annual</u>	<u>Cumulative</u>
80	3,000	---	---	---
81	30,000	3,000	151,000	151,000
82	60,000	30,000	1,593,000	1,744,000
83	90,000	60,000	4,323,000	6,067,000
84	120,000	90,000	8,115,000	14,182,000
85	---	120,000	12,670,000	26,852,000

The investment per barrel of oil equivalent saved for the first six years is \$11.30 per barrel.

Reference information for above table:

"Industrial Markets for Organic Rankine Cycle Bottoming Systems," DOE report dated Dec. 1978, prepared by Resource Planning Assoc.

"Venture Analysis Cost Study: Steam Rankine Recovery Cycle Producing Electric Power from Waste Heat," DOE report dated Feb. 1978, prepared by Thermo Electron Corp.

ATTACHMENT C

A Proposed Commercialization Incentive for Energy-Efficient Process Equipment and Process Machinery

The highest payoff energy-efficient process equipment falls into two general categories: industrial heat pumps and process machinery.

DOE is currently developing high-temperature heat pumps for industrial process heat. Electrically driven low-temperature units are commercially available, but thermally driven high-temperature heat pumps are not. High-temperature electrically driven systems can displace the use of premium fuels where coal- or nuclear-fueled electricity is available. Thermally driven heat pumps in all temperature ranges, fueled with oil or natural gas, promise the highest conversion efficiencies from fuel to process heat. The thermally driven heat pumps need and deserve extensive development efforts to become commercialized, while electrically driven high-temperature heat pumps could be implemented beginning in 1980-81 with proper incentives. The current economics of utilizing these systems is marginal due to the relatively low value of energy to industry and to the high equipment costs with limited production. Adding the perceived business risk on the part of the customer, due to a lack of product history, makes a private venture to commercialize this equipment prohibitive.

An expenditure of \$212,000,000 to support the introduction of the electrically driven high-temperature units will save 8,232,000 BOE during the next six years by shifting 8,232,000 BOE to fuels such as coal, nuclear and hydro instead of gas and oil. The expenditure is based upon a subsidy to the purchaser equal to approximately one-half the cost differential between a packaged oil boiler and an industrial heat pump. The expenditure and incremental energy savings are:

Expenditures (\$ in Thousands)			Annual Fuel Conversion (BOE)
<u>FY</u>	<u>B/A</u>	<u>B/O</u>	
80	4,000	---	---
81	20,000	4,000	156,000
82	54,000	20,000	940,000
83	64,000	54,000	3,058,000
84	70,000	64,000	5,488,000
85	---	70,000	8,232,000

The investment per barrel of oil equivalent saved or converted for the first six years is \$11.86 per barrel.

Machinery such as motors, pumps, compressors and small steam turbines have been purchased on the basis of reliability. First cost has been the second purchase criterion; fuel cost or energy efficiency has been the last purchase criterion. Therefore, most process machinery is relatively inefficient. The current economics will justify higher-efficiency equipment for new installations; however, retrofits or replacements cannot be economically justified due to the higher installation costs plus the impact of writing off the book value of the replaced equipment. The recommended actions would be 1) the government purchases the old energy-inefficient machinery at book value, and 2) the government provides a retrofit allowance. This allowance could take the form of the \$15 per barrel of oil saved as suggested in the Energy Productivity Act.

**STATEMENT OF BENO STERNLICHT, TECHNICAL DIRECTOR,
MECHANICAL TECHNOLOGY, INC.**

Mr. STERNLICHT. I am accompanied by Mr. Donald Colosimo, manager of business planning at MTI, who is also a coauthor of this testimony.

It is with great pleasure we testify before you today on the Government's role and policy on industrial energy conservation.

This is a subject which we at MTI are deeply concerned about and one which we feel particularly well suited to address.

Mr. HARVEY eloquently and procedurally presented an overview of industrial conservation. He and his staff should be very proud of their accomplishment. He has shown a very large cost benefit coming from his R.D. & D. program. To accelerate the industrial conservation process, especially in the area of introducing it into the industrial sector, this could greatly be enhanced by a much larger R. & D. budget than he presently has.

When MTI was founded in 1961, it was our objective to make our company the model for the innovation and commercialization of high-technology electromechanical equipment.

While MTI has developed, and is developing, products for the consumer and industrial markets, MTI only manufactures products for the industrial market. In trying to develop and commercialize advanced machinery products for the industrial market, MTI sought to use energy efficiency and reliability as the new product attributes. Thus, we have been strong advocates for the life-cycle cost philosophy. Energy efficiency was a product feature that MTI tried to promote even before the advent of the energy crisis. With the energy crisis, we have increased our efforts to develop and commercialize energy efficient machinery for the industrial market. Our comments today draw upon this experience of MTI in developing and commercializing products for industrial energy conservation.

To conserve time at this hearing, our oral presentation is limited to general observations, recommendations and conclusions.

The written text presents in some detail industrial energy productivity, with emphasis on energy cascading, of which cogeneration is a part. Also, the Government actions and variety of incentives are discussed in considerable detail.

Thus, we hope that there will be sufficient time for questions and answers covering all sections, both of our testimony, and various other testimony presented here.

Mr. Chairman, we have been blessed with a long period of plentiful energy at cheap prices.

During this period, the vast bulk of the industrial equipment designs, housing design, transportation mode selection, and general lifestyle evolved.

Energy efficiency was not important or cost effective. Therefore, today we have in place energy inefficient processes, machinery, buildings, appliances, and vehicles.

For example, we are driving automobiles which are nominally 15 percent efficient, we are heating our homes at 55 percent efficiency—less with electric resistance heat—and our industries are characteristically 35 percent efficient.

In addition to wasting energy, these practices also lead to environmental problems. The energy left over after conversion is present in a myriad of waste heat streams leading to thermal pollution. The use of more energy than necessary results in more particulates, SO_2 , CO_2 , NO_x , hydrocarbons, et cetera, and all the other environmental pollutants.

The wastefulness of our society is clearly indicated in a report issued in 1973 by the Joint Congressional Committee on Atomic Energy entitled, "Understanding the National Energy Dilemma."

Figure 1 in the text is extracted from this report and shows that about 55 percent of the energy used is wasted. Obviously, the laws of thermodynamics will not permit 100 percent useful work, so some waste is necessary, but not as much as indicated. The waste indicated is actually understated since through energy productivity, with improved utilization technologies, the same useful work can be accomplished with less energy,

The need for improved utilization technologies has been clearly recognized; however, actions to encourage them have been lacking or ineffective. On many occasions, we have noted in the Federal Government the lack of emphasis, commitment, policy, and funding toward improved energy utilization technology development and utilization. Efficient energy utilization or "conservation" technology has been subjugated to the supply technologies. This is partly because the word "conservation" has evoked images of doing without and making sacrifices, while supply has been regarded as an insurance policy for continuation or improvement in our lifestyle. There seems to be, also, a pervading belief that the public will conserve through change in lifestyle, that industry can be forced into conservation measures through regulatory initiatives, or that our free enterprise system will lead naturally to the required technological end-use improvements.

It appears that, for these reasons, the governmental authorities have concluded that the supply technologies must be largely federally supported and that the end-use technologies can be left largely to their own devices.

I am personally delighted that this committee is holding this kind of a hearing.

It is really an indication for the first time that there is a recognition that industrial conservation can have some very significant impact.

It is essential that Congress and the executive branch understand that energy conservation, through efficiency improvements and the development of new processes, can actually preserve or improve our lifestyle and, very importantly, provide more time for a transition to the use of synfuels and renewable resources.

Improvements in end-use conversion equipment efficiency are the lowest cost way to produce fuel availability; or in other words, it is less expensive to make a barrel of oil available by saving it with improved efficiency equipment than it is to produce a barrel with a synfuel plant.

This was discussed by several of the other people here.

Energy conservation should not mean "doing without" or "suffering". It is unfortunate that this meaning is the accepted meaning. In order to secure popular support for true energy conservation, we will need to call it something else. The term "energy productivity" has been introduced recently. This term is very reflective of what we are

trying to accomplish and does not have any negative connotations. Therefore, we will try to use the term "energy productivity" throughout the remainder of our testimony.

Personally, I hope this term will become widely used and accepted so we will not confuse conservation with aspects of doing without.

While energy productivity is important in all sectors of our economy, it is fitting that this subcommittee is placing particular emphasis on the problems of energy productivity in the industrial sector. The opportunities for conservation in the industrial sector are immense, both in relative and absolute terms, and while we will not argue about the exact number of quads, as was evidenced, there are a large number of quads that could be saved.

Relative to the other industrial nations, the United States uses more energy per unit output in comparison with Germany, as shown in figure 2. This is true even today, after what we have been able to accomplish with energy conservation.

There are three reasons for this difference.

First: The European and Japanese industrial capital plant is newer. Having been destroyed during World War II, it was rebuilt with newer technology.

Second: The cost of energy in the other industrialized nations has always been higher, due both to the costs of the raw energy stocks and high taxes. The high costs of energy made energy productivity pay.

Third: Their social attitudes are more attuned to practicing conservation. The United States has been conditioned to a "throwaway" economy. In an absolute sense, industry wastes a vast amount of energy. Figure 3 presents data from a recent study for DOE which shows that about 11 quads of heat are rejected from industrial processes. Obviously, industry is a prime target for energy productivity. The problem then is, how can this potential for energy productivity be realized.

Implicit in the fact that hearings are being held on industrial energy productivity, and that there are industrial energy productivity programs in DOE, is the belief that government has a role in making industrial energy productivity a reality.

In order to address the Government's role, it is necessary to clearly define the objective. It is our understanding that the Government's objective in energy R. & D. is to stimulate and accelerate, and I will repeat, accelerate the "commercialization" of revolutionary energy end-use equipment and supply technologies.

In this way, we, as a Nation, can continue to maintain and improve our standard of living without the excessive impact of foreign entities such as OPEC. The basic questions relating to this objective are:

One: Why is government involvement needed?

Two: What can government do that is effective?

I hope, as a result of this testimony, this subject is not going to be repeated on a yearly basis.

The three questions posed in Representative Ottinger's letter are really subsets to these two more basic questions as related to industrial energy productivity. In order to effectively respond to Representative Ottinger's questions, the more fundamental questions will be addressed in light of our perception of the Government's objective.

The first step in responding is to distinguish among the various types of industrial energy productivity options. Next it is necessary to understand the commercialization process and decision criteria that impact upon commercialization.

To understand commercialization, it is also necessary to understand the commercialization barriers of which there are many. Each one of these barriers has to be overcome before we can transfer a concept into an end product which somebody is going to use. Any one of these barriers that exists in the way of commercialization can stop the utilization of the things that we are discussing today and we will continue discussing in the future.

Finally, it is necessary to relate the impact of current and proposed Federal policies on these decision processes as they relate to energy productivity. We will then be in a position to respond to the specific areas of concern today. All these points are covered in the written statement in some detail.

In our verbal presentation, we will limit our comments primarily to the first and last points.

We have discussed the need for industrial energy productivity, the industrial decisionmaking process and the impacts of Government policy. We are now in the position of pulling this altogether into a concise set of recommendations.

The key problem is the uncertainty and the unknown risk associated with any new product development or purchase. Industry reacts badly to uncertainty and unknown risk. The principal cause for this uncertainty is the erratic Government actions on energy. The first step by the Government is the formulation of a clear, consistent and steady energy policy. This is the sine qua non of the whole energy situation. We have heard on a continual basis, where is our energy policy? We still don't see it.

Mr. OTTINGER. You are asking too much.

Mr. STERNLICHT. Without the basic policy, every other action is simply a chewing-gum-bailing-wire patch.

Given the existence of the energy policy, the actions relative to industrial energy productivity are shown in the next Vu-Graph. I am sure you won't be able to read it from the Vu-Graph but it is in the text. The thing that is apparent from this is that throughout this whole process of taking the equipment or process from the incubation and idea into the marketplace, there are a number of different roles that the Government plays. In some cases, it requires full support. In other cases, it is a corporative undertaking. In another case, it is some form of incentive. In some cases an investment tax credit. Those are discussed in quite a bit of detail in the printed submission.

The various steps in the product development process are related to the commercialization barriers. Government actions are then indicated for each appropriate combination of steps and barriers. These actions range from a full Government commitment to basic research in the machinery and process technologies to the energy rebates. We shall cover briefly each action.

Mr. OTTINGER. This is figure 25 on page 50?

Mr. STERNLICHT. Yes. This is figure 25 on page 50.

Now, I will go to page 51 for the balance of the statement.

The problems of matching product concepts with market needs can be addressed by cooperatively funded programs with industry, both manufacturers and users.

The relative funding participation between Government and industry should be reflective of the stage of the concept development, risk, and commercialization timespan.

Another action by Government is along the lines of the energy study rebates as proposed by Senators Kennedy and Durkin. Here, the energy studies would be more in the line of problem statements rather than investment analyses. That is, the user industries would take a specific problem, examine an energy productivity alternative, and identify the needed modifications in order to make it technically or economically acceptable. This problem statement could then be used by the manufacturers and technology developers. The national laboratories could play a very constructive role in this area.

The cooperative programs will reduce the risk and long lead time investments for industry. This combined with a more flexible patent policy to recognize industry's funding participation in funding the developments would provide a very meaningful incentive to the manufacturers.

Loan guarantees for manufacturing investments would be a very low priority incentive. Loan guarantees for buyers and operators of new industrial processes will be as necessary as they are for synfuel developers.

In figure 16, some general numbers are given for the funding requirements for the development of energy productivity technologies—I might add, this was material I used in testimony 2 years ago. It still hasn't changed.

We would like at this point to become very specific as to the future development funding requirements for Rankine bottoming cycles. These numbers are presented in figure 26.

These numbers, I might add are by a factor of 5 larger than the kind of budget that exists at the present moment in DOE.

If we use the rule of thumb evaluation criterion for Federal support of \$1 per barrel of oil equivalent saved per year, the 4,500-megawatt potential of bottoming cycles should receive about \$300 million of funding. Significantly less is needed.

So even using the criteria that Mr. Doug Harvey's staff has generated, that is now being evaluated by the National Academy of Science, and that, in the future, I hope it isn't going to have to be evaluated by God, it is still going to be the same numbers. We are way off between the existing budget and the kind of budget justified by the payoff's.

It is important to make the risks as low as possible to the buyer when the new product is being demonstrated in his plant.

I might add, the risk is not associated with his cash flow. More risk is associated with the perceived concept of the reliability of the equipment within his plant.

The risks are related not only to the possible failure of the new equipment but also the impact on production. Direct subsidies, energy studies rebates, and cooperative programs are possible alternatives. The energy studies rebates are not much of a financial incentive but more of a psychological incentive. A detailed energy study will quantify the risks. The reduction of risks to the buyer in the commercial demonstration and product introduction steps is very close to giving a direct incentive to the manufacturer. In this case, the incentive has to go to the buyer since he has to make the decision.

The final incentives are those needed to offset the imbalance between the price of energy to industry and its value to society. The most effective incentive seems to be the energy rebate. However, there are numerous types of industrial investments. Even though the energy rebate seems most effective for the investments we examined, other incentives may be more effective for other investments. This has to be examined almost on a case-by-case basis.

As you can see from this particular slide, waste heat recovery at \$15 energy credit and 25 percent price subsidy provide equal incentives.

Now, that is an interesting point. This doesn't necessarily apply to other equipment but waste heat.

So here if the Government would provide 25 percent subsidy or provide this proposal that Senator Kennedy and Durkin have brought in, it is almost equivalent.

There is another alternative shown on the top of this figure, which probably is not going to be acceptable. Yet it could make a revolutionary change.

If the Government would suddenly not permit the tax disallowance on energy costs to the industry, so that the industry would have to pay the entire cost for energy, the energy cost would effectively double. Three cents per kilowatt-hour electricity would appear to cost 6 cents per kilowatt-hour. This action, which would be strongly opposed by industry, would create rapid introduction for these technologies. While this proposal may be laughable and not readily acceptable, we have to come up with highly innovative conservation techniques in order to accelerate the conservation philosophy in our Nation.

It is important to note that not all incentives affect all investments equally. The investments range in scale from a simple motor retrofit to an entire process replacement. The investments range in maturity from products such as the Rankine bottoming cycle, which is in the commercial demonstration stage, to well-established products such as recuperators and waste heat boilers.

I might add that there are some recuperators in the development stage. Doug Harvey mentioned some of those.

The incentives needed to make waste heat boilers more readily used are quite different than for the Rankine bottoming cycle. Figure 27 shows the current investment returns for a waste heat boiler with and without the energy rebate. MTI is discussing with an industrial customer a waste heat boiler with an estimated installed cost of \$20,000 per million Btu's per hour of steam. This industrial customer should install the boiler even without incentives.

So here is an example of a product which today is highly viable from the cash flow requirements by the industry.

Mr. Chairman, it is important for us to recognize that there is a very wide spectrum of industries, from the very small to the very large, that manufacture consumer products, industrial products, materials, and processes.

They cover a very wide variety of products. There are those that manufacture for domestic markets and those that cover international markets. This diversity of products and industry suggests that a flexible and diverse program be implemented for promoting industrial energy productivity. In developing this program, the rewards of energy productivity are clearly recognized but the risks must also be recognized.

History has provided a number of lessons of what happens when new product innovations or government regulations arise. New products can create whole new industries and destroy existing ones. The automobile and the buggy whip is an old time example.

Regulation can create new industries and weaken or destroy others. The whole industry of pollution control equipment and services is an example. Weak companies and weak industries are very susceptible to any change, be it product innovation or regulation. Today, Chrysler is a prime example of this. Thus, in our eagerness to save energy, we should not inadvertently cause harm to some of our industrial companies.

One question we have not directly addressed is "Why is Government involved?" Basically, there are two answers.

One is that Government is already involved and must extend its involvement to obtain a balanced result, which is in the long-term best interest to the public.

The second is that the energy savings potential is so large and vital to the health of our economy that the Government has a responsibility to insure that industry have available options and practice energy productivity.

We find it very curious that the question of Government's role in industrial energy conservation is raised so often. Each year, we and others supportive of energy conservation or productivity are forced to prepare lengthy program justifications, testify before Congress, and discuss the subject with high levels of DOE management and with the Office of Management and Budget. The topic is a \$40-million Industrial Conservation budget.

The priority and fundings of miniscule portions of this miniscule program are questioned.

However, an \$88-billion—or whatever it will turn out to be—Federal synthetic fuel program is readily accepted. The money will be derived from windfall taxes on the obscene profits of the oil companies, and the oil companies will be the principal beneficiaries.

We will spend billions on providing an admittedly more expensive fuel but spend next to nothing to use that fuel efficiently and cost effectively. While we are fully supportive of a synthetic fuel program, it needs to be tied to an energy productivity program. Otherwise, the type of illogical situation as illustrated in figure 28 will occur.

This is the best example I can give for energy improvement, even in synthetic fuel plants; otherwise, we are going to find tremendous wastes in those processes.

It is clear that the Federal Government has a responsibility to the public to insure that we maintain a healthy national economy. In the energy area, this must be translated into both energy supply and energy productivity. There appears to be a commitment to energy supply in the form of synfuels. We cannot, however, afford to ignore other supply options. More importantly, we cannot afford to continue to ignore energy productivity in the U.S. industrial complex.

We hope that our comments today will help Congress in formulating a responsive position to accelerate industrial energy productivity.

This concludes our testimony.

We would be pleased to respond to any questions.

Mr. OTTINGER. I want to thank you all for what I consider really extraordinary, important, good testimony.

I have had the opportunity to read the full testimony submitted by each of you and I think it is so impressive I personally am going to send it to Secretary Duncan, to the Appropriations Committees of both Houses, Authorization Committee in the Senate, and to OMB and ask them to read it.

I think there is such an important lesson to be learned from what you have testified and documented in terms of potentially resolving our energy crisis through increased efficiencies which you call energy productivity.

Our voice simply has to be heard to the extent that it is possible.

I think it is particularly important the distinction you draw, Dr. Sternlicht, in the beginning of your testimony between conservation and sacrifice: using less by turning down thermostats and driving less as opposed to increasing efficiencies.

That is just critical because there are such dramatic savings without impairing life styles, indeed allowing fully for the improvement of our life styles.

I think it is a lesson that has just gone by the boards.

I addressed over this weekend the Zionist Organization of America. Of course, they have a critical interest in what happens in the energy picture, of pressures on Israel as a result of the energy crisis. They missed this completely. They are talking about, "Well, conservation, yes, that is something that is nice but you are never going to be able to achieve it, it will mean much higher prices for energy, and we are continuing to consume more." They think of reducing driving, and so forth. I made this point as forcefully as I could about a whole other aspect of conservation in terms of increasing efficiencies for which there is a much larger potential than any other form, that has a much lower price tag on it and much lower environmental consequence than any other form.

I am continually frustrated by our inability to get this story across.

I think the work that you have done in documenting what is achievable through conservation in this particular area of the industrial sector, is just very important.

I will do what I can to get it heard.

I would like first to recognize my colleague from Missouri, Mr. Volkmer, and give him my personal thanks for sitting in for me while I attended a conference.

Mr. VOLKMER. I wanted to thank the gentlemen, too. They invoked a great deal of thought in my mind.

I do see some areas where there probably are some conflicts.

I will ask you if you will correct me if I am wrong in this conflict. If there is conflict, maybe it can be rectified; maybe because we have conflict is why we don't have that energy policy.

I also wish to congratulate and encourage Mr. Harvey to continue the good work.

To be honest with you, you are one that I feel is a bright light in the Department of Energy.

Mr. Sant, as I understand your testimony in going through it, you propose basically a policy that the Government do little, is that correct, as far as energy usages are concerned, as far as regulatory processes are concerned, as far as directives as to the utilization of higher cost energy sources in order to get away from imported oil, am I correct in that?

Mr. SANT. Yes.

Mr. VOLKMER. That is the basic philosophy, we should leave it alone and, we can indirectly reduce imported oil as a result of that policy.

Mr. SANT. I would like to clarify it.

I think what we want to do is broaden the context in which we do something. It seemed to me that we have gotten way off the track by focusing on a narrow part of the problem, for example, imports.

The broader view of the problem is really the whole economic impact within the United States of energy and energy services, and I found by looking at that broader context, you not only satisfy the import problem, you deal with a lot of things which have been running counter to the economic problem. That is, I think mandatory coal conversion is a good example of getting so preoccupied with imports that we have done something that is economically unsound and has prevented industry from responding more appropriately.

It is not that I am saying that Government ought to get out of the picture completely. I'd rather see a process of trying to enhance the competitive elements that I know are there—which include all the conservation technologies—so that those things really have a chance to compete for lowering the cost of industrial energy services. Not to mandate some coal use or mandate some particular energy technology.

Mr. VOLKMER. Natural gas or anything else.

Mr. SANT. Exactly.

Mr. VOLKMER. Because of the cost of those they will naturally go to the—more efficient use and less-cost fuel?

Mr. SANT. Yes.

Mr. VOLKMER. For utilization of their industry, whatever, it may be?

Mr. SANT. While that mix may be wonderfully difficult to predict, I believe in this particular instance, a market seems to work. I am not advocating a market response to every social problem by any means.

It appears that with regard to the energy problem, a market type of competitive system turns out some very interesting and very valuable results which we ought to do more to encourage rather than discourage.

Mr. VOLKMER. Mr. Reid, what do you say about all that? I don't think you are saying that.

Mr. REID. No; I am not.

Mr. VOLKMER. You are not saying the opposite, not quite, though?

Mr. REID. I thought conservation could pay off much more than the synfuels program, certainly in this century. I don't think we shouldn't be pursuing the synfuels programs, but I think you have to set it in some kind of perspective.

Mr. VOLKMER. You are also saying, too, it is a good idea to go to coal, and so forth?

Mr. REID. I think so. You have to place it in chronological order, in the context of the timeframe we are dealing with to achieve the things we are talking about achieving within the industrial sector.

We are talking about within 25 years, something along those lines.

We have seen two disruptions to our energy supply system in the last decade. We are looking at a 1985 scenario where we could have significant disruptions of oil supply over that period of time.

I am not too encouraged concerning the supply response we are going to get to higher natural gas prices. I don't know what it will be. I think it is a real question of just how price elastic the supply of natural gas is.

So I am saying that I would hedge my bets over the next 10 years, I would not forsake energy productivity, for example, in the name of pursuing these other investments. Let them all compete on the same footing. The Government wants to give a premium for energy productivity or energy supply because of our dependence on foreign oil supplies. Then allow all the technological options that we have at our disposal, including conservation technologies, to compete on the same basis. We can afford to provide additional incentives to become less dependent.

Mr. VOLKMER. We are going to have to do that, while if we follow Mr. Sant's idea, you are not going to need the incentives.

Mr. SANT. See, that is the first time—

Mr. VOLKMER. There is a question in my mind, if we follow what Mr. Reid is saying, we have to look at the incentive coming from Kaiser and others in order to get where you want to be; drop the incentives, you are not going to do it on marginal, perhaps. Not just Kaiser.

Mr. GOMES. Naturally, the productivity projects are going to be done. It is a question of time.

Mr. VOLKMER. They are going to be done if they are cost economical for industry. If it costs too much to use coal, you are not going to do it.

Your process at the end became unprofitable, the company is not going to do it.

Mr. OTTINGER. Would the gentleman yield?

Mr. VOLKMER. Yes.

Mr. OTTINGER. If I understand correctly, I think all the witnesses have indicated that as you replace new plants, you introduce productivity. If you want to accelerate that, have the efficiencies introduced earlier, it is not likely to happen without some kind of an incentive, is that correct?

Mr. VOLKMER. There is certain technology that cannot be implemented, right, Mr. Harvey, that cannot be implemented without incentive?

Mr. HARVEY. I think the question of technology that is implemented has to do more with the perception of the risk associated with that technology rather than its particular efficacy or efficiency in a given process.

As Dr. Sternlicht pointed out, the risk of production failure, that is reducing production because of failure of some piece of equipment, so outweighs the benefits that can be gained from energy savings and the reduced operational cost that reliability becomes an overwhelming consideration in new technology.

Reliability is associated with risk of introducing that technology. There are very few companies, especially in the commodity industries like steel and aluminum, that are going to introduce a new technology that is going to jeopardize their production.

Mr. VOLKMER. In other words, have to be shut down 2 weeks at a time.

Mr. HARVEY. That is right.

I think everybody is saying, basically, the same thing, that there are forces, economic forces, that will introduce technology into the industry.

Dr. Sant said if we let the free market forces persuade or provide that motivation, that indeed within some period of time, that optimum mix will develop.

Dr. Reid I think has said that period of time, that reaction time, may be significantly longer than the country can afford.

Mr. SANT. I would like to clarify.

I am completely agreeing with Mr. Reid in the sense there are so many subsidies on the supply side you almost have to do something like Kaiser is proposing in order to offset these. If they weren't there, maybe we could be purists about this. They are there. And, in fact, average cost pricing is creating a large subsidy in electricity. Therefore, we are getting a very bad signal of what the cost of a new electric powerplant is. In that sense, I think we are in complete agreement about the nature of this situation.

Mr. VOLKMER. I'd like to also agree with something that was said by Mr. Sternlicht when looking at the testimony that just the residential home furnace, and when you look at it as efficient, actually it is 55 percent efficient instead of 75 percent efficient. If we make a more efficient furnace, you don't have to turn back the heat, is that what we are really saying?

Mr. REID. It's good to do both.

Mr. VOLKMER. In other words, there are alternatives to turning back the thermostats.

Mr. STERNLICHT. I think we have to look at a much broader picture than just look at increasing energy cost and at the same time find ways of accelerating these conservation programs.

There should be absolutely no question in anybody's mind that energy costs are going to increase. This increase will be initiated by oil producing nations or by the actual cost of producing synthetic fuels.

The real question is how do we maintain high employment and make the products that we consume in this country and export so that the public, especially the low and middle income public, can afford to buy. If the cost of energy is going to be very high and if efficiencies are also going to be very low, the public is not going to be able to afford to use these products. What we really need is much higher efficiency of those products, so that the public can afford to use them even with escalating energy costs.

Industry can afford to pay higher energy prices since these will be transferred to the consumer. Much of the public cannot. We really have to look at what is the total cost to the consumer on a life cycle cost basis. That is the broad question that we really have to look at.

Mr. VOLKMER. What you are telling us, we put more money into the programs we have in order to get more involvement, is that right?

Mr. STERNLICHT. Absolutely.

I don't think there is any one of these things that is going to cure it. We have to recognize that price increases are definitely accelerating the introduction problems of some of these things but also recognize that demonstrations are essential in order to accelerate market acceptance.

Mr. VOLKMER. In order to get the reliability.

Mr. STERNLICHT. Proof from the industry that they are going to buy it and that the consumer is able to afford the end product.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

Mr. OTTINGER. I'd like to ask a few questions at this point.

I am going to have to leave again unfortunately.

I would like to get your reaction to a proposal that I intended to put forward in the conservation basket this week alongside of the proposals that have been made by Senator Kennedy and Senator Durkin and Senator Bradley. It would try to get private investment funds into the energy conservation area by creating a facility to subsidize interest rates, make low interest loans available to companies and commercial establishments and maybe even to residents for the financing of energy conservation improvements.

There are the various incentives you have discussed. I wondered what you consider the utility of approaching the insurance companies—who, as I understand it, invest something like a \$100 million a day in various enterprises throughout our country, and that is a huge amount of money—on this idea.

They say, "Yes, we think energy conservation is a good bet. But we have difficulty in retaining our investment funds so that unless you are talking about the very large investments for big industry, it can't be in that marketplace. But if you could use the existing financial institutions and provide some means by which we could lend to them and they in turn could lend on a subsidized basis, that would be very attractive to us."

I wonder if any of you care to comment?

Mr. STERNLICHT. I think what you are proposing would be good if it was tied to the percentage improvement in efficiency. The interest to the individual would be dependent—on the kind of product he produces, because what you really would like to do as rapidly as possible is obsolete the inefficient products.

Mr. OTTINGER. Does anybody else wish to comment?

Mr. HARVEY. I will comment a little bit.

We have looked at loans and loan guarantees as a potential motivation to a certain degree, not a detailed economic analysis.

In the industrial sector, I think that loan guarantees for the consuming sector, the residential/commercial sector, are entirely different considerations, but for the industrial sector, every company usually has a bylaw, prescribing a given debt-equity ratio. While smaller companies may be able to take advantage of a loan guarantee, the larger companies generally are pretty well set on that debt-equity ratio. Unless they did something by off balance sheet financing; for example, set up a separate corporation to introduce a new technology or existing technology, into a process stream.

One of the difficulties I see in industrial processes is that the commingling of equipment in a given process stream makes it very difficult for one company to own one piece of equipment and the parent company to own another piece of equipment, and to be able to identify those two pieces of equipment sufficiently such that they are not intimately interrelated. For example, recuperators—there is no way an off balance sheet corporation could own a recuperator. It is too intimately intermingled with the reheater furnace itself.

I think there may be applications for this type of thing but I think they are relatively limited in the energy-intensive industries.

Mr. OTTINGER. We are trying to get your reaction to Mr. Gomes' comments with which I am very, very much impressed and concerned. He says there is a rough cutoff; I don't know whether it is true generally for industry. That they won't make any industrial process efficiency investments unless there is a 15-percent return or more.

Mr. HARVEY. That is correct.

Mr. OTTINGER. What we are trying to do is to make more investments come within that 15-percent limitation.

Mr. GOMES. If one looks at the components of cost of capital, the impact to guarantees can be better understood. The guarantees will decrease the cost of capital. Let us look, for example, at the impact of decreasing the interest rate by 2 percentage points due to Government guarantees.

If we assume a 50-percent debt to total capitalization ratio, the after tax capital cost will decrease by 0.5 percentage points. So the impact would be very small to make the difference in investment decisions.

Mr. OTTINGER. If we offered the investment in energy conservation at a capital for that at 8 percent and the Government was subsidizing the difference between 6 percent and the market rate, wouldn't that make a—

Mr. GOMES. Assuming you have a 50-percent debt-to-equity ratio, a 6-percent advantage in interest rate would have approximately a decrease of 3 percent in cost of capital.

Mr. SANT. One and a half after taxes.

Mr. GOMES. Three percent before tax, 1½ after tax.

Mr. VOLKMER. Would the chairman yield on that?

Mr. OTTINGER. Surely.

Mr. VOLKMER. Let's compare that to your proposal. Let's say you had a 15-percent tax credit. Where does that end up on your investment?

Mr. GOMES. Our proposal is based on whether you need incentives—

Mr. VOLKMER. Assume you do. Assume you got a 15-percent tax incentive in order to make it hit that 15-percent productivity. OK.

Now, where does that get you on your investment?

Mr. GOMES. Well, it would all depend on the amount of incentive you need to reach from whatever return of investment you have to the level you require, if that difference was 2 or 3 or 4 percentage points a 15-percent tax credit would do the job. If the difference in return on investment was 6 or 7 percent the 15-percent ITC would certainly not do the job. It depends how much you have got to get the 15-percent from where you are.

Mr. VOLKMER. The way yours works, as I understand it, if you need to get to 6 percent or so through a 20 percent, you would go to 20 percent?

Mr. GOMES. That is right.

For example, that project No. 3, I think it had a return investment of 7 percent. To go up from 7 percent to 15 percent in that project, you would need the whole 30-percent.

Mr. VOLKMER. By the way, what would we do on your proposal if the 30 percent gets you 14.5, they could still do it if they wanted to?

Mr. GOMES. Yes.

Mr. VOLKMER. On one of your proposals, No. 1, I remember is 14.2 or 14.5, something like that, therefore, there would be very little tax incentive?

Mr. GOMES. Yes.

Mr. VOLKMER. That is why you like the tax incentive better than the other proposal, either reduction or subsidy on interest rates or guarantees or anything else?

Mr. GOMES. Right.

Mr. STERNLICHT. Let me add one comment.

It is important for you gentlemen to recognize that whenever you calculate discounted cash flow, the one thing you have to assume is that the system is going to operate for so many hours per year without any trouble and extensive maintenance.

The first thing we are asked when we go to industry is: "Show me where such equipment has been operating for X number of years so I, myself, can see it, can kick it and can find out exactly what the heck has been its availability." All of these calculations on discounted cash flow are absolutely meaningless unless you can prove that the system has been operating trouble free for the specified time.

The same thing applies to synthetic fuel plants. It doesn't make any difference.

One of the things I think was emphasized here and may have been missed is that we see the perceived risk of the end users as being much more associated with the question of the availability of that system, the ability to operate it on 8,200 hours per year, vis-a-vis, repairing it every 500 hours. Many of the plants do not have the personnel for this. And it is this kind of problem that was discussed as really needing demonstration programs. This is the only way you can show what is going to be the availability of this equipment. All the other questions of discounted cash flow can be misleading the management, and management understands this problem. One guy would give a very conservative number; and another guy, who is less conservative, will give another number of discounted cash flow.

In the end, management discounts all these numbers of discounted cash flow. When it comes to new technology, you are not accepting 15 percent in cash flow, not even in Kaiser.

I know very few companies around the country which will accept a discretionary investment of 15 percent. So you are talking about 30, 40, 50 percent because of this perceived risk—not 15 percent.

Industry can invest today in product improvement, increasing the number of products that are going to be put out the door, and have to invest to satisfy, and emission regulations which are costing them a lot of money. Keep in mind the use of discretionary investment funds for energy are often viewed as just a learning expense that there is a problem and it will cost more money.

You can also prove it. These various incentive techniques are really not applicable to industry but are much more applicable to the consumer product area.

Mr. GOMES. I think Dr. Sternlicht and myself are not at the same frequency.

I was talking about projects which do not require new technology; projects which have been implemented for the last 10 years, and therefore have technology which has been proven. These projects are not the question you have to prove.

Mr. VOLKMER. Not just to cost efficiency or energy cost.

Mr. GOMES. That is my second point.

Mr. VOLKMER. You are seeing developed technology already.

Mr. STERNLICKT. Let me comment on that. When people talk about developed technology, very often they mean that there is a piece of technology over here and another piece of technology over there, and another piece of technology some place else that is developed. It is then a question of putting them together in a full-scale system. While component technology is "developed," it turns out that the system technology is not developed. The technology has not been converted to demonstrate that the system is really going to give you 15 or x percent of discounted cash flow.

Mr. VOLKMER. I am not disagreeing with you.

What I am saying is that I think we have to look at both.

I think Mr. Gomes is saying we have to put more into this, more demonstrations even with that. We still may have to go down this street. Also, they are proposing demonstrations in order to get some of it utilized because of the costs of it, costs to the industry.

Mr. OTTINGER. I only have 5 minutes left to be with you.

I would like to turn for a minute to page 15 of Mr. Harvey's testimony in which he indicates various ways we can facilitate conservation and just clarify some of your reactions.

He hits first on regulatory policy, minimum performance standards, regulatory productivity targets, energy taxes, mandatory fuel switching.

I would like to get some feeling from Doug and from the other panel members as to how useful you think that kind of an effort would be.

We have been discussing financial incentives for a bit.

Mr. HARVEY. I'd like to discuss that a little bit first, Mr. Chairman.

We did consider things like performance standards. I have testified before the Metzenbaum committee, as a matter of fact, on some of the performance standards he recommended. We are evaluating many of these potential policies that could be adopted by the Federal Government against some criteria for evaluation. The criteria includes: What the energy savings would be, what the fuel switching impact would be, the risk returned and diversity of policy, the compatibility with other Federal mandates, administrative cost of the policy, displacement of industrial initiatives, and expediency of implementation.

The performance standards we found would be extremely difficult and expensive to administer. For example, they would only introduce technology that is currently existing. One could not set standards for some new piece of equipment that had not been proven in industry.

For example, on an electric motor you could go to the Gould motor, E-plus motor, as a base line for a standard or some other industrial standard that is within grasp.

Mr. OTTINGER. That available technology standard is what you use now for scrubbers.

Mr. SANT. The variable speed motor wouldn't be covered. That may be the major advance.

Mr. HARVEY. Something like the 1,600 motors would have to be evaluated, standards established and enforced. It looks like to me to be a very expensive enforcement administrative program. We looked at productivity targets, and we set productivity targets. They are voluntary at this point in time.

Again, you would have to set them within existing technology and indeed you may be forcing industry to invest in technology that is not on the forefront of capability, but rather things that Beno pointed out have been proven in reliability. Energy taxes, I think, essentially are a financial motivation, just as deregulation is a financial motivation. Falsely increasing the cost of fuel through a tax program, let's say, for where industry had to pay a tax on a given fuel, sure, that is a financial motivation, It can be analyzed by—

Mr. OTTINGER. I like Dr. Sternlicht's idea of reducing the tax deductability.

Mr. HARVEY. I haven't examined that one.

Basically, we found in general the regulatory policies and incentive policies do have motivation for introducing existing technologies.

Those courses provide no motivation for either of those courses for introducing advanced higher risk technologies.

They would make an impact, and they could probably make a short-term impact. They may be more expensive than you want to consider.

Mr. SANT. I would like to comment just briefly having run the Nation's conservation program a little bit.

I have looked very seriously at mandatory standards, even advocated them at one time. In the research we have done, you really end up with so many technologies, I mean in the thousands and tens of thousands of technologies that perhaps can compete for making some process or part of a process more cost effective, that I have thoroughly discarded mandatory standards in favor of looking at some measure that would reflect the real fact that there is not much capital available for these kinds of investments. Not that there is not much capital available in the whole energy industry, that is, including the oil companies and utilities. If you could somehow find a way of getting that capital to the efficient technologies, I think there is enough capital to handle the energy needs up to the year 2000 at least.

But I have not been able to determine a way to do that. Therefore, I would like to applaud your major objective in what you propose to us, but agree with the others that it may not be the optimal way. I completely agree with Mr. Harvey in terms of the infeasibility of a mandatory or regulatory approach, just in terms of workability, not in terms of right or wrong, in terms of workability.

Mr. OTTINGER. Do you all agree that tax incentive is the best financial incentive for conservation?

Mr. STERNLICHT. The Kennedy proposed energy rebate looks like a very promising incentive subsidy for the industrial sector. To answer your question, which is similar to one Doug Harvey also posed to me, with reference to the one advantage that a tax-based incentive system has is that you can be selective. You can be selective in saying to those industries that are highly profitable, for instance, and that are not conserving for whatever reasons, you cannot over the next 5 years take a tax deduction for energy cost. The amount of money that comes from such a system could be appreciable and could be plowed back into development work for those specific industries via Government programs.

Second, it eliminates the problem, to which everybody is opposed, of eliminating or allowing the energy costs to just flow to whatever the economic parameters will allow it. This problem impacts the public because the public in many cases cannot afford to buy at much higher prices. So it has got some advantage.

I am not necessarily proposing that it be adopted because there are many negative elements to it that one could also come up with, but it does show the tremendous incentive that could be generated by a push and pull situation with reference to industry.

Mr. OTTINGER. I wish I could stay, but I can't.

I will turn the Chair over to Mr. Volkmer.

We are going to resume again at 1 p.m. I am afraid you will have to cut this off very quickly.

Mr. KEZAR. I would like to comment on Mr. Sternlicht's thought that the regulatory mode might be very selectively applied.

I think how we are coming on international markets selectively applied regulatory standards to one industry, when we have international markets—

Mr. STERNLICHT. I would like to make a general comment. I am personally completely opposed to regulations unless it is absolutely essential in providing an incentive. When I mention that it could be selective, I meant that it is the function of the congressional leaders, the President and the governmental groups to really have a look at international markets to see if that is the market we are trying to serve. They have to be selective with a specific industry in order to try to insure that particular industry is going to be able to meet both the domestic market and international market.

I meant selective with respect to the world, not necessarily selective to the local situation.

Mr. GOMES. May I comment on that, also.

Our studies have shown that mandatory conservation via forcing implementation of new technology could force the shutdown of valuable domestic production capacity. If we are trying to solve the balance of payments problems, such a policy could compound the problem of balance of payment, since shutdown of domestic capacity would imply importing, in many cases, products that have a higher value added than crude oil.

Mr. KEZAR. What I think I am hearing from the panel and all the witnesses, there are a number of different incentives that would apply depending on the size of the company, or the business arrangements. For example, a newly formed corporation may find loan guarantees very attractive; a very large corporation with a fine bond rating may not find loan guarantees attractive at all, but may find tax incentives very attractive or may find a direct loan attractive.

Would anyone care to comment on this relationship? It is a flexible policy depending on corporate arrangement and size, OK.

I wanted to ask a question as to the role of the national labs that Mr. Sternlicht mentioned and Mr. Harvey mentioned. What role do you see lab support of the Department of Energy playing in industrial conservation?

Mr. HARVEY. Shall I answer that?

I think the labs can play a very significant role. Certainly the national laboratories have as much expertise in high-temperature materials, and corrosion-resistant materials capability as anyone in the world with some very capable people in this area. I think they can make a significant impact of evaluation of different ceramic materials for example, those compatible with a glass flue. They are doing the evaluation of samples for us and doing an extremely superb job.

However, in developing industrial technology, I think the role of the laboratory is limited because I am strongly of the opinion that if industry is going to believe something they better be directly involved with its development. If the aluminum industry is going to believe in direct reduction I better have an aluminum company involved. If we are going to develop a new forge, I better have a forging company involved in the demonstration. I think it is essential that demonstration and development of technology be done by industry, cost shared by industry, because then they also have a vested interest in seeing it succeed.

I think the role of the laboratory in that kind of a program is relatively minimal.

Mr. STERNLICHT. I fully agree with Doug Harvey's comment.

I think it is referring to generic technologies which are broadly applicable. Some of them could be developed in laboratories. When it comes to the development of a system which is going to be put in in industry, industry must be involved, and there is absolutely no question about that.

Mr. KEZAR. Another question for Mr. Harvey.

Where is the research funding or the technology base funding coming from in context with the Department of Energy that supports your more applied activities? You mentioned material as one example for national laboratories. I don't see any structured program in ET that really creates a technology base for industry conservation. There are hundreds of technologies. I don't see the base structure on which you can continue to draw. Certain basic research programs, in between there is a missing gap.

Mr. HARVEY. There is a gap in the basic research program. This is something I discussed with Dr. Snow of ER and discussed with the people at ET as well. I don't think there is sufficient emphasis on research or on development of technology.

Obviously, ET is doing a great deal of work on the bottoming cycle technology and heat exchanger technologies.

There are so many other things that really ought to be investigated, reduction of friction, advanced techniques for beneficiation of ores, extraction of metals in dilute ore situations, advanced ideas for purification of metals.

We had one program which looked at the volume reaction of chlorine with metals in an ore. The chlorides formed are volatile and would be separated by distillation. This very advanced technique compares with the standard technique of crushing, grinding, ore beneficiation, extraction with chemistry reduction, and so on. A process essentially that is years old. There is no advanced research going on and very little advanced development going on in the Department.

I think that is one of the objectives of the reorganization of the Department if indeed it comes to pass.

I suspect that conservation if it is separated out from the supply sectors will have this responsibility, but I only read in the newspaper what this organization is going to look like. I don't have any inside information, the supply sector presumably would be something like solar, fossil, nuclear, and so on. There would no longer be an energy technology division and research division under that type of an organization. I think there does need to be research. I think there does need to be basic development that is not undertaken at this point in time.

Mr. KEZAR. Would anyone else like to comment?

Mr. STERNLICHT. The reorganization of DOE is a subject very near and dear to the heart.

It is my hope that they will put the emphasis on technology for end-use conservation and that such an operation is going to be well funded, well managed, and establish visibility within the DOE. This doesn't exist at the present time.

Mr. SANT. Certainly, the recent administration of DOE had no appreciation for the technologies on the end-use side and it was just almost impossible to discuss in the same supply context the technologies on the end-use side, and have them perceived as competitive.

So I don't know whether Doug got any support other than in his own ability to articulate the advocacy. Maybe there are a couple of new guys now and maybe that will change.

Mr. REID. I have been working for the Office of Policy since its inception and recently got a call, about a month ago, asking for information on energy conservation. The reason for this request was posed on new information. They believed it might be appropriate to give conservation increased emphasis. Therefore maybe we are making progress.

Mr. VOLKMER. Interesting. Very interesting.

Mr. KEZAR. In budget hearings this committee has in many cases gone through an exercise of saving, if I can use the term, or improving the funding on one technology or another that has fallen through the gap. This may be the role of Congress, but it is a very, very expensive way of managing comprehensive programs. It takes a lot of congressional time to hear the testimony that eventually ends up and has to go through the whole process as an exception. It is much better if the balance can be created at the DOE level and the OMB level, and come through as a balanced program.

This really means that there is a communications problem between industry and the creators of the budget which hits this committee.

Would anyone like to comment on that kind of a problem and what can be done as the time of this committee, I see as a staff person, is enormously involved in the winter and springtime with a saving of technologies that have been overlooked or missed or merely evaluated at some level?

Mr. VOLKMER. We have to learn the details of those technologies. That shouldn't be necessary.

Mr. HARVEY. I have recently had my first opportunity to talk with Secretary Duncan.

I think we ought to wait a bit before we come to any strong conclusions.

I like everything the man said. He seemed to be very strongly in favor of conservation, very strongly in favor of an R. and D. program.

I think the jury is out at this point in time, and I think that before any affirmative action is taken by this committee or any member of Congress, the new administration of the Department of Energy could well set priorities that are perhaps more realistic in terms of which efforts are emphasized.

Mr. KEZAR. I have no more questions.

Mr. VOLKMER. I have no more questions.

I want to thank you all very much and appreciate the time you have taken.

Maybe we will have better results in the future and maybe if we get a windfall profits tax, maybe it all doesn't have to go to synthetic fuels.

Oh, yes, I do want to make a point.

Congressman Wydler wasn't able, because of conflicts, to be here. He has a statement and that statement will become a part of the record immediately following the statement at the beginning by the chairman, Mr. Ottinger.

We will reconvene at 1 p.m.

AFTERNOON SESSION

Mr. OTTINGER. We will resume our hearings on industrial energy conservation and revolutionary technology, and address that problem by means of a very distinguished panel this afternoon.

My apologies for being delayed.

We will hear from Noel Jarrett, assistant director of research, Aluminum Co. of America. I understand he is accompanied by Mr. Allen C. Sheldon, vice president, environment and energy resources; Dr. Robert L. Myers, vice president of technology, St. Regis Paper; Mr. Howard Hagler, Principal Resource Planning Association in Washington, and Mr. Peter Bos, Principal Resource Planning Association in Cambridge, Mass.

We welcome you and I will have to advise you in advance that I have to go to conference at 2 o'clock. We will have somebody continue and we will hear first from Mr. Jarrett.

[The biographical sketch and prepared statement of Mr. Jarrett follows:]

BIOGRAPHY OF NOEL JARRETT

EDUCATION

High or preparatory school (name, city): Wilkesburg High School, Wilkesburg, Pa.

University (undergraduate): University of Pittsburgh, BS 1949; Major Chemical Engineer.

Activities, honors: Sigma Tau; Phi Lambda Upsilon; Fellow, American Society of Metals, Member, National Academy of Engineers.

Postgraduate work: University of Michigan; MS 1951; Major Chemical Engineer.

BUSINESS CAREER

Company: Freedom-Valvoline Oil Co.

Dates: June 15, 1949 to June 15, 1950. Location: Freedom, Pa.

Type of work: Lubrication Sales Engineer.

Employment history with Alcoa or subsidiaries:

September 1951 to February 1956, Alcoa Laboratories Process Metallurgy Div., Research Engineer.

February 1956 to November 1959, Alcoa Laboratories Process Metallurgy Div., Section Head, Chem. Engr.

November 1959 to March 1969, Alcoa Laboratories Process Metallurgy Div., Asst. Chief, Process Met. Div.

March 1969 to May 1, 1973, Alcoa Laboratories Process Metallurgy Div., Chief, Process Met. Div.

May 1, 1973 to present, Alcoa Laboratories, Alcoa Technical Center, Asst. Director, Metal Production.

PROFESSIONAL AND TECHNICAL ACTIVITIES

Professional societies: ASM, AIChE, AIME, Electrochem. Soc. Sigma Xi.

Books, major magazine articles, or technical papers: A New Process to Produce High-Purity Aluminum; Transactions of Metallurgical Soc. of AIME, Vol. 239, 67-10 (with A.S. Russell, S.C. Jacobs, B.M. Starner).

TESTIMONY BY NOEL JARRETT, ASSISTANT DIRECTOR, ALCOA LABORATORIES,
ALUMINUM COMPANY OF AMERICA

before the

Subcommittee on Energy Development and Applications

of the

House Committee on Science and Technology

Washington, D.C.

1979 September 11

Good afternoon. I am Noel Jarrett, assistant director for metal production at Alcoa Laboratories. With me today is Allen Sheldon, Alcoa's vice president, environment and energy resources.

I am here today to discuss the work Alcoa Laboratories is doing with direct, or carbothermic, reduction of aluminum. We are in the second year of a three-year, cost-sharing contract with the Department of Energy to determine the feasibility of direct reduction.

Since this work is being done solely at Alcoa Laboratories, a brief review of our organization seems appropriate. Alcoa Laboratories is the largest light metals research and development organization in the world. With nearly 1,100 people and an annual budget of approximately 55 million dollars our effort represents about half of all the R&D being done on light metals in the U.S.

Our laboratories are primarily at Alcoa Technical Center, near Pittsburgh. At the Center, we have more than 800,000 square feet of laboratory space.

My primary area of responsibility is metal production. I am concerned with the segment of our industry where metal is extracted from ore. This is the most energy-intensive step in aluminum production. Our research goals in this area are clear. We want to increase the productivity of existing equipment with minimal expense. And we want to increase the efficiency of our raw material use, and that includes electric energy and petroleum-based raw materials.

To meet these objectives, Alcoa Laboratories is working in three basic areas.

We have under way both short and long-term programs to increase the productivity and improve the energy efficiency of our existing, conventional Hall smelting cells. Alcoa and the other aluminum producers have major capital investments in existing facilities and they will be our primary means of metal production for at least the next 25 years.

We are continuing to work on the Alcoa Smelting Process, today's only practical alternative to the Hall process. We are, however, several years away from determining the economic feasibility of this process, and even further from the point when it will be in commercial use.

And we are exploring the feasibility of direct reduction. It's important to stress "feasibility" at this point. In dealing with both the Hall and Alcoa Smelting processes, we are attempting to modify and improve existing technology. The direct reduction process entails all the risks that go with the unknown aspects of new technology.

Essentially, we are attempting with direct reduction to combine a number of energy-intensive production processes into one process. The goal of direct reduction is the production of an aluminum-silicon alloy plus a number of other valuable by-products simultaneously. To determine whether this can be done economically is the aim of our current investigation. However, we feel direct reduction offers the potential of being a major metal-winning breakthrough using less total energy and imported raw materials.

I'd like to briefly describe direct reduction. Ores containing aluminum and silicon are mixed with coke and are charged into the top of a vertical reactor similar to an iron blast furnace. As this mixture proceeds down the blast furnace shaft, a number of chemical changes take place, each at an increasingly high temperature. The result is an aluminum-silicon metal tapped from the bottom of the furnace and a great quantity of carbon monoxide gas exiting near the top. This gas, by the way, is one of the valuable by-products I mentioned. I'll discuss its value as a fuel shortly.

Let's examine the advantages of direct reduction.

First, this process reduces our dependence on imported bauxite. Our typical reactor charge so far has contained half bauxite and half domestic clay. Considering a 300,000-ton-per-year direct reduction aluminum plant -- the basic size we use in our economic planning and evaluation -- we could replace about 750,000 tons per year of imported bauxite . . . about 10 percent of Alcoa's current requirements.

Second, the process has the potential for recovering both aluminum and silicon from waste materials. In the future, we plan to explore three basic sources: coal wastes, fly ash from power generating plants and oil shale tailings. We have estimated that the coal wastes generated from a mine supplying one large-sized power plant contain up to 100,000 tons of aluminum and 200,000 tons of silicon per year. Using this coal waste as part of the feed stock for a direct reduction reactor, we can produce appreciable quantities of these metals.

Third, the direct reduction process uses domestic coal instead of petroleum-derived coke, which is presently used in the Hall process for electrodes. We feel this is a major advantage of this technique.

And last, direct reduction reduces the energy required to make aluminum-silicon alloys. It needs substantially less energy than current processes to produce the same product.

As I mentioned earlier, one of the by-products of direct reduction is carbon monoxide. Our hypothetical 300,000-ton-per-year aluminum plant would produce 49 trillion BTU's per year of this low BTU gas.

Used as a fuel for an electricity-generating plant, this amount of carbon monoxide converts to 550 megawatts . . . more if the next generation fuel cells are used. This is an excellent example of co-generation.

Another valuable by-product of the process is ferro-silicon, a basic material for one production method for magnesium, a light metal whose use in the transportation industry is sure to increase.

That brings me to a crucial point about direct reduction, and that's the end use of aluminum-silicon alloys themselves. These alloys, the product of direct reduction, are the basic raw material of the aluminum casting industry for many transportation applications. We think there may be a shortage of aluminum-silicon alloys in the coming years as the use of aluminum castings increases. Here's a situation where our nation can ill afford a materials shortage.

It's probably obvious that I'm optimistic and enthusiastic about our direct reduction research. But I must remind you that we are still working to determine the feasibility of this process. We have built and are operating a pilot unit. The next step is a demonstration reactor with a capacity of 2,500 tons per year. It appears that 1986 is the earliest that we can do this. By 1990, we would hope to be able to scale up to a commercial reactor with 160,00 tons-per-year capacity.

There are a number of difficult engineering problems to solve before any of these plans become reality. And we're still at least a decade away from realizing any of the advantages the process offers. As I said at the outset, this is only one of three metal production paths we are exploring. Improving the technology for our current facilities and continuing to develop the Alcoa Smelting Process remain our primary objectives.

But we do feel that direct reduction has the potential of being a significant breakthrough for our industry. We are pleased with the encouragement and support we have gotten from the Department of Energy. This support has enabled us to accelerate the research we had already begun.

This excellent example of cooperation between industry and government has put us further ahead on this research than either of us had predicted or would have been able to achieve alone. We have uncovered some tough technical roadblocks, and removing them will take time and perseverance.

**STATEMENT OF NOEL JARRETT, ASSISTANT DIRECTOR OF
RESEARCH, ALUMINUM CO. OF AMERICA**

Mr. JARRETT. Thank you.

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We are hopeful of success.

Thank you. I will answer questions if you have any.

Mr. OTTINGER. Thank you very much. That is very exciting.

My colleague from New York, Mr. Carney, has a statement he would like to make. I was unaware at the outset of the hearing, would you like to do that now?

Mr. CARNEY. Mr. Chairman, I apologize for this, as you know, I had to be at the Panama Canal Conference with the Senate all day, and I have an industry in my district who is very concerned about this and, if there is no objection, I would like to submit for the record a synopsis of the program the Grumman Aerospace Co. has been utilizing for the past 10 years in energy conservation, I think this information will be beneficial to this committee in its hearings, and also I think it will be beneficial to industry in general. If I could submit it at this time, I would appreciate it.

Mr. OTTINGER. We would be very pleased to receive it.

Mr. CARNEY. Thank you very much.

Mr. OTTINGER. We have been working very closely with the Grumman people in solar and—

Mr. CARNEY. Wind as well. Well, we think they are leaders.

Thank you, Mr. Chairman.

Mr. OTTINGER. I hope so for the sake of the country and of New York.

We will hear next from Dr. Robert Myers, St. Regis Paper Co.

[The biography and prepared statement of Dr. Robert L. Myers follows:]

PREPARED STATEMENT OF ROBERT L. MYERS, VICE PRESIDENT, TECHNOLOGY,
ST. REGIS PAPER CO.

Robert L. Myers is Vice President - Technology, St. Regis Paper Company, West Nyack Road, West Nyack, New York 10994.

He received his BS degree in Chemistry at Kent State University and his PhD degree in Organic Chemistry at the University of Illinois in 1947.

He began his career in basic and applied research at General Electric in 1947, moving to Borg-Warner as Associate Director of Research in 1960. In 1963 he joined American Cyanamid as Director, Chemical Research in the Central Research Division, becoming Director of Research for the Lederle Laboratories Division in 1966. In 1969 he was named Vice President of Research and Development of the GAF Corporation.

He joined the St. Regis Paper Company in 1973 as Director of Technology and was appointed to his present position in 1976.

Dr. Myers is a member of the Board of Directors of the Technical Association of the Pulp and Paper Industry; a member of the Board of Governors of the National Council for Air and Stream Improvement; a Fellow of the New York Academy of Sciences; a member of the American Chemical Society; the American Institute of Chemists; the American Management Association's Research and Development Council; and the American Association for the Advancement of Science. He has received the Distinguished Alumnus Award from Kent State University.

10/4/79

Mr. Chairman, Members of the Committee, Ladies and Gentlemen:

My name is Robert L. Myers. I am Vice President - Technology for the St. Regis Paper Company, one of the larger integrated forest products companies. I am responsible for the generation and implementation of new product and process technology for our company, including energy saving innovations. I would like to outline for you some of the energy saving potentials inherent in the adoption of new process technologies in the pulp and paper industry and some of the problems that are associated with that adoption.

I would like to make two specific points. First of all, that conservation represents the most immediate and surest way of achieving significant energy savings in our industry; and secondly, that while many processes have been discovered or are under development, their potential will not be realized unless and until someone demonstrates these technologies at essentially full operating levels.

I have no problems with programs directed to alternate fuels. In fact, our industry is one of the most active in concentrating on the utilization of our own large energy supply in forest residues. But I still maintain that conservation represents the largest single opportunity for us.

In 1972, an energy conservation program was initiated in our industry, and in spite of the addition of large energy consuming elements associated with air and water compliance programs, we had in 1976 reduced the energy requirements from 19 million btu's per ton of paper to 16.7, or 0.36 bbl. This is an outstanding achievement but still leaves an impressive amount that is required. We believe that current on-going programs could result in an equal amount of reduction per ton of product, or an additional 0.36 bbls. Based on a total paper production in the U. S. of 64,791,000 tons per year, this is a total reduction of 48 million barrels.

The paper industry is in the unenviable position of being the number one user of fuel oil among manufacturing industries. In the large, kraft process segment of the industry, purchased fossil fuel comprises only 45% of this segment of the industry's energy requirements. The other 55% is obtained from burning wood residues and spent pulping liquors. A modern kraft mill can supply up to 70% of their fuel needs from wood residues and spent pulping liquor. Where available, other sources of forest residues augment those generated by debarking and chipping and in these cases even higher levels of self-sufficiency are achieved.

However, the primary source of energy production in the kraft pulping industry is the burning of spent liquors to recover both energy and pulping chemicals.

In the production of kraft fiber from wood chips, approximately one ton of inorganic chemicals, primarily sodium hydroxide and sodium sulfide, are added in the form of a cooking liquor. This strong caustic liquor dissolves away approximately 50% of the dry weight of the wood, liberating the fibers for subsequent papermaking operations.

The remaining water solution of the dissolved wood substances, which are primarily carbohydrates and lignin, together with the remaining inorganic chemicals, are concentrated by evaporation to a high solids level, where they take on the appearance of bunker C fuel oil. They are fired to a specially designed boiler where both the energy present in the carbohydrates and lignins, and the inorganic chemicals are recovered. This process, which is called the Tomlinson furnace after its inventor, has been refined and optimized over the last 50 years and is an integral and vital part of the kraft process.

However, in its present state-of-the art it is thermally inefficient and has serious safety problems, due primarily to the fact that the inorganic chemicals are recovered as a molten lava or smelt. When water from any source, such as the boiler tubes, comes in contact with this smelt, serious explosions can and do occur.

Consequently, our industry is ready and eager for an alternative which would provide greater safety and improved energy recovery.

More than 12 years ago the St. Regis Paper Company embarked on a search for such a new technology, and 10 years ago, in the laboratory, discovered the new process which we call Hydropyrolysis.

Hydropyrolysis means simply that we heat a dilute solution of the black liquor to temperatures sufficiently high to decompose all of the carbohydrates and lignins into a carbonaceous char which resembles finely divided charcoal. In this process the inorganic chemicals are simultaneously reduced or returned to their active configuration ready to go back into the front end of the process. The char is removed by filtration and is dried and burned in a separate furnace.

Because we have separated the necessary chemistry from the combustion of the organics, we are able to optimize each of these independently of the other. As a direct consequence, we can calculate that if Hydropyrolysis were adopted by our industry we would reduce the purchased oil requirements by 26%. This would amount to an annual savings of approximately 17 million barrels of oil throughout the U. S. kraft industry. Incidentally, the U. S. kraft industry represents approximately one-half of the total worldwide kraft production and the adoption by Canada, Scandinavia, Japan, or any other principals, would double that amount.

Recall that I said that this discovery was made more than 12 years ago, and that the potential for this process was clear as long ago as 5 years ago when we began operating a 10 ton a day pilot plant at Pensacola, Florida. You will recall that I said at the outset that many of the energy saving processes that have already been discovered or are under development will not be utilized until someone demonstrates their economic and technical utility at essentially a full operating level.

In my judgment, the largest single barrier to the introduction of any innovative energy saving technology is the large capital cost and the attendant high risk associated with this necessity of demonstrating the plant at full scale. Unlike a product oriented business, which can limit its risk and exposure through test markets and step-wise addition of capacity as required, the process industry such as kraft paper, can only be economic at large scale levels where the capacity increments are very large.

Today, a typical southern kraft mill represents an investment of approximately \$500 million and consists of a series of unit operations closely tied together with many feedback loops. If any single part of this chain fails to operate the entire investment is idled. Hence, our preoccupation with the demonstration of the reliability and operability of any new technology at full plant scale.

In order for us to demonstrate Hydropyrolysis at a full plant scale we will have to build a plant of approximately 350 tons per day capacity at a cost of \$35 to \$40 million. Because such an effort was substantially beyond the scope of even a large paper company such as St. Regis, we elected to share the risk and share the benefit with other members of our industry, and we have been attempting to

organize a consortium to finance this program. As of this date, four other major paper companies, together with a major engineering company, have joined with us. We are also seeking the assistance of the Department of Energy and we hope by this mechanism to reduce the financial risk to acceptable levels.

Obviously, we believe that the Department of Energy's demonstration program is the keystone for this kind of program. I believe that it is appropriate to comment that the Kennedy/Durkin initiatives to provide financial incentives for the engineering and construction of energy saving devices is a major step in the right direction.

Finally, I would like to comment that there is yet another risk which can be very significant that is associated with the introduction of a new technology.

In the introduction of a major new process such as Hydropyrolysis it is entirely possible that adverse affects upon other portions of the mill to which it is attached can or will occur which will produce significant economic losses. A mature business can ordinarily obtain Business Interruption Insurance to cover this kind of loss. However, this is seldom available for new and unproved technologies. You might wish to address this problem in providing incentives for the adoption of new energy saving technology.

Our industry and my Company are proud of our achievements in meeting air and water regulations. However, in the process of demonstrating a new technology, rigid regulatory compliance may significantly deter investigation of new technologies by increasing the investment and delaying and extending construction and operating costs. I would like to suggest to you that during the demonstration phase of new energy saving technologies, waivers or temporary exemptions

recognizing that compliance would eventually be necessary.

I believe that the process industries, such as pulp and paper, face unique problems in the introduction of new energy saving technologies, and I hope that this committee would recommend initiatives to ease the adoption of these technologies.

May I thank you for this opportunity.

Robert L. Myers
Vice President - Technology
St. Regis Paper Company
West Nyack Road
West Nyack, New York 10994

STATEMENT OF DR. ROBERT L. MYERS, VICE PRESIDENT OF
TECHNOLOGY, ST. REGIS PAPER CO.

Dr. MYERS. Thank you, Mr. Chairman and members of the committee. I appreciate the opportunity to tell you about a novel piece of technology in the paper industry.

I am vice president, technology, for the St. Regis Paper Co., one of the larger integrated forest products companies, and I am responsible for the generation and implementation of new product and new process technology for our company, including energy saving innovations.

I would like to outline for you some of the energy saving potentials inherent in the adoption of new process technologies in the pulp and paper industry, and some of the problems that are associated with that adoption.

I would like to make two specific points.

First of all, I believe that conservation represents the most immediate and surest way of achieving significant energy savings in our industry. Second, while many processes have been discovered or are under development, their potential will never be realized unless and until someone demonstrates these technologies at essentially full operating levels. I will expand on that in a moment.

I have no problems with programs directed to alternate fuel supplies, although I lack a certain amount of enthusiasm for the synthetic fuel program.

Our industry has been one of the most active in concentrating on the utilization of our own large energy supply in forest residues. This will become an increasingly important source of fuel for our industry. But I still maintain that conservation of fossil fuels represents the single largest opportunity for us.

In 1972, along with many other industries, our industry undertook a conservation program to meet voluntary standards or goals in energy reduction. I don't think people are aware of this fact, that in spite of the addition of large quantities of energy consuming elements that have been associated with air and water compliance programs, the industry by 1976 had reduced the energy requirements from 19 million Btu's per ton of paper to 16 of 17 or a little over a third of a barrel. That turns out to be about 10 percent.

This is an outstanding achievement but still leaves an impressive amount of Btu's per ton of product that is required. We believe that current on-going programs, some but not all of which are in that house-keeping category that was referred to this morning are going to produce within the next year or two, an additional third of a barrel, and if you take the current production of paper in the United States at around 65 million tons. This is going to result in or will have resulted in a total annual reduction of 48 million barrels of oil per year. Obviously, that is an on-going savings.

The paper industry, however, is in the unenviable position of being the number one user of fuel oil among all of manufacturing industries.

In the large, kraft process segment or roughly 60 percent of the industry, purchased fossil fuel comprises only 45 percent of the total energy requirements. We get the other 55 percent from burning wood-residues such as wood bark and debris from cleaning the logs, and from the spent pulping liquors. That is the subject of my discussion today.

A modern kraft mill can supply up to 70 percent of its fuel needs from wood residues and spent pulping liquor. The previous numbers I gave you were industry averages and a modern up-to-date, brand new facility would be able to provide almost 70 percent from these two sources. By increasing additional forest residues conventionally left in the forest, that can move very close to self-sufficiency.

However, the primary source of all this energy is in the burning of this spent liquor which we refer to as black liquor. I will have to explain to you how we get black liquor.

For each ton of wood, in our process, we add approximately one ton of chemicals, a caustic sodium hydroxide and sodium sulfide, and this is put into a large pressure cooker and we dissolve away the carbohydrates and lignins which constitute the glue which holds the fibers together. When we wash that product after we have discharged it from the reactor, with all of the inorganic chemicals that we added, all of the sugars and lignins come out as a dilute black liquor. Roughly 50 percent of the wood that goes into that reactor comes out as dilute black liquor. The remaining 50 percent is the fiber which we carry over to the paper making process.

It is obvious first of all that the industry has had to recover this material for years, because you could not afford to throw this away if you wanted to. Consequently there has been evolved over the years a process which is called the Tomlinson furnace. By evaporating this dilute solution of material to about 60 percent solids, it takes on the appearance of Bunker C oil and it will burn, or support combustion. It is sprayed into a large furnace about seven stories tall, and the organic materials, the sugars and lignin are combusted and they generate heat and steam in top of the furnace. In the lower half of the furnace the inorganic materials collect as molten lava, or smelt.

Now, this process has been under optimization for 50 years in our industry and a conventional furnace, the kind which I described, represents about a \$50 million investment today..

However, this furnace is thermally inefficient. We are evaporating a large quantity of water from the remainder of the aqueous solution and we are doing two things at once. We are trying to recover this inorganic chemical at the bottom of the furnace and trying to recover energy at the top. Because of this, we are making compromises and the compromises generally work to lose energy, and the furnace is less energetically efficient.

There is another unfortunate feature of this furnace. This lava or smelt at the bottom of the furnace, when it comes in contact with water from, say, a broken boiler tube or any other source, results in serious explosions. These can and do occur, and the industry still loses about 2½ to 3 on the average of these furnaces per year due to these explosions. This is a serious safety problem, and it is that reason that we undertook, 15 years ago, to find a superior technique to recover this chemical and energy value.

Twelve years ago in our laboratory we discovered a new process which we call hydropyrolysis. By that we mean simply that we heat a dilute solution of this black liquor, the solution of inorganic chemicals, lignins, and carbohydrates, to temperatures sufficiently high so that all of the organic chemicals present are converted to a carbonaceous char resembling finely divided charcoal. In this process the inorganic chemicals are simultaneously reduced back to the chemical configuration which they need to go back into the front end of the digester.

The char is removed by filtration and we take it to a separate furnace and burn it to generate power.

Because we have separated the two processes, the chemistry from the combustion, we are able to optimize each independently of the other.

As a direct consequence of this, we can calculate that our new process will generate as much or reduce our purchased oil requirements by as much as 25 percent. This would amount to an annual savings of approximately 17 million barrels of oil throughout the U.S. kraft industry.

Incidentally, the U.S. kraft industry production is only one-half of the total and so if the rest of the world adopts it, we would double the amount. Of course, those countries that I am talking about and the other kraft producers are all OPEC dependent.

Recall that I said that this discovery was made more than 12 years ago, and that the potential for this process was clear as long ago as 5 years ago when we began operating in Pensacola, Fla., a 10-ton-a-day pilot plant.

You will also recall that I said at the outset that many of the energy saving processes that we have already discovered will never be utilized until somebody demonstrates their technical and economic utility at essentially full operating level.

Let me tell you why that is the case.

In a typical southern kraftmill today, the plant investment represents approximately \$500 million. This is a series of unit operations all the way from the woodroom to the digester, the pulp washers, paper machines—

Mr. OTTINGER. When you are talking about kraft, you are talking about kraft paper?

Dr. MEYERS. Kraft paper, yes, sir, which is responsible primarily for the corrugated box business and multiwall sacks. The word "kraft" comes from German meaning strength. It is the strongest paper we know how to make and represents over one-half of the total U.S. pulp and paper production. You can't make paper of this kind [shows written text of speech] without having substantial amount of kraft fiber in it. Even newsprint contains large quantities.

Now, if any single part of this \$500 million chain, any reactor, any portion, any process step in that chain goes down, the entire \$500 million worth of equipment goes down.

In order to be economic, the kraftmill has to run at about 85 to 89 percent to even break even, so we must run at 355 days per year, 24 hours a day, without interruption in order to make this \$500 million investment profitable, to return a profit of any kind.

Therefore, it is perfectly obvious that the introduction of any new technology into this chain will only take place if somebody has proven it works essentially at the same quality standard of performance and reliability that is demanded of all of the rest of the operation.

In order for us to demonstrate this process at full plant scale we will have to build approximately a 350-ton-a-day plant at a cost of between \$35 and \$40 million. This may not sound like a great deal of money but it is entirely too much for the St. Regis Paper Co. to take on its own, and so we elected to share the risk and share the benefits of this process with other members of the industry, and I have spent the last several years organizing a consortium to finance the industry

portion of this program, and as of today three other major paper companies, together with a major engineering firm, have joined together. Mr. Harvey said that we have already formed our corporation. We are imminently to give birth to this corporation, but getting six sets of lawyers to agree has proven to be more time consuming than I had anticipated.

We are also seeking the assistance of the Department of Energy and we hope by this mechanism to reduce the financial risk of this project to an acceptable level for all parties.

We obviously believe that the Department of Energy demonstration program is the keystone for this pioneer program.

I believe that it is appropriate to comment that the Kennedy-Durkin initiatives to provide financial incentives for the engineering and construction of energy saving devices appears to be a major step in the right direction for those of us in our industry.

I would like to make one additional point that does not appear in the written text.

If we establish the reliability and the economics of this process at this full plant scale that I spoke of, and it runs the way we say it is going to run and it produces the efficiency we say it will do, that is the last incentive the government will have to provide, because the industry will immediately adopt this technology right across the board, and even some relatively modern plants would be forced on an ROI calculation to dismantle or mothball their older or less efficient operations. I think that is an important point when we come and talk about demonstration programs. A successful demonstration really will only have to be helped once and from there on the industry will have to take over. I can guarantee you that.

There is just one last point I would like to make, and it was referred to by several of the speakers this morning. In the introduction of a major new technology, it is entirely possible that adverse effects will occur on other portions of the mill to which it is attached, which could produce severe economic losses. I have to tell you that St. Regis and my partners in this venture are worried about who is going to be responsible for that.

In a mature business, one can obtain something called business interruption insurance to cover losses of this kind, say, a boiler failure. But when you are introducing new technology there is no basis, there is no experience for the underwriters to look at, and so it is very difficult to get business interruption insurance for anything that involves the introduction of a brand new process. I invite you to think about that as a possible role for the government.

Our industry and my company are very proud of our achievements in meeting air and water regulations. However, in the process of demonstrating a new technology, rigid regulatory compliance may significantly deter investigation of new technologies by increasing the investment and delaying and extending construction and operating costs.

I will point out to you that 1 year's delay in this project will require that I go out and find two more partners because the annual inflation rate will raise the cost of the poker game by at least that much.

So delays of introducing new technology are very expensive from a capital and operating standpoint.

I would like to suggest to you that during the demonstration phases of a new energy saving technology, waivers or temporary exemptions from environmental regulations might be desirable, recognizing clearly that compliance will ultimately be necessary and obviously desirable. We are not asking for relief except on a temporary basis in order to expedite the adoption of these new technologies.

I believe that the process industries such as pulp and paper face unique problems in the introduction of new energy saving technology and I hope that this committee will be able to recommend initiatives to ease the adoption of these technologies.

I thank you for the opportunity and would be delighted to answer any questions you may have.

Mr. OTTINGER. Thank you very much.

I have some familiarity with the problems, certainly something named U.S. Fibre Corp. now Champion Paper.

Are they one of your partners?

Dr. MEYERS. No, they are not, sir. I would be glad to call on them.

Mr. OTTINGER. We will hear next from Resources Planning Associates, as I understand it, both Mr. Howard Hagler and Mr. Peter Bos are here.

Mr. Hagler is going to testify.

Mr. HAGLER. That is correct.

[The biography and prepared statement of Mr. Howard Hagler follows:]

Howard Hagler, Principal
Resource Planning Associates, Inc.

Mr. Hagler has 30 years experience in general management and consulting in the energy and environmental areas. During this time, he has worked closely with industries, utilities, and federal and state governmental agencies to help promote energy conservation. Prior to joining Resource Planning Associates, Inc., Mr. Hagler was President of Hittman Associates, Inc.

Mr. Hagler is currently a member of The American Association for the Advancement of Science and the American Nuclear Society. He is a former member of the State of Maryland Governor's Science Advisory Council.

STATEMENT BY HOWARD HAGLER, PRINCIPAL RESOURCE PLANNING
ASSOCIATES, INC.

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

SEPTEMBER 11, 1979

I would like to thank you, Mr. Chairman, and the committee for the invitation to appear here today to discuss industrial energy conservation.

The company I am associated with, Resource Planning Associates, Inc., (RPA), is an international management consulting firm with extensive experience working with industries, utilities, and federal and state governmental agencies. Much of this work has been related to the problems posed by shortages of essential resources such as energy. My own background is in general management and consulting in the energy field. In 30 years of working with both the public and private sectors, I feel I have developed a sense of what industry and government are contending with in their efforts to conserve energy.

The industrial sector consumes 40 percent of all the energy used in the United States. Therefore, any reduction in industrial consumption, especially of oil and gas, not only reduces the need for imports, but frees those critical fuels for the transportation, commercial, and residential sectors, which have less flexibility in the fuels they use. In addition, the cost savings realized from energy conservation help blunt the inflationary effects of rising fuel prices on the consumer.

Recognizing the economic realities of energy conservation and its potential contribution to the nation's well being, industry has succeeded in reducing its energy consumption over the past few years. One conservation measure that industries have used to a limited extent for many years is now attracting increased interest: cogeneration.

Cogeneration is an efficient way to produce electricity and thermal or mechanical energy simultaneously, from the same energy source. Cogeneration is attractive from two standpoints: first, it uses the energy content of fuel more efficiently than central power stations can; second, it presents fewer siting problems than larger facilities, which are now experiencing construction periods sometimes in excess of 10 years.

Whether fueled by coal, oil, or natural gas, cogeneration seems to offer prospective users a reasonable way to meet future electrical and thermal demands. Not only can the smaller cogeneration plants be built relatively quickly, but it appears that the added increments of power can be made available with no compromise of overall system reliability.

In a study performed for the U.S. Department of Energy, RPA projected the market potential for process steam and electricity cogeneration in the six most energy-intensive industries by 1985 and determined what that potential means in terms of energy savings.¹ We considered the question in two ways: What would happen without any additional government action? What would happen with additional government action?

In 1976, more than 4,000 megawatts (MW) of cogeneration capacity were available in the United States. This figure has remained fairly steady over the last 10 years. In our study, we estimated that this level of industrial cogeneration will more than double by 1985 -- without any special government action. Specifically, we estimated that almost 80 billion kilowatt hours (kWh) of electrical energy are likely to be cogenerated by 1985 in the six industries. This electricity will be produced from over 10,000 MW of cogeneration capacity (see Exhibit 1.)

However, through programs designed primarily to mitigate financial and regulatory constraints, the federal government can stimulate additional cogeneration development. Although our study was completed before the final passage of the National Energy Act of 1978 (NEA), many of the actions we evaluated were similar to those envisioned in NEA. We found that these government actions could stimulate up to 6,000 MW of additional cogeneration capacity by 1985 (see Exhibit 2).

The development of this potential, together with the amount of cogeneration capacity developed without government action, would represent only about two-

¹ Resource Planning Associates, Inc., The Potential for Cogeneration Development in Six Major Industries by 1985 (Cambridge, Massachusetts: December 1977).

Exhibit 1

**Estimated Output and Operating Capacity of
Cogeneration Plants in Six Major Industries**

Industries*	1985 Output	Capacity	
	Electric Energy (10 ⁹ kWh)	1985 Total Cogeneration Capacity (MW)	1976 Total Cogeneration Capacity (MW)
Food	2.1	343	189
Textiles	0.6	98	114
Pulp & Paper	38.3	4,861	1,286
Chemical	21.1	2,677	1,451
Petroleum Refining	6.0	763	118
Steel	11.2	1,423	887
Total	79.3	10,165	4,045

* Industries named are defined according to the Standard Industrial Classification Codes (SIC): Food, 20; Textiles, 22; Pulp and Paper, 26; Chemicals, 28; Petroleum Refining, 2911; Steel, 3312.

Exhibit 2

**Estimated Impacts of Government Actions on
Cogeneration Development in Six Major Industries**

Government Actions	Net Savings (trillion Btu)		Cogenerated Electricity Energy (billions kWh)	Cogeneration Capacity (megawatts)
	1985	Cumulative 1978-1985	1985	Cumulative 1978-1985
30 - percent ITC	94	720	20	2,600
12 - year depreciation	38	295	8	1,100
Government load guarantees	21	160	5	600
Exemption from FERC/PUC jurisdiction	8	60	2	200
Equitable prices	13	100	3	400
Flat rate structure	65	480	14	1,800
Exemption from oil and gas use tax	16	120	4	500
SO ₂ emissions relaxation	24	170	6	800
Allocation priority	5	40	1	100

thirds of the total cogeneration development feasible by 1985. The remaining one-third reflects the hesitancy on the part of both utilities and industries to proceed with cogeneration ventures before several uncertainties are resolved and financial attractiveness improved. In interviews with members of RPA's study team, potential cogenerators expressed concern about the possible regulation of industries operating cogeneration plants, the economic viability of cogeneration given regional differences in costs, the difficulties associated with creating new industry/utility relationships, and the technical reliability of cogeneration systems. Their decisions will also be influenced by recent legislation: the Powerplant and Industrial Fuel Use Act (FUA), the Public Utilities Regulatory Policy Act (PURPA), and the Clean Air Act. However, specific questions arise regarding implementation of those laws.

Importantly, the regulations use different criteria to define what qualifies as a cogeneration facility. FUA applies to all cogeneration facilities having a heat input rate greater than 100 million Btu per hour; the act defines cogeneration facilities as power plants (which are subject to the most stringent restrictions on the use of oil or gas) if they sell more than half the electricity they generate annually through a utility grid. The new source performance standards adopted by the Environmental Protection Agency (EPA) under the Clean Air Act, on the other hand, apply to facilities with a heat input rate greater than 250 million Btu per hour and define cogeneration facilities as power plants if they sell more than one-third the electricity they generate. The prevention of significant deterioration (PSD) provisions of the Clean Air Act use potential emissions, rather than heat input rate, to determine applicability: they apply to all facilities with potential emissions greater than 250 tons per year, and to no facilities with emissions less than 100 tons per year. If a facility has potential emissions between 100 and 250 tons per year, it is subject to the PSD provisions only if it is a fossil-fuel fired boiler or steam/electric plant with heat input greater than 250 million Btu per hour, or if it is one of a specified list of industries regardless of heat input. EPA has not yet indicated how cogeneration facilities will be classified for PSD purposes.

PURPA uses the ownership of cogeneration facilities, rather than physical criteria, to determine applicability: cogeneration facilities may qualify for exemption from regulation only if they are less than 50-percent owned by utilities.

Thus, the same cogeneration facility could be treated as a major fuel burning installation under FUA and a power plant under the new source performance standards. It is not possible to determine what it would be under the PSD provisions. And it may or may not qualify for the benefits of PURPA, depending upon who owns it.

The government should undertake a major effort to clarify and explain these regulations so that prospective users are able to make timely, well-informed decisions. I cannot emphasize too strongly that any delays on the part of the government to interpret the regulations will only cause prospective users to delay management decisions to proceed with cogeneration.

As efforts are being made to address these issues, new -- and in some ways, more complex -- issues have developed regarding energy supply. But a few years ago, natural gas was perceived to be in short supply. Now there are strong indications that it will be available for industrial use well into the future. The availability and price of oil, on the other hand, remain highly uncertain. And recently, major uncertainties have arisen with regard to electrical supply, specifically the nuclear option.

Many utilities that rely heavily on nuclear electrical supply are expected to have continued problems maintaining the required reserve margins. Numerous plants have been delayed or construction halted, raising questions about the availability of sufficient long-term energy supply. This situation is particularly critical for industry, which often operates on interruptible service.

It is important to recognize that a ripple or domino effect is inherent in this situation. If a utility that relies on nuclear is forced to delay plant construction, it will seek to purchase supply from other utilities to meet its customers' needs, albeit at a higher price. However, if the exporter of electrical energy also relies on nuclear supply, it

too will eventually experience a shortage. Many areas of the country are already beginning to suffer from this critical problem.

Also an area of uncertainty and some concern is the state of current technologies. Based on our experience, it appears that cogeneration offers the best close-in option for filling in expected shortfalls in electrical capacity. This does not mean, however, that efforts to develop other options, such as solar, should be diminished.

The federal role with regard to technological development should be to continue its efforts to ensure that potential users have a range of highly efficient systems from which to choose. These systems should have multi-fuel capabilities and must meet environmental standards.

Advanced technologies have generally been regarded as systems that use coal or other alternative fuels as their primary source of energy. FUA has blurred this distinction between current and advanced technologies. The problems involved in using coal in cogeneration plants are as significant as those encountered in central station power systems. In many instances, in fact, the technological problems are even more severe because industrial-size systems have not received the attention that utility-size systems have received. It is therefore important to ensure that development work is balanced between large, central-station plants and smaller, industrial-size systems.

Major efforts should be undertaken to develop combined-cycle power systems, emission control systems, and high-efficiency energy converters. In keeping with the need to achieve fuel flexibility, efforts should also be directed to the various externally-fired systems.

The high capital cost associated with installing dual-purpose equipment brings with it financial uncertainties with which potential cogenerators are not accustomed to dealing. An industrial owner of a cogeneration system will have to pay for the power generation component (turbine and generator); in contrast, he would not have to make any investment to buy electricity from the grid. A utility will have to pay for the

thermal generation component (e.g., waste heat recovery boiler) and sell the steam or heat produced to industrial or residential/commercial customers -- an activity that the utility would not undertake if it were investing in single power generation equipment.

In all cases, the additional capital must be recovered to make the investment in cogeneration attractive. The savings the industrial owner of a cogeneration system realizes on his electricity bill will enable him to recover both the additional capital and the additional fuel costs associated with electricity generation. The utility will recover its additional capital investment and fuel costs through the sale of process steam or process heat.

The determining factor in deciding whether or not the additional capital required to install a cogeneration system can be recovered is the return on investment (ROI). Through interviews with over 50 industrial companies, 7 electric utilities, and 7 state public utility commissions, RPA has determined that market development will be substantial if cogeneration offers an ROI greater than 15 percent. Therefore, any government action that enhances the expected ROI, such as increasing the investment tax credit, reducing the period for equipment depreciation, or establishing equitable prices for purchased cogeneration power, would accelerate cogeneration development. The ultimate cost of these actions and their consequent energy savings must be considered carefully.

The federal government does not alone bear the responsibility for assisting industries and utilities in understanding and resolving the uncertainties associated with cogeneration. The states will play an important role in implementing PURPA and the air quality regulations. In addition, the state energy conservation plans all include provisions to encourage industrial energy conservation. Presently, DOE is working with many states to determine their specific needs and interests. This cooperation is essential and must be continued to ensure that the unique opportunities and problems presented by each cogeneration venture are addressed.

I thank you for your attention. I would be happy to respond to any questions you may have.

STATEMENT OF HOWARD HAGLER, PRINCIPAL RESOURCE
PLANNING ASSOCIATION, WASHINGTON, D.C.

Mr. HAGLER. I would like to thank you, Mr. Chairman, and the committee for the invitation to appear here today to discuss industrial energy conservation in general and cogeneration. I will summarize my comments as briefly as I can. A formal paper has been provided for the record so we will be available to provide the maximum amount of time to answer your questions.

I am a partner with Resource Planning Associates, which is an international management consulting firm with extensive experience working with industries, utilities, and Federal and State agencies, and much of this work has been related to the problem posed by shortages of essential resources such as energy.

My own background is in the general management and consulting field and for a considerable period of time I worked both in the public and private sector, so I feel I have developed a sense of what industry and government are contending with in their efforts to conserve energy.

The industrial sector consumes 40 percent of all the energy used in the United States. Therefore, any reduction in industrial consumption, especially of oil and gas, not only reduces the need for imports, but frees those critical fuels for the transportation, commercial, and residential sectors, which have less flexibility in the fuels that they use. In addition, the cost savings realized from energy conservation help blunt the inflationary effects of rising fuel prices on the consumer.

Recognizing the economic realities of energy conservation and its potential contribution to the Nation's well being, industry has succeeded in reducing its energy consumption over the past few years, and you heard numerous examples of how they have done so. One conservation measure that industries have been using to a limited extent for many years is now attracting increased interest: cogeneration.

Cogeneration is an efficient way to produce electricity and thermal or mechanical energy simultaneously, from the same energy source. Cogeneration is attractive from two standpoints: first, it uses the energy content of fuel more efficiently than central station electric producing only plants, and second, it presents fewer siting problems than larger facilities, which are now experiencing construction periods sometimes in excess of 10 years.

Whether fueled by coal, oil, or natural gas, cogeneration seems to offer prospective users a reasonable way to meet future electrical and thermal demands. Not only can the smaller cogeneration plants be built relatively quickly, but it appears that the added increments of power can be made available with no compromise of overall system reliability.

In a study performed for the U.S. Department of Energy, RPA projected the market potential for process steam and electrical cogeneration in the six most energy-intensive industries and determined what that potential means in terms of energy savings.

We considered the question in two ways: What would happen with government action and what would happen without government action?

In 1976, more than 4,000 megawatts of cogeneration capacity were available in the United States. This figure has remained fairly steady over the last 10 years. In our study, we estimated that this level of industrial cogeneration will more than double by 1985, without any special government action.

However, through programs designed primarily to mitigate financial and regulatory constraints, the Federal Government can stimulate additional cogeneration development. Although our study was completed before the final passage of the National Energy Act, many of the actions we evaluated were similar to those envisioned in NEA. We found that these government actions could stimulate up to an additional 6,000 megawatts of cogeneration capacity by 1985.

The development of this potential, together with the amount of cogeneration capacity developed without government action, would represent only about two-thirds of the total cogeneration development feasible by 1985.

The remaining one-third reflects the hesitancy, the uncertainty on the part of both utilities and industries to proceed with cogeneration ventures before these uncertainties are resolved and the financial attractiveness improved.

We interviewed a considerable number of people in connection with this study, and they expressed some considerable concern about the possible regulation of industry operating cogeneration or power producing plants. The economic viability of cogeneration given the regional differences in costs, the difficulties associated with creating new industry/utility relationships, and the technical reliability of cogeneration systems, were all part of their uncertainty and concern.

These decisions were also influenced by major legislation that has comparatively recently come on the scene, the Fuel Use Act, the Public Utilities Regulatory Policy Act, and the recent amendments to the Clean Air Act.

The Fuel Use Act as you are undoubtedly aware is a law which has its primary purpose of moving fuel users in the direction of using coal. It distinguishes between major fuel burning installations and powerplants and sets up procedures whereby those who do not wish to use coal for good and sufficient reasons, can obtain either temporary or permanent exemptions. These procedures as of the moment have not been completely worked out and there is comparatively little experience in working with the impact of this fuel use act.

Similarly, the prevention of significant deterioration and resource performance standards as well as the nonattainment provisions of the Clean Air Act amendments are all not completely understood, particularly by cogenerators with major uncertainty or concern about what the impact is going to be on their specific situation.

At this point I think it might be worthwhile mentioning that when one thinks about cogeneration for any length of time and worked with it for any length of time, you very quickly reach the point where you cannot look upon it in a completely national perspective. You must think about it in a regional and very site-specific way.

The PURPA Act is one that comparatively recently was passed and gets at one of the major barriers that was previously identified in our studies, that is, the transactions between the cogenerator and the utility, again dealing with the questions of transaction, payments that would occur for either the export or standby use of this power.

I wish to emphasize many of these laws seem to deal with national needs and are quite important, but from the perspective of the cogenerator, it represents uncertainty and that uncertainty then leads to an unwillingness to make management decisions that would be appropriate.

Therefore, the Government should undertake a major effort to clarify and explain these regulations so that prospective users are able to make timely and well-informed decisions. I cannot emphasize too strongly that any delays on the part of the Government to interpret the regulations will only cause prospective users to delay these management decisions to proceed.

As efforts are being made to address these issues, new and in some ways, more troublesome ones have developed, particularly relating to energy supply. But a few years ago, natural gas was perceived to be in short supply. Now there are strong indications that it will be available for industrial use well into the future. The availability and particularly the price of oil, on the other hand, remain also highly uncertain. Recently, major uncertainties have arisen with regard to electrical supply, particularly because of the nuclear option.

Many utilities that rely heavily on nuclear electrical supply are expected to have continuing problems maintaining the required reserve margins. Numerous plants have been delayed or construction halted, raising questions about the availability of sufficient long-term energy supply. This situation is particularly critical for industry, which often operates on interruptible service.

It is important to recognize that a ripple or domino effect is inherent in this situation. If a utility that relies on nuclear supply incurs delays it will seek to purchase supply from other utilities to meet its customers' needs, albeit at a high price. However, if the exporter of that electrical energy also relies on nuclear supply, it, too, will eventually experience a shortage. Many areas of the country are already beginning to suffer from this critical problem.

Also an area of uncertainty and some concern is the state of current technologies. Based on our experience, it appears that cogeneration offers the best close-in option for filling in expected shortfalls in electrical capacity. This does not mean, however, that efforts to develop other options, such as solar, should be diminished.

The Federal role with regard to technological development should be to continue its efforts to insure that potential users have a range of highly efficient systems from which to choose. These systems should have a multifuel capability and must meet environmental standards.

Advanced technologies have generally been regarded as systems that use coal or other alternative fuels as their primary source of energy.

Mr. OTTINGER. Let me just halt you for one second and have a minute's recess.

Mr. HAGLER. Surely.

[A short recess was taken.]

Mr. OTTINGER. I am sorry for the interruption.

Mr. HAGLER. No problem.

May I continue?

Mr. OTTINGER. Yes, indeed.

Mr. HAGLER. I was starting in on the importance of technology.

The advanced technologies have generally been regarded as systems that use coal or other alternative fuels as their primary source of energy.

The Fuel Use Act has somewhat blurred this distinction between current and advanced technologies. The problems involved in using coal in cogeneration plants are as significant as those encountered in larger central station powerplants. In many instances, in fact, the technological problems are even more severe because industrial-size systems have not received the recent development attention that the larger utility-size systems have received. It is therefore important to insure that development work is balanced between large, central-station plants and smaller, industrial-sized systems.

Major efforts should be undertaken to develop combined-cycle power systems, and appropriate emission control systems, that will be required to comply with environmental standards and higher efficiency energy converters. In keeping with the need to achieve fuel flexibility, efforts should also be directed to the various externally fired systems which in my mind offer considerable advantage.

Industry's determining factor in deciding whether or not a cogeneration system will be purchased or not as we heard from the numerous witnesses here this morning is heavily based on financial factors, the return on investment. Through interviews with over 50 industrial companies, electric utilities as well as various public utility commissions, we determined that market development will be substantially greater if cogeneration offers a return on investment greater than 15 percent. You heard that number mentioned oftentimes today.

Therefore, any Government action that enhances the expected ROI such as increasing the investment tax credit, reducing the period of equipment depreciation, or low-interest loans, would all be moving into the direction of accelerating cogeneration. The ultimate cost of these actions, however, and their consequent energy saving must be carefully considered so as not to provide unwarranted subsidy to this technology.

The Federal Government alone does not bear the complete responsibility for assisting industries and utilities in understanding and resolving the uncertainties associated with cogeneration. The States will play an important and critical role in implementing PURPA and the air quality regulations.

In addition, the State energy conservation plans all include provisions to encourage industrial energy conservation.

Presently, DOE is working with many States to determine their specific needs and interests. This cooperation is essential and must be continued to insure that the unique opportunities and problems presented by each cogeneration venture are addressed.

I thank you for your attention. And I and Mr. Bos, who is director of many of the cogeneration studies within our firm as have I, would be happy to respond to any questions that you might have.

Mr. OTTINGER. I want to thank you all very much.

I would like, I suppose, first to get your opinions as to the most effective kinds of Federal assistance for these savings efforts, get some idea whether there is common agreement that industry pretty well makes these investments itself if the return on investment exceeds 15 percent, assuming that technology is adequately demonstrated.

Mr. MEYERS. That is the key phrase, Congressman.

There is no problem as long as the technology is mature and has been demonstrated to be of low-risk character. A 15-percent return will implement those that are ongoing right now such as all these housekeeping programs mentioned earlier.

Mr. OTTINGER. A representative of one of the major corporations in this country told me that he is in charge of energy conservation for that corporation; he was not permitted to make these investments unless he gets a return in 2 years.

Is the 15 percent a pretty solid one in your experience?

Mr. HAGLER. If I might and I am sure Mr. Bos can also comment from his set of experiences, in our experience it seems to be a good rule of thumb. A lot depends on the well-being, the status of the industry itself, and the other demands that are on it for capital for investment. What those investment opportunities are, and what options they have available, options they have available to them.

Other comments, witnesses you heard here today mention that there are a lot of demands placed on that available capital to do a number of things, including compliance with environmental regulations thereby depleting the amount of capital investment to be required for more productive investments.

Also, the 15 percent seems to be general.

Mr. OTTINGER. I suppose what I am getting at, we are trying to work out a system of relationships between government and industry, and in this important aspect, are we pretty safe in not applying any market incentives as opposed to technology assistance to processes that have a rate of return on investment better than 15 percent?

Mr. HAGLER. Let me try to respond in a way that hopefully will shed some light on it.

I sense that you are focusing on one aspect, the return on investment.

Dr. Meyers has made an important point in his correspondence that agrees with our own experience. We must make sure industry doesn't find itself in a situation whereby a major investment is compromised because of nonreliable equipment.

Mr. OTTINGER. That is why I made the assumption I did. I think there is no question of the need for Government participation in improving new technology, but we are now starting to deal with a range of options; before Congress are numerous bills including one from myself to try to accelerate the introduction of proven technology. In that range where it is important for the country to see these individual companies make the investment, can we get some idea how we ought to target what type of investment to use?

Mr. SHELDON. I think it varies quite a bit by industry. In the aluminum industry, for example, a 3-year return pay-out is about the same as 15 percent, and in examining these different potential programs that have been mentioned, or possible program, such as the Kennedy program, 15 percent might speed up by six-tenths of a year. If your pay-out is 3.6 years, you would get down to 3; if you are at 3 years, you are all right. If you are at 5 years, it wouldn't get you down to 3, and in terms of return on investment, it's the thing that we are really faced with. We only have so much money. We can't put all that money in conservation projects even though we get a comparable return. We have to maintain our place in the market. We have to maintain our equipment. We have to spend money for maintenance of our plants and that sort of thing. We have projects that are available for all of last year's money. We will spend \$450 million for all these various things. You might have a project that has 15 percent but didn't get in the \$450 million because there were other ones that did. We developed, through computer modeling, a new design for the

furnaces that we use for baking our anodes, which according to Doug Harvey's table up there, takes a fairly high percent—around 6 percent of the total energy we use. And this modeling brought out the fact that we could save 50 percent of the energy we were using so we built one, tried it, and we go better than 50 percent savings. And we have seven more to replace. Well, we can't shut them all down. We will do them one at a time, and all of those sorts of things come to bear on the picture while the return is very adequate. For example, as a passing interest with the Kennedy proposal, these furnaces cost about \$37 million, so you can't do a lot of them in a year. The Kennedy proposal would give us a return of \$7 million on that \$37 million investment, which is a pretty good sum of money.

Mr. OTTINGER. Of course, the public at large, maybe even Congress, is recognizing the Federal Government, taxpayers, also have limits.

Mr. SHELDON. That's right.

Mr. OTTINGER. What they can invest, I suppose what we are seeking for is what kind of mechanisms within the amounts of money that we might be able to anticipate, devote to energy conservation, what kind of mechanism—

Mr. SHELDON. I think the key word is acceleration and how fast you can afford to accelerate, because we will get there in time. No question about it.

Mr. OTTINGER. Mr. Bos.

Mr. Bos. Mr Chairman, you asked what can government do for technology that is already proven, and there are two things that I think are most effective and the first is to take steps to remove a risk or a barrier that in some cases is in fact created by the Government.

That is a very cost-effective approach, if one can find it.

I might take as one example your question about stimulating insurance company, financial institutions this morning to invest in energy conservation or conversion technologies.

If such a—if legislation could be passed to structure in a way such as to remove the 20-year take or pay obligation that an industrial company really has to commit to, if it is going to reach an agreement with a utility, that would be a very positive action that would be taken through that mechanism. At the same time, it would guarantee the utility the 20-year cash flow that it wants and the only time Government would incur costs is if the industrial plant did in fact shut down, and a shorter life time in that, and since there is always a probability it might be, the industrial company doesn't like to make that 20-year commitment.

But if it doesn't shut down, there is no cost and so in the aggregate it can be a fairly cost effective action. Removing risk very frequently can be very cost effective.

The other type—

Mr. OTTINGER. Does that point to loan guarantees.

Mr. Bos. Well, I think a loan guarantee might be coupled—might be the central part of such an action if one were going to stimulate or allow financial institutions to invest or stimulate—

Mr. OTTINGER. Mr. Myers introduced an idea I hadn't heard before, some kind of a plant interruption insurance.

Mr. Bos. It removes risk.

Mr. MYERS. That would be particularly valuable for new technology, obviously. You can buy that insurance on a mature technology and we do, of course.

I'm a little out of my field when I talk in this area, but I would like to tell you that cash flow, even in a \$2.5 billion corporation like St. Regis becomes a problem, and so that anything that you might do to accelerate cash generation, and I guess I am talking about accelerated depreciation, and things of this sort, would enhance energy saving projects, and would just have to make them far more attractive.

Mr. OTTINGER. The problem with tax incentives is that it is very hard to make distinctions between those which are very efficient in energy savings and those which aren't.

Mr. MYERS. Unfortunately, that is true.

Mr. OTTINGER. I am going to have to go to conference. We have the gentleman from Missouri, Mr. Young, who is going to take over.

I want to thank you very much for your help. I do think that it has been very helpful indeed. Sorry I have to leave you.

Mr. YOUNG. Thank you, Mr. Chairman.

Apparently we are in the question and answer period with the panel. I'm walking in here cold, so you gentlemen have your own head, I guess at this point.

Mr. CARNEY. Mr. Chairman—

Mr. YOUNG. Yes.

Mr. CARNEY. I'd like to ask a couple of questions of Mr. Jarrett, if I may.

Is there any way to accelerate the commercialization of the direct reduction process or do you believe the 1990 target is the closest time that you could scale up to a commercial reactor?

Mr. JARRETT. If you plot the curves of most large developments of this type through history, you will find that, on the average, they take between 10 and 15 years and that you may spend between \$100 and \$200 million before the process actually gets its first prototype test. You can always add money and people but this doesn't necessarily increase the rate at which people are creative and develop the breakthroughs.

We do have some major engineering problems. We have demonstrated direct reduction on bench scales successfully but these engineering problems are formidable. If they weren't difficult, the process would have been developed long ago.

So I don't know. I don't believe that we can intelligently spend much more money or manpower than we are at the moment. When we have cracked some of these engineering problems, we might. There will be a time when additional funds will accelerate implementation. I don't think it is at this moment.

Mr. CARNEY. What you need now is time more than anything else?

Mr. JARRETT. Well, you need ideas. People say, "Why didn't you get that idea last week?" Who knows why, you simply didn't get it until this week.

Mr. CARNEY. Do you think the Federal programs for industrial conservation as we know them now are adequate? That is a leading question to industry.

Mr. JARRETT. I can only speak narrowly from my point of view. I have gotten good support.

Mr. CARNEY. So you're satisfied. Why don't I open that up to everybody.

Mr. MYERS. I would have to tell you, Mr. Carney, I believe there are many processes out there dying, waiting for full-scale demonstration that simply lack the venture capital, and I do not believe that we have

by any means reached a limit in terms of findings good projects for this demonstration phase of work. I can recite several more for you right now. I would love to be able to go out and buy a gasifier to convert forest residues into a moderate to low Btu fuel which would go into existing boilers in our mills.

But I can't buy that equipment.

The technology is 100 years old. People have been gasifying wood wastes; the Germans did it extensively during World War II, but I cannot today go out and buy a wood gasifier. Someone has got to build and operate a full-scale, very large-scale wood waste gasifier before anybody can will go and buy one.

That is one example. There are others. There is a cold-corregating program which I gather probably will be funded that has enormous potential.

Mr. CARNEY. You said before that in your industry you have a consortium of six?

Mr. MYERS. That is just for this one project, the hydrolysis program.

Mr. CARNEY. That hydrolysis program is a spinoff of your research because maybe you had it—maybe I misinterpreted it.

Mr. MYERS. That is correct.

Mr. CARNEY. You had a direct problem with explosions by residue with water.

Mr. MYERS. We started on the basis of a safety problem. We recognized this very clearly, but within the last several years the real incentive in this technology is the energy saving.

Mr. CARNEY. Right.

Mr. MYERS. So we will get the energy saving, plus the safety factor.

Mr. CARNEY. This started because there was, indeed, a necessity to get around the safety problem?

Mr. MYERS. That is correct. Fifteen years ago when we first started looking for this new technology, it was to avoid the smelt explosions. Our industry has spent a fortune trying to find how to operate a Tomlinson furnace and not blow it up. And in spite of all of the effort that has gone on, they are still blowing up approximately three a year.

Mr. CARNEY. That, of course, must add to your insurance.

Mr. MYERS. Yes. Strangely enough you can get interruption insurance on that. I'm sorry Mr. Ottinger had to leave, but one of the first people that I approached to help fund the development of this thing was the insurance company which carries the insurance on our recovery boilers.

I was told by the president of the company that he wasn't allowed to invest in speculative operations. So I am not too optimistic. That is different than, say, making cash available for some—

Mr. CARNEY. You are saying put a furnace, the best word I can come up with on the line, the prototype furnace on the line that this consortium has vested in, has pooled their resources and would cost about \$35 million; is that correct?

Mr. MYERS. That is correct; 35 to 40. We have already collectively invested well over \$5 million to this program.

Mr. CARNEY. You as an individual company.

Mr. MYERS. Between St. Regis and—I said I haven't really organized my corporation yet, but we have got a gentlemen's agreement and we are spending money at the rate of about \$1 million a year now. We expect to be incorporated within the next 90 days.

Mr. CARNEY. I can understand the problem in general, but when you brought this scenario to me it seems a little bit funny that you're talking about \$35 million to put a new prototype on line.

Mr. MYERS. Correct.

Mr. CARNEY. Six companies.

You talk about the expense involved in interruption in insurance—

Mr. MYERS. No, no; I'm sorry. I didn't mean to mix those two apples and oranges.

The \$35 million is the construction and operating costs, and we will be asking the Department of Energy to supply a significant portion of that, of those capital and operating funds.

The business interruption insurance is something that we would—

Mr. CARNEY. I am not mixing the apples and oranges. What I am saying is you, yourself, represent a 2-odd billion dollar company. You have six companies involved in this. We are talking about a \$35 million furnace; correct?

Mr. MYERS. Correct.

Mr. CARNEY. That will solve a problem that adds a tremendous amount of probably, downtime. I assume when one of these explosions occurs, you are down for a considerable period of time and you are into an awful lot of retrofitting or repairing and capital investment.

Mr. MYERS. That is certainly true.

Mr. CARNEY. And probably three of those would be the equivalent of \$35 million. Would that be fair?

Mr. MYERS. You are getting close.

Mr. CARNEY. We are getting close.

Now, what I can't understand is why your industry is not willing to put that \$35 million and come to—

Mr. MYERS. Well, I guess I can only tell you that there are sufficient other demands on our capital, that for productive return that do not contain the risk that is involved, and with this particular project. The reason I went out to form a consortium was because neither—because my company did not wish to undertake this risk by itself. So we elected to share the potential benefits from this and share the risk with our collaborators.

Mr. CARNEY. Now, how much would you suggest you would be coming to DOE for?

Mr. MYERS. That is an interesting question because one of my problems has been inflation, and the passage of time, and I originally anticipated that not more than \$10 million would be required, but in the several years that have elapsed, the project has gone from a gross of about 22 and 25 up to 35, so now I have the alternative of going back to my partners for more money or asking the Department of Energy for additional funds.

As I say every year's delay, every year's delay in this program is costing at the moment, is costing about \$3½ to \$4 million of additional capital I have to generate.

Mr. CARNEY. Behoove you to get it off the ground.

Mr. MYERS. Yes, sir; you are correct.

Mr. CARNEY. In your testimony you refer to the problem of lost capital, of course.

Do you believe that you could obtain the necessary financing if the Government loan guarantee was available, privately, that is, backed up by Government loan guarantees?

Mr. MYERS. I would say yes, that part—once again, this gets into this question of debt equity ratios, and I am out of my field when I start talking about those things.

So I think that money could—I think a loan guarantee would certainly be a potential source.

Mr. CARNEY. It's funny. The purpose of these hearings are to stimulate—

Mr. MYERS. I understand.

Mr. CARNEY [continuing]. The conservation of energy and see how Government can help, because we do recognize the fact that the area we can conserve the most energy is in industry.

However, you came and you gave this scenario. Maybe I don't fully understand it, but if I was to ask to react on that particular scenario, I am sure there are many good investments in your industry and other industries, I think I would shy away from that as somebody who watches the purse strings of the American taxpayers as rapidly as possible. That just seems to me like you are not willing to invest in yourself.

Mr. MYERS. Well, I have to tell you that not only will St. Regis not do it but nor would 25 of the other major corporations in our industry, even join my party. So I have to—

Mr. CARNEY. Apparently I misinterpreted to downtime and interruption time when you said before you have to run like 351 days.

Mr. MYERS. That is correct.

Mr. CARNEY. Wouldn't this be a significant advantage to your industry then?

Mr. MYERS. That varies by company by company.

For example, St. Regis Paper Co. has not had a disabling boiler explosion in the last 15, 20 years. But nevertheless, we were the ones that began this work, and these explosions cost approximately \$25 million a year in insurance payments, and that is why I had to tell you I was a little disappointed when the insurer displayed such an immense lack of interest in finding, or helping to finance a program that might help to obviate this risk.

I guess those are the limitations imposed on his business, Mr. Carney, and I don't know that. He simply is not allowed to invest in speculative ventures of any kind.

Mr. CARNEY. Thank you.

Mr. SHELDON. Mr. Carney, could I please make a comment relative to what you were saying?

One of the big problems we see is that you have to separate clearly those projects where the technology is not clearly established, and those projects where the technology is established. I can't speak for Dr. Myers, but I suspect that the technology is not so sure there that his company is willing to assume the technical risk of going ahead with the project.

Now, in our company, Alcoa, in the project that Noel Jarrett is talking about, we would get to that project slowly over a period of maybe 20 years because we think it has a potential, but we wouldn't do it much faster than that because we haven't got that much money to put in that kind of a very high risk project in our R. & D. effort.

But there are other R. & D. projects where we are spending a lot of money. We have a new smelting process where we spent a great

deal of money—over \$50 million before we started scaleup, and we have spent more than that in the commercialization stage; and we aren't there yet.

There we thought we had reached a point in the technology development where we could assume the risk, and clearly you have to separate those two types of projects. And it is even more true when you get over in the synthetic fuels and other energy projects.

With those projects that need demonstration, the technical risk generally is so great that industry cannot assume it. And whether we have loan agreements or anything else, we still can't make that assumption.

We can borrow money just as well, you know, on our own as with a Government loan agreement.

So we don't have the problem of borrowing money. And if you gave us a 1-year writeoff, we might gamble and go ahead on our own. Even then, probably on a high technical risk project we wouldn't. But once the technology is established and even with some risk, relatively, it is purely a matter of how rapidly you want to accelerate the project. We will go ahead on an economic, technically feasible project on our own.

But we can only do it as far as our cash flow allows. As I said, we will spend this year around \$460 million on maintenance and capital expense. We have built one \$37 million furnace, but we aren't going to build three or four of them because that is just one part of our operation. But we save 50 percent of the energy necessary in that furnace.

Mr. CARNEY. How much have you invested in the Alcoa smelting process?

Mr. SHELDON. I don't have an exact number. I doubt we would want to make such a number public knowledge anyway.

But in the beginning, before we ever started, we stated that we had spent over \$25 million between 1957 and 1972 when the project started, and we built the first pilot you might say of a commercial plant, down in Palestine, Tex.

And I don't know the exact cost of that. We modified it a lot and we added to it, and so on and so forth, and I am sure it is more than an additional 25.

Mr. CARNEY. When would you see the significant gains attained?

Mr. SHELDON. The gain we would get from it is potential energy use in kilowatt hours per pound of production approaching 4; between $4\frac{1}{2}$ and 4. In our industry today, smelting averages 8 kilowatt-hours a pound of metal produced of all our energy use in the industry, and we use almost a quad, 63 percent of it is electric energy going into the smelting process. And if we could reduce that in half, we would achieve a very substantial saving.

In the aluminum industry we use about 4.2 percent of the U.S. electrical energy. In one of these testimonies, I believe it was Doug Harvey, said 6 percent. We only use 4.2 percent of the total U.S. electric energy in the aluminum industry, in the smelting process.

And if we could cut that in half, it would be tremendous.

Mr. CARNEY. It was just that one particular scenario that he offered just seemed funny to me.

Mr. SHELDON. I suspect there are technical risks that they are not willing to go ahead.

Mr. CARNEY. I don't think I want to belabor the point. That is not what we are here for. We are trying to establish a way we can work with you.

I think what you did key in my mind, I certainly would be very careful in evaluating all this as to the merits and as to the reluctance of industry to sit back and say maybe we can get the Department of Energy to go for this project, and you might have been unwilling to do it on our own without us, if we get overzealous and try to invest very rapidly we could get into a problem, right?

Mr. MYERS. I just have to—I can reassure you, sir, that in the absence of a significant DOE support for this program, it will never get off the ground, period. And I don't know why this industry is the way it is. But it is, I can just guarantee you that we are not going to do it on our own.

Mr. CARNEY. Yes, sir.

Mr. HAGLER. Mr. Carney, this might be a remark that might bring this into some slightly different perspective, and that is that there seems to be a great tendency to take a look at well what happens if it works, and look at all the benefits that are, therefore, going to accrue to the companies and to the Nation at large.

But there is the other side of that.

What happens if it doesn't work, and they got a—four or five other companies that have invested several millions of dollars, and so forth, and so forth, that is a different perspective.

Mr. MYERS. I can answer that question. My boss says we would have a new president of the company and a new vice president of research. [Laughter.]

Mr. HAGLER. I think that that perspective is what happens if it does, but also what happens if it doesn't has got to be kept in mind.

I would like to comment if I could upon your earlier query with regard to the DOE program, if I might. I think that word that comes to my mind is timid. The speakers this morning, on this morning's panel, I think made a very, very compelling argument that conservation, if you will, is another supply technology, and there is a great preponderance of the DOE investment that is going to supply technologies and it might be a little bit more helpful in due respect to Dr. Sternlicht's energy productivity if we somehow could sweep it under the supply technology area which seems to have a great deal more favor.

The magnitude of Mr. Harvey's budget as compared to the magnitude of investment seems way out of portion. I don't want to belabor it.

Dr. Sternlicht and a number of speakers this morning made the argument very, very eloquently, and to bring it up to even somewhere closer to parity would probably be, I don't know, tripling or quadrupling the budget anyway, which could very well profit from it and meaningful investments made in technologies to accrue those energy savings.

But timid is the world that comes to mind.

Mr. CARNEY. As to your investment—

Mr. HAGLER. Investment in energy conservation in the industrial sector.

Mr. CARNEY. Mr. Chairman, that is all the questions I have. I appreciate your testimony. It is very, very enlightening.

Mr. YOUNG. Mr. Kezar?

Mr. KEZAR. Mr. Chairman, I would like to ask some questions of Mr. Jarrett.

It seems to me that the magnitude of savings is potentially very, very large, if I recall your testimony, direct reduction aluminum producing aluminum silicon alloy, that is an alloy material, considerable projected demand in the transportation industry, as I think the transportation industry has attested to this.

Second: It produces a high quality silicon which has great potential in the photovoltaics industry.

Third: Secondary process allows the production of magnesium and improved cost, all of these I understand are improved cost, cost and energy savings which is a nice surrogate situation, nice synergistic situation.

Fourth: An off-gas, a valuable producing gas to be used in fuel cells to produce electric power or it could be used as salable gas to a nearby user.

I wonder if you might review the magnitude of the savings in either as an aggregate or in each one of these areas.

I don't think enough emphasis was given to this. It is very exciting and as a researcher, I know you are being careful and cautious in your time projections and enthusiasm that you are showing.

But a lot of us have heard a lot about the process and would like to hear more.

Mr. JARRETT. I purposely was restrained a little bit so people wouldn't get carried away into thinking that something was going to solve the world's problems instantly.

No. 1: If you are only going to use direct reduction to make aluminum and charge everything to making aluminum, the capital required is actually higher than today.

The essence of this project is the ability to combine a number of present processes into a single process which results in a net saving on all the products produced. If you put all of those products together, Co, FeSi, Mg, you can save about 50 percent of the energy that went into producing each of them individually.

But you have to want that much CO. This is what troubles a company who has been in one area, this combination of a whole series of new products. As long as everyone understands that there are large potential savings in both energy and capital, if you want all of these products at that place and at that time, then it is great.

So I think it has a definite place in the industry.

And you are absolutely correct, ferrosilicon is a reductant for dolomite from which magnesium is made and we presently operate such a process at Addy, Wash. Again, taken as a combination the process would reduce the end product cost of the reductant for magnesium.

The aluminum silicon alloy when produced in the blast furnace if you take credit for the CO, ferrosilicon and silicon, comes out to be significantly lower in energy costs. Something like 20 percent—if you want all the other products.

Mr. KEZAR. Is the 20 percent below the 4 kilowatt-hours or 20 percent below the 8 kilowatt-hours?

Mr. JARRETT. Well, presently, it takes you about 12 kilowatt-hours to make a pound of silicon.

And if it takes 8 to make a pound of aluminum on the average and you make them as an 18 to 20 percent mixture, you can calculate that you are going to be over 8 kilowatt-hours per pound of alloy.

Theoretically, you can make that aluminum silicon alloy for 3.8 kilowatt-hours per pound if you used all electrical energy at 100 percent efficiency, and the process hopes to supply at least 50 percent of the energy by burning carbon and oxygen.

So, yes, the potential is to come down to 2 kilowatt-hours per pound of alloy and perhaps less.

But, again, I have a great deal of trouble with cost accountants taking credit for the CO. They say, "What do we want with 15 tons of CO for every ton of aluminum?" That is the reason it is not easy to sell direct reduction as a replacement process. We would certainly have to want the byproducts because the total capital investment for that amount of aluminum alone is a lot higher than we presently invest with current smelting processes.

The fact that we get the ferrosilicon and the CO is not that easy to sell to an accountant. No great investment in technology is ever made with the blessing of the money managers. They like to put the money in the bank and see the return for sure and not on a gamble.

I hope I have answered your question.

There is a large potential there if you want everything that direct reduction produces.

Mr. KEZAR. The second question on accelerating development, disregarding the accountant problem at the moment.

You mentioned earlier that the program was adequately funded and what you are looking for was a more rapid pace of initiative, innovation within the team or within the group attached to your work.

Is there no way that this process, this work can be accelerated?

Mr. JARRETT. The creative process can't be done on demand. We know exactly what we have to solve and we have people working on it who are pretty darn bright. And we have ideas. They have to be ground out. I have seen this tried before where you say, "Well, we want to double the rate, so we will double the people." It never happens. You don't double it. You get something a little more than the one, you add three, it is not tripling it, you reach diminishing returns pretty fast.

I am not saying you can't do some things, accelerate some things with a crash program. But it becomes inefficient rather fast. I think we have an efficient team, and I think at the end of next year we will know what the feasibility of this process is and we will be better able to judge whether additional funds would accelerate the program or not.

I am reluctant to say we could accelerate it with more funds at this time.

I think we are making good progress as it is and I would rather wait and see how it looks at the end of this year.

Mr. KEZAR. Two short questions.

You mentioned we would be getting off some of the importation of bauxite.

I don't think it is particularly clear how much we are relying on domestic—

Mr. JARRETT. Well so far, we are using a charge of 50 percent imported bauxite and 50 percent domestic materials, that can be clay or some other materials.

We have high hopes that with proper adjustment and learning how to reflux the system, we can ultimately feed all domestic ores and we have high hopes we can ultimately learn how to feed coal as the reductant.

Right now, we are working on what would seem to be the least complex version of the process.

If we mix bauxite with domestic materials, we can get the right ratio of alumina to silica. We think that is important at the moment. We have hopes of progressing into all domestic material.

Mr. KEZAR. Commercialization. It would seem that if much of this technology is public because of your relationship with DOE, that the commercialization may be a question.

How does one address commercialization with a brand new technology?

Mr. JARRETT. Well, as Mr. Sheldon has said, when there is a certain amount of capital available, everybody puts in their projects from all over the company, and they are ranked in order of that which will yield the greatest return and also that which will yield the greatest return with the minimum risk. Since we are making rather significant progress in our regular smelting process, and we are making a good deal of progress on our new process—ASP—it is doubtful to me if the company would wish to undertake a third one without a lot of outside assistance.

I really have to reserve this opinion until we have demonstrated the feasibility of direct reduction and see how it racks up with all our other opportunities.

We are doing that at the moment. We are doing some very careful cost accounting on all the things we are doing in R. & D. to see just which are the leaders.

And this one has greater risk, is further away, and so it is hard to answer.

But I doubt if we would develop it on our own.

Mr. KEZAR. Thank you very much.

Mr. YOUNG. I want to thank the panel on behalf of Mr. Fuqua and Mr. Ottinger for appearing this afternoon, and giving us the benefit of your—of the industries that are involved in this. I do appreciate it very much.

I do want to say to Mr. Jarrett from the Aluminum Association, I had a little bit off the record, I guess, I see you are recycling, the public lends a hand, I gave Lou Brock an award in St. Louis Friday night and came back and my 6-year-old grandson had a whole bunch of aluminum cans in a plastic bag, and so that portion, I think is very, very helpful for a young person to be paying that much attention.

I didn't realize that we were going to walk out with all this Coca Cola and some sort of beer cans and after the ballgame was over with, I felt like we were robbing the icebox or something.

But they are paying attention to it, I know in my particular district in St. Louis.

The public is aware of what your industry is doing, so I think that is some of the good things that we are all trying to do.

Mr. SHELDON. Could I just add a little to that?

We, of course, pay him for taking those cans to a point where they are turned in, and many church groups, charitable groups, raise money that way. Then we recycle that metal back into cans or other metal uses for only 5 percent of the energy it would take to make that same metal from imported bauxite. So it is a real savings.

Mr. YOUNG. I was very much impressed with a 5½-year-old grandson.

Mr. SHELDON. He is quite an entrepreneur.

Mr. YOUNG. Thank you very, very much for appearing this afternoon.

We will close the hearing.

[Whereupon, at 2:45 p.m., the subcommittee hearing was closed.]

APPENDIX 1

Process Integration and
The Second Law of Thermodynamics
Future Possibilities

by

Charles A. Berg

PROCESS INTEGRATION

C.A. Berg
Buckfield, Maine

The term process integration is used with many meanings. When one uses the second law of thermodynamics to examine the workings of a process such as petroleum refining, oxygen production or steelmaking, one often finds that certain of the requirements for fuel can be traced by the use of more exacting heat exchange, or by transferring the heat rejected from certain high-temperature steps in the process to stages where lower temperature heat is required, or by combining steam generation with electrical generation, etc. This is one sense in which process integration is frequently used. In essence, this use of the term means the economic optimization of the use of energy in processing. The history of such work in engineering is long. Among the lucid and valuable contributions to this aspect of process design the work of M. Benedict offers an outstanding example from which every engineering student and practicing engineer could profit.

Since the techniques of second law analysis, as applied to process integration, are of long standing in the profession, one can assume that these techniques have been applied, if not invariably at least frequently, to the design of the process equipment which is currently in use. It is important today to recognize the great power and utility of the techniques displayed in the earlier work of Benedict and others and to apply these both to the design of new plants and to the redesign of existing plants, as is required by today's continuing increases in costs of energy.

This form of process integration, in which one applies the scientific techniques of the profession to optimize the operation of given processes is both important and highly satisfying. No small part of the satisfaction it offers derives from its being a form of homage to those verities of physics upon which the practice of our profession resides.

However, there is another form of process integration which may merit as great attention as the more familiar form described above. It entails the integration of processes from raw materials to finished products via the application of the understanding of physics and chemistry that has developed since the last major wave of process invention, in 1856. The processes of steelmaking, glass melting, coal chemistry, etc. that emerged during the mid-nineteenth century's wave of "heroic invention" have served the industrial world well. The crisis of natural resources and environmental effects which we face today appears to be sufficiently severe to call forth new conceptual organizations of production. In certain instances the second law of thermodynamics--in the form of second law analysis--appears to offer valuable suggestions as to the character which new technology of production might assume.

Process Integration and
The Second Law of Thermodynamics

Future Possibilities

by

Charles A. Berg

Introduction

When I was invited to prepare this essay on process integration I had been thinking, for some time, about the possibilities for future forms of industrial processes. It struck me that the possibilities before us for future development of process technology do entail integration and that these possibilities are strongly related to concerns that may be best perceived in light of the second law of thermodynamics. Thus I decided to address these future possibilities rather than the more traditional notions of process integration upon which a considerable body of professional practice is now based. To begin to consider future avenues for development of process technology, in respect to process integration and the second law, it will be useful briefly to consider the present meaning of the term process integration and the character of professional practice conducted as process integration.

Process Integration: Its Recent Form

The general notion of process integration is conceptually simple. (Most valuable notions are!) One examines the process through which a given method of production is executed. One finds where streams of energy, materials, etc., discarded in one stage of the process may be used to supply the needs for these at another stage. One then optimizes the design of the equipment required; one usually concentrates upon optimizing the equipment used to transfer a stream from one station to another because this equipment enables one to dispense with certain purchases of fuel, electricity, or raw materials.

An outstanding example of process integration, given by Manson Benedict in 1949, has recently been republished (Ford Foundation, 1974). Benedict considered the operation of an oxygen separation plant and, in particular, showed how to select the size of each component of this somewhat complex plant so as to optimize operation of the plant as a whole. The chief "inputs" for operation of an oxygen separation plant are energy of various forms (electric power, heat fluxes--both in and out). Thus economic optimization of the plant naturally entailed thermodynamic considerations which, also naturally, led to the measurement of fluxes--particularly losses--in the process via the second law of thermodynamics.

The particular technique which Benedict used was to determine the entropy production in each stage of the process and the

relationships between this entropy production and the costs of the equipment and the cost of power required to run the plant. He then determined the proper trade-off between the cost of equipment and costs of operation to optimize the design of the plant. The precise calculational procedures he used are probably now obvious to many people here today; they have become so much a part of current professional practice that they may seem intuitively obvious to many. But when Benedict gave this example, the methods were not obvious. What was especially unobvious then, and what may be somewhat paradoxically unobvious now because of the current nearly instinctive acceptance of the methods Benedict used, is the special advantage to which Benedict was able to use the second law of thermodynamics. Benedict's determination of the entropy production at each state permitted him to estimate the total requirement for purchased energy to sustain the inefficiencies of the equipment at that stage of operation. The additional determination of the relationship between the additional costs of equipment required to reduce entropy production (inefficiency) and the reduction of entropy production attained allowed Benedict finally to determine the optimal design of the plant. The second determination above requires only the exacting application of the engineering disciplines; any competent engineer can do it.

The first step, the identification of local consumption of the total resources used in the process via the entropy production required the keen insight in which Professor Benedict has always

excelled. The only advance in this aspect of process integration via second law analysis which it seems worthwhile to mention here is the use of the rate at which Gibbs' thermodynamic availability is destroyed in the process rather than the rate of entropy production. The local destruction of thermodynamic availability can be interpreted as remote consumption of fuel more directly than can the entropy production. But this is a slight advance of technique, not one of insight. (See Berg, 1974 or Hatsapoulis, 1977, for the use of availability.)

Professor Benedict did not invent process integration and optimization via second law analysis. But his example still offers one of the clearest and most powerfully effective illustrations of the technique. I would urge anyone with a professional interest in this subject to read Professor Benedict's example if they have not done so already.

I would like to reemphasize the importance of the first highly insightful step in Benedict's example and also to examine its character further. One important aspect of this step is that it permits one to use a local measurement to gain information directly about the demands that local phenomena place upon resources required at a distance. As Berg (1974, Hatsapoulis (1977) and numerous others have pointed out, this information cannot be obtained through the use of the first law of thermodynamics alone.

The second law of thermodynamics is required to extract this type of information from the system.

The capacity of the second law analysis to reveal directly the connection between local inefficiency and remote consumption of energy resources is, of course, highly useful in a practical sense. It permits one to evaluate various possible designs of equipment through which a process might be executed, as in the now classical example offered by Benedict. And this will probably be the principal use to which the technique is put in the immediate future. However, the technique may offer certain stimulating insights into the design of new processes as well. This aspect of second law analysis, and other techniques that may be its eventual conceptual descendants, may well be its most important and ultimately most useful aspects.

Improved Processes - A Critical Problem

The "energy crisis," as we now know our time, demands that one extract from fuels the utmost that can be extracted, given our existing state of technical knowledge and subject to the prices (and implied abundance) of all other resources. This is just another way of saying that fuel is too costly to waste. But the longer and somewhat more cumbersome expression of this thought is, nevertheless, the more nearly precise and the more useful. For fuel has never been so cheap that one could waste it. Any review of the history of design of (say) petroleum refineries, chemical plants, utility boilers, etc., will

show even the uninitiated that the engineering arts have long been applied to reduce the fuel required for production to the minimum, consistent with the costs of attaining the reduction. (See Sporn 1969 for a review of design, thermal efficiency, and economics of electric generating plants.) In some industries, particularly the electric utilities, use of second law analysis in various forms has been a long-standing practice in design.* In other industries the more direct techniques of second law analysis were not widely used; other less direct and less exacting techniques were used to optimize plants. Even though the approach to optimization in the latter cases was slower, and ultimately less perfect, than in the former, the approach nevertheless was made. That is, the attempt to strike the optimum economic balance between investment in equipment to raise efficiency and the costs of energy for operation is a long-standing endeavor in process design. The method of second law analysis, as illustrated by Benedict, has been an important part of this endeavor. But even where this method was not used, the endeavor was nevertheless made. Thus there is no meaningful sense in which one can say that process design in the past led to wasteful use of energy. Designers of the past responded to the past prices of energy, and their response was, on the whole, as

* As Kuhn (1959) points out, those industries that have dealt with energy conversion have, generally, led in both the development of thermodynamic science and its applications.

effective in conserving fuel as the price of fuel indicated that to be worthwhile.*

Now we are faced with declining supplies and increasing prices of the fuels which our processes are designed to use.** Increasing prices of fuels implies the need for even more exacting application of design for optimal performance of processes. And here second law analysis can be extremely useful. But here, also, one encounters a problem which may not yield even to the second law of thermodynamics. The problem is this: the latitude for improvement in many industrial processes of great economic importance has been reduced to the substitutions that can be made within the constraints of the now well-explored production functions which represent the now well-understood methods of production currently in use. Recall that the conceptual forms of a large number of the processes in use today are well over a century old. The first blast furnace of record in our era was invented in 1735 by Darby.*** The basic concept of the vertical shaft blast furnace has survived as a paradigm method for reduction of iron ore to the present day. To be sure, the execution of this method has been progressively refined, improved, and perfected through more than two centuries of

* There are, of course, some individual exceptions to this rule. But these exceptions still do not contradict the general rule cited here.

** I will not digress here to discuss the fact that the design of any process is strongly influenced, in nearly every aspect, by the form of energy which it is to use.

*** Blast furnaces and pneumatic steel converters were apparently used in Africa 20 centuries ago. Ancient Indians made steel of superior quality prior to Alexander's conquest of the Indus Valley.

metallurgy and engineering. One reflection of the effect of the long-sustained effort to improve the execution of this method is that now one knows, with a high degree of precision, what the limitations on further improvements are.* And this is the point which I have stated above. The process has been thoroughly explored. Much the same can be said of pneumatic steelmaking that was invented by Bessemer in 1856.** Open-hearth steelmaking along with regenerative glass melting were invented by Siemens, also in 1856. Many of the central concepts of petroleum refining --a much younger industry--were introduced prior to 1940 (see Enos, 1962). Ammonia synthesis was invented by Haber and Bosch in 1913. All of these processes, including even the youngest cited, petroleum refining, have been well explored. The plants that are used today to execute these reflect, on the whole, a thorough-going attempt on the part of the designers to realize economically optimal performance.

Of course, now that the price of energy has increased by more than a full order of magnitude since the optimal design of these plants was determined, there is latitude to decrease the energy required to operate them and thus to reduce the costs of operation. However, since the production functions of methods of production associated with these processes have been well explored,

* See, for example, The Making, Shaping and Treating of Steel, U.S. Steel Corp., 1971, Chapter 13, for a discussion of the thermochemistry of blast furnace processes.

** The American inventor, Killy, also produced a pneumatic steel-making process in the same year.

the measures that may be used to reduce energy requirements necessitate the use of other, presumably somewhat less costly resources. For example, the consumption of fuel in a plant may be reduced by installing additional heat exchanger surface, insulation, improved burners, improved combustion control, etc. The additional costs of applying this additional equipment offsets to some degree the savings in costs of energy they afford. ~~[/Add note on — viral~~ *re*
~~application.]~~⁷ Thus these substitutional modifications of plants can save energy; they can reduce costs as compared with making no response at all to the increased price of energy. But these modifications, being essentially substitutional and being applied in thoroughly well-explored methods of executing equally well-explored concepts of processing, cannot reduce production costs to the level that obtained prior to the increase of energy prices. And of course, there is no hope that these modifications can reduce production costs below those that obtained prior to the increase in energy prices.

The effects of the increase of production costs that result from increased energy price are exacerbated by two additional influences. First, the price of energy appears destined to continue to increase; there appears to be no definite limit to which the price of energy will ultimately rise, and each seemingly dire prediction of future energy price seems to be realized on time.*

* In 1975 John Lichtblau's estimate that before 1980 the price of imported oil would reach \$20.00 per barrel was viewed as extreme by many. This morning imported oil landed in Boston costs \$24.40 per barrel.

Second, the prices of many of the other raw materials that are essential to industry, and especially those that are required in (e.g.) high-temperature heat exchangers and other items of equipment used to modify the design of plants for "energy conservation," are climbing nearly as rapidly as the price of oil.*

Further to compound the effect of increased energy price on production costs, there is a current of belief abroad that the substitution of investment in new equipment for consumption of fuel should be pursued so far that the costs of the equipment to conserve fuel are equal to the costs of the fuel saved.** ("A barrel saved is a barrel earned.") If industry as a whole were to follow such a policy it would leave total costs of production exactly as high as if no response to the increase in energy price had been taken. (The exacting use of second law analysis might enable one to save more fuel for a given amount of money than through other techniques; but the effect of this policy on production costs would still be the same.) The framers of national energy policy have (mercifully) not yet adopted this repeatedly recommended policy for conservation.

Now the essential problem to which I alluded above may be brought into a focus. In a great many sectors of industry the

* See the monthly Minerals Commodity Summary (U.S. Department of Interior, Bureau of Mines) for records of the prices of chromium, molybdenum, alumina, etc.

** This argument does not urge that the marginal cost of equipment equal the marginal cost of energy saved. Such an approach is more nearly rational, but still has serious drawbacks. See Berg, 1979.

measures which may be applied to reduce fuel requirements entail additional investment in equipment, which results in inevitable and apparently interminable increases in production costs. This fact implies ultimate contraction of the markets for the products of these sectors of industry. And this conflicts fundamentally with mobilizing the investment required to construct the new plants and equipment that are required if the technically feasible gains in efficiency are to be realized.

The effects of rising production costs in constraining the investments required for fuel conservation are especially viscous because of the large "sunk" capital investment in (now) older plants and equipment. As Salter (1966) among other points out, once a plant has been built the earnings it needs to make in order to remain in production are rather small. Irrespective of the original cost of the plant, its age, etc., the plant can--and will--remain in production so long as it can earn a reasonable rate of return on the sum of its working capital, the scrap value of its equipment, and the salvaged value of the site it occupies. An existing plant need not pay any return on the capital costs of its construction in order to remain in production.* Many of the existing plants of industry, even though they were designed to use energy and other scarce raw materials at the much lower prices of these than obtained in the past, can still therefore remain in production.

*This can be a most unpleasant truth for the owners of the plant to face; nevertheless it is true.

A new plant, which might be designed to use energy and natural resources more efficiently, will not be constructed unless it can pay all expected returns, including a return to the capital represented by its costs of construction. Anyone who might contemplate building a new plant, which might embody the best form of production practices available today, or a major investment to modify the performance of an existing plant knows (or will quickly learn) that he will face competition from older plants which, although they may be less efficient, can still meet the price competition offered by a new, more efficient plant simply by foregoing payment of returns to capital. (Reorganization under the provisions of bankruptcy is the classical method for this. See Chilton's Iron Age, July 23, 1979 for a discussion of recent bankruptcies in the metals industries.)

In view of these circumstances the classical criterion for new plants has been that a new plant requires a new market. As a rule, most major waves of technical change toward higher efficiency have been effected through major waves of new plant construction, and most waves of new plant construction have been motivated by a general expansion of consumption of the products produced by the plants (see, for example, Berg, 1979,). It may seem at first to be somewhat of a paradox, especially in view of certain of today's popular attitudes concerning conservation, but the long-established vehicle of improved efficiency in production has been economic growth. It seems seriously doubtful that this vehicle

can be relied upon to introduce the improvements in efficiency that are required to adapt process technology to the realities of energy and natural resources in our era.* ←

There is however (and fortunately) another circumstance in which the new markets required for construction of the new plants, through which new and more efficient methods of production can be introduced, can be found. It is the introduction of a new method of production which offers such overwhelming economic advantages that it may simply appropriate the market served by older, less efficient plants, in spite of the deep cuts in price that the older plants can offer in response. Such leaps in industrial technology do not occur every day. But they do occur. And their occurrence is not so infrequent as the generally "smooth" character of the statistical curves often offered to represent economic data, might suggest.

Recent examples include the introduction of the float glass process for manufacturing flat glass (Pilkington, 1969), hot isostatic press^{ing} of non-ferrous metal compacts to replace forging (Evans, 1975, 1976), the conversion of polymer yarns to strong ultra light-weight graphite fiber, and integrated computer-aided design and manufacturing (C.A.D.C.A.M.). The distinguishing characteristic of each of these, and of the earlier inventions

*The increasing prices of these resources reflect developing scarcities that conflict with the growth of consumption through which more efficient methods of production might be introduced.

cited above, is that they represent a new method of production which is sharply different both in concept and in economic effect from that which they replace. In each case the new method enables one to reduce the requirement for all factors of production. This type of technical change is in sharp distinction to the other (largely) substitutional change cited above in which the use of one factor of production (fuels in this case) is reduced through increased application of others.

I have referred to one conceptual process, the blast furnace as introduced by Darby, as providing a paradigm method of production. In fact, all of the examples of the recent and profound technical changes cited immediately above offer new paradigm methods of production. The role of these paradigm methods in technology appears to be somewhat similar to the paradigms of scientific thought identified by Kuhn (1962) and proposed by him to be the central fact of the scientific revolutions which he has so incisively described. Of course, the character of a shift from one paradigm method of production to another in technology is not entirely the same as a shift of paradigms in science. Nor is the character of a paradigm method in technology entirely similar to the paradigms of science identified by Kuhn. For example, a paradigm of scientific thought must reveal, or at least must be thought to reveal, some essence of nature. A new paradigm of scientific thought may be adopted to replace another because it reveals the essence of nature in

a more faithful but an entirely different way. (Consider, for example, the way relativistic mechanics was adopted to replace Newtonian mechanics.)

It is clearly not necessary that a new paradigm method in technology reveal the essence of nature. But it does reveal aspects of the essential transformations by which resources are converted to products. And when a new paradigm method is adopted, it is because it reveals more direct transformations of resources to products. This is how new paradigm methods (ultimately) reduce the requirement for all factors of production.* Thus Pilkington showed how to form flat glass directly in a continuous sheet by floating the molten glass on a bath of molten tin. This eliminated the less direct, and highly wasteful, practices of casting glass slabs and then grinding them flat. In hot isostatic pressing metal powders are squeezed under great pressure to form parts directly in the shape which is ultimately desired and which have the same mechanical and chemical properties as forged parts. The new process eliminates excess consumption of material that in conventional processes is caused by losses to oxide scale, trimmings, and scrap in general. This method has reduced the material required to make certain complex high-performance parts by 50 percent! The

* As Enos (1962) shows, some inventions which in the longer run reduce the requirement for all factors of production may, in their early forms, increase slightly the requirement for one factor of production.

method affords immense savings in costs, and reductions of the requirements for each of the resources used in production.*

The paradigm methods of technology that I propose here share one important aspect with the paradigms of science identified by Kuhn. Once they are accepted, they shape fundamentally the concept of the field of technology they affect, which is held by the professional practitioners of that field. If, prior to the introduction of (say) hot isostatic pressing an expert in metal forming were asked a question about how to form complex parts from non-ferrous alloys, his answer would be framed in the context of his understanding of the conventional forging processes then exclusively in use. After the introduction of the new technique the answer to such a question would be different. And what is even more important, the questions of significance will be different too. The new paradigm method of production reshapes one's understanding of production at a broad and fundamental level of perception. It changes not only one's understanding of how a set of resources is transformed to some useful form. It also, in general, may change the set of disciplines upon which one draws to carry out engineering design of process equipment. It therefore may change the distributions of professions from which individual technologists are called to design, and to improve, plants and equipment. This may well be why the introduction of a new paradigm method of production

*The reductions are effected not only in natural resources but in "economic" resources (e.g., capital investment) as well. The term resources is used throughout this essay in its broader economic sense, except where a specific resource is cited.

is most often followed by a wave of improvement in its overall economic performance.* To be sure, economic influences admit both the improvements and the original inventions to use in production practice. But the ideas themselves for the improvements are unlikely to be created by "market forces."*** The source of the new ideas, I propose, may be more subtly related to intellectual processes than to "market forces."**** This subject cannot be pursued further here. However, the possibility that the process cited here can strongly influence the future of process technology will be considered again below.

Future Directions for Process Technology and Second Law Analysis.

The trap explained above is this: It may not be possible to mobilize the investments required to improve efficiency of production because the improvements themselves raise costs of production relative to the historical level that obtained when the present plant capacity was built, and thus restrict the markets for the products to be produced. Growth of these markets is likely to be further restricted by scarcity of the very natural resources with respect to the use of which the efficiency of production must be improved.

*See, for example, Enos' (1962) history of invention in petroleum refining, especially his Table 5.

**The "market forces" are often found to have prevailed for a long time prior to the introduction of the new ideas. In any event, the new ideas for improvements are meaningful only after there is something to improve.

***Those economists who currently study technical change, especially those who were originally trained as engineers, appear collectively to have been gripped by a belief in the paradigm theory of market forces as the sole explanation of change. Kuhn's (1962) insightful essay, especially pp. 149-150, may explain the conviction with which the current belief in the market is held.

This trap arises because the "improvements" to which one conventionally refers are modifications in the execution of long established paradigm methods of production. The latitude for substantial economic advances in these methods has long ago been exhausted. The changes that remain to be made in the execution of these methods are largely substitutional.*

One way, perhaps the only way, to escape from this trap is to introduce new methods of production that, as Salter (1966) has explained, reduce the requirements for all factors of production simultaneously and significantly. This not only has been done in the past; it has been the principal feature of the history of technical change. Solow (1957), for example, demonstrated that nearly all the growth of the productivity of labor in the U.S.A. between 1909 and 1949 was due to technical change which reduced requirements for both labor and capital simultaneously and by the same degree. The main problem of technology before us now, I propose, is to find avenues of technical change for the future through which we may find the new paradigm methods of production required to deal with the realities of energy and natural resources of our era. Here, I believe, the second law of thermodynamics in the form of second law analysis may, if it is tempered by certain other broad understandings of economics and technical change, be most usefully applied.

*I intend here to direct attention to sectors of production in which long-established methods are still used. Obviously, in some sectors of production, such as those in which new paradigm methods are now being introduced, a different situation already obtains.

The central technical problem of future technology may well be to eliminate excess requirements for fuels and other critical natural resources in production.* I reemphasize that the type of technical change advocated here to deal with this problem does not (in fact cannot for reasons of economic dynamics) result in the mere substitution of labor for energy or scarce minerals, etc. But the motivating concern in the search for new methods may be to eliminate excessive use of energy. The second law, of course, provides excellent methods for determining where energy is wasted in a given process (as in Benedict's 1949 example). It can also provide insights into the limitations of the performance of processes even in their ideal forms; it can help one to identify, for example, the irreducible losses of fuel, the irreducible losses of material, and the irreducible requirement of time for execution of many long-accepted processes. (See, for example, J. Keenan's collection of second law analyses of idealized processes of various sorts, on pp. 303 to 309 of his 1953 classic, Thermodynamics.)

I propose (speculate) that reexamination of the irreducible losses (costs!) of conventional, long-established methods of production may stimulate the thought through which the new paradigms of production we require may be found.

* I, at least, believe this to be so. This concern may even replace the long-established concern with the productivity of labor in production.

Some examples of possible directions toward new paradigm methods may be useful here. And I am fortunate to be able to offer a few.

To begin, consider heating processes. In conventional heating processes, as used in metal forming, plastic molding, or other production practices, it is customary to expose the surface of the material to be heated to some environment at higher temperature (e.g., an atmosphere of combustion products, a radiant heat source, an electrically heated ^{plate}~~plant~~) and to permit heat to diffuse into the interior of the material from its surface. This diffusion process takes time. In fact, the time required for thermal diffusion through a given part is determined by the thermal properties of the material (its diffusivity) and the size of the part. It cannot be affected by modification of (e.g.) the temperature in the furnace or other process variables. It is one of the irreducible "costs" of conventional heating practices. It is interesting to note that thermal diffusion is an intrinsically irreversible process and that one may calculate the rate at which entropy is produced, or availability is destroyed, in it. How might one conduct heating to eliminate this phenomenon, and to what effect?

One suggestion can be seen in the recent work of Suh (1979). Suh has found a new method of heating polymer grains for forming. The conventional method is to pour polymer pellets into a mold, to heat the pellets via electrical heating of the walls of the mold cavity itself until all the pellets fuse, and then to permit the

fused polymer to cool and solidify. This requires long and costly waiting times as thermal diffusion first heats and then cools the material. Suh has found a method to treat the surface of the polymer grains so that they become electrically polar. He directs microwaves through the mold cavity. The energy they carry is absorbed in the treated surface layer and melts only the surfaces of the grains. When the microwave energy is turned off the unheated bodies of the pellets serve as heat sinks, and the molded polymer part cools and solidifies very quickly. Suh's new method reduces the energy required for processing (the whole mass of polymer is not melted), the time of processing, and consequently the total costs of production. His novel approach to heating may well point the way to new paradigm methods.

Similarly novel emerging methods for heating may be found in electrical heating of metals for forming and for welding. The introduction by Astec Corporation of Austin, Texas of modern forms of the homopolar generator, capable of providing very high fluxes of electric power for very short periods of time, enables one to heat metals virtually instantaneously. This in turn enables one to complete (e.g.) resistance welds on large-diameter pipe (e.g. 48 in.) in a few milliseconds. Such a technique obviously reduces the labor required for such welding. But it reduces even further the total energy required, and it also reduces the metallurgical problems of large-scale welding by confining the "heat affected zone" to a

small area immediately adjacent to the weld. High fluxes of electric power can be used to heat metals for forming virtually instantaneously. This not only eliminates the time usually required for thermal diffusion; it also eliminates the chemical damage to the heated material (e.g., oxidation) that usually occurs during this waiting period. And the process can reduce the requirement for labor and for capital equipment as well. The application of well-known frequency effects in electrical heating of metals, the effects through which electrical conduction (and dissipation) are confined to the immediate vicinity of the surface of a metal when the frequency of the electrical signal is very high, has as yet hardly been applied in production. But losses of heat from metal surfaces at high temperature are responsible for many of the costly rate-limiting effects in conventional heating processes. Electrical effects enable one to apply energy for heating precisely where one desires, precisely when one desires, and in precisely the quantity one desires. They also allow one to dispose of the irreversibilities of long-distance diffusion processes through which conventional heating is effected. The exacting use of previously unexploited electrical effects may well offer the means to realize new paradigm methods of heating.*

*I digress here to discuss a point which is probably obvious to an audience that is conversant with second law analysis. However, the discussion may nevertheless be necessary for other readers. There is somewhat of an aversion to the use of electrical heating today because electric power plants now convert "only" about 34 percent of the heat of combustion of the fuel they consume into electricity. This is thought to be a "low" efficiency, and it is popularly assumed that a furnace for high-temperature heating could work at 100 percent thermal efficiency. However, those conversant with the implications of the second law of thermodynamics

Another example, of a somewhat more advanced nature, is the possible application of lasers in production. With laser chemistry it is possible to break or make specific chemical bonds in a molecule, selectively, rather than simply to shake the whole molecule apart by the brute force methods of conventional thermochemistry. (See the article by Avigdor Ronn, May, 1979 for an excellent review of this field.) Laser chemistry actually permits one to conduct certain reactions that are not possible by conventional thermochemical means. (The basic thermodynamic limitations of thermochemistry are much more restrictive than the constraints of laser chemistry.) As with the simple example of electrical heating above, the more profound effect of laser chemistry is to eliminate from the conduct of a given chemical reaction the pro-

(footnote continued from previous page)

will recognize that the electric power plant converts approximately 65 percent of the thermodynamic availability remaining after combustion of the fuel into electric energy. This is not a "low" efficiency by any means. Also, the heating of material to high temperature means raising the material to a high state of thermodynamic availability. The same economic considerations affect the design of small furnaces as affect the design of power plants insofar as the efficiency with which the thermodynamic availability of the hot combustion products of a fuel can be transferred into a hot material or converted into power. It is very costly to improve the (second law) efficiency of heating furnaces. Seldom does a small, high-temperature furnace exhibit a heating efficiency greater than 30 to 35 percent.

duction of entropy that occurs in the diffusional steps that are used in the conventional thermochemical process. (In this case the diffusion in question is diffusion of vibrations through a molecule. Prigogine, 1962, especially pp. 15 and 19, describes these diffusional phenomena and illustrates the diffusional character of the phenomena in the phase space of the molecule.)

The use of lasers to harden metals and to construct metal parts from powders has been demonstrated by Kear (1979) and others. This method permits one to form parts directly, in one step, with the shape finally desired and with the mechanical properties that are usually obtained by rolling, forging, and heat treating. Kears' method eliminates the conventional and wasteful processes of heating, forming, reheating, reforming, machining, and heat treating. When one examines the use of materials in the conventional processes that are used to convert metal to parts and when, in particular, one examines the many excursions of temperature (in repeated heating and cooling and chemical reactions--repeated surface oxidation, ²²for example), one is struck by the immense rates at which entropy is produced as an ordinary piece of metal is converted from (say) raw cast form to a finished part. These rates of entropy production are large, even when the processes in question are carried out in their "ideally efficient" form. (Whenever a material is heated by thermal diffusion over long distances, as in conventional heating, entropy production occurs. Whenever material that has been heated to high temperature is subsequently permitted to cool

by dissipation to the atmosphere, entropy production occurs irrespective of the apparent "efficiency" with which the material is heated. Whenever materials are oxidized in the combustion products of a furnace, as they always are, entropy production occurs. Such processes recur repeatedly in conventional conversion of metal to parts.)

Associated with each such site of entropy production there is irreducible, but ultimately unnecessary consumption of the resources required in production. These represent the irreducible costs of the method of production which have been so well explored that the remaining latitude for technical change is substitutional.

I propose that the key to finding new methods of production may be suggested through examination of these irreducible costs. Kear, in his work with laser forming, provides a new method for making parts which eliminates many of the irreducible losses of the conventional method by circumventing many of the processing stages that method requires.

Kear has also experimented with combinations of plasma arc metallurgy and laser forming. The plasma arc is used to reduce metallic ores and to produce fine sprays of refined, or alloyed, metal. These sprays are directed upon forms (e.g., mandrels) where they condense, as would a powder. The laser is used both to prevent development of porosity and to control grain size of the final part. This direction of work could conceivably lead to a method of production in which one could transform metal ore, in one step and in one device, directly to finished parts. The implications of such a method to eliminate the irreducible entropy production of conventional processing, and through that to reduce the demands for resources in production and the total costs of production, are immensely promising and important.

Another possible example of a direction toward a new paradigm method of production is direct electroforming of metal parts (ASM 1969). Electroforming has been used to make complex parts from certain pure metals and simple non-ferrous metals for many years. More recently Agarwal and his coworkers have incorporated electrorefining of copper with direct electroforming of wire, tape and other simple shapes.* Electroforming, electrorefining, electro-alloying and electrodeposition of a wide variety of metals, as alloy parts, appear to be technically feasible. Such a possibility could offer another new paradigm of production in which metal ore could be converted directly into finished parts without the intermediate and costly steps of heating, cooling, machining and treating upon which industry now relies. As with the other examples above, this too would provide a more direct transformation of resources to products. It would eliminate the irreducible losses and costs of currently conventional technology. As with the other examples, the new method might be suggested through examination of the older method via second law analysis to reveal the stages at which irreducible losses (costs) are presently sustained.

Numerous speculative examples of directions in which new paradigm methods of production might be found can be offered. These include the use of electrochemical reactions to replace the conventional thermochemical reactions now used in (e.g.) synthesis

*J. Agarwal private communication.

and oxidation/reduction steps. They also include the possibility of circumventing certain of the chemical reactions upon which we presently rely, entirely, by introducing novel and more direct biological processes. However, further citations of speculative examples are unlikely to contribute further toward realizing the main purposes of this essay: These are to propose that the essential problem of industrial technology is to find new paradigm methods of production and to suggest that the use of "second law analysis" may provide helpful stimuli to the imagination and the capacity for insight from which new methods spring.

Having urged the use of second law analysis, especially in examination of the ideal forms of current process technology, I should like, in closing, to specify the restricted forms of application to which my urgings pertain. I do not urge that one simply apply the second law of thermodynamics to determine where entropy production occurs in the present-day execution of processes and then redesign the equipment so as to reduce the entropy production to its economically optimally minimum. This activity is process design. It has been pursued, and it will continue to be pursued, vigorously, irrespective of my urgings. And it can make significant contributions toward conserving scarce fuels. If pursued to the extremes that are sometimes urged by less thoughtful advocates of energy conservation, it can result in the excessive and wasteful application of some scarce resources (e.g., chromium,

high-temperature alloys) to conserve one specific resource (energy.) Process design is good engineering. It is sound economics. It is of doubtful value as a strategem of policy. And, I believe, it has only a relatively small place in engineering research. It has, as ever, a very important place in engineering practice.

As distinct from the practice of process design, I urge reexamination of the conceptual forms of the methods of production currently in use. I propose that "second law analysis," applied to the conceptual forms of processes, can help to reveal the sites at which energy and other scarce natural resources will be needlessly consumed, irrespective of how exactly the process equipment may be designed. This will be equivalent to an identification of the irreducible costs of production entailed in use of a given method. I expect that once these irreducible costs are identified and perceived as such by scientists and engineers of imagination, the insights through which new and more productive methods may be found, may be forthcoming. I also expect that if "second law analysis" can have the effect suggested here, new techniques will be invented to identify irreducible costs of older methods of production, so as to reveal the means through which these can be circumvented. This may well prove to be a valuable field of engineering research.

I hasten to say that I do not propose either "second law analysis" or any of the additional possible new techniques

suggested above as formulae for invention. Indeed, I reject the notion that such formulae exist. But I do propose that when the nature of an exhausted and failing paradigm method of production can be analyzed so as to reveal the essential physical limitations responsible for its exhaustion and failure, the imaginations of the scientific explorer and the inventor may be more readily brought to bear to find new and more productive methods. This, I wish to propose, may be the most important rôle for "second law analysis" in the future of process technology.

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APPENDIX 2

STATEMENT OF
DONALD B. STEIN,
DEPUTY DIRECTOR FOR ENERGY CONSERVATION SERVICES,
FACILITIES ENGINEERING DEPARTMENT,
GRUMMAN AEROSPACE CORPORATION,
BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
U. S. HOUSE OF REPRESENTATIVES
9/13/79

GRUMMAN AEROSPACE CORPORATIONEnergy Conservation Services

Since 1971 the technical expertise used by Grumman Aerospace Corporation to design and build the NASA Apollo Lunar Landing Module has been applied to today's problems of decreasing energy supplies and increasing energy costs. In 1973 a unique team of analytical aerospace and plant facilities engineering personnel was organized as the Energy Conservation Services Department of the Grumman Aerospace Corporation and charged with the responsibility to identify and design practical and cost effective energy conservation techniques and devise alternate energy sources for buildings and facilities. This team initially surveyed, analyzed, recommended and designed energy conservation modifications for 7 million square feet of the Grumman Aerospace Corporation facilities space. Grumman Energy Conservation Services also follows these recommendations through the implementation, operating and verification phases. Grumman has in its organized energy conservation program targeted itself for a 40% reduction in energy usage by 1985 from the base year of 1972.

Later in 1973, the experience acquired through our in-house program was offered to government and commercial clients. Grumman has performed or is performing 60 studies covering over 88 million square feet of facility floor space in which we have identified more than \$27,000,000 of annual energy savings. Annual energy savings ranged from 10 to 70 percent of previous usage and the recommended retrofit projects have usually had simple paybacks ranging from 1 to 3 years.

Grumman Energy Conservation Services provides a unique brand of energy conservation since it combines the highly trained skills of theoretical aerospace disciplines with the practical experience of facility design and

operating engineering personnel. This mix of talents has been blended into an experienced analysis, design and operation team of energy conservation specialists who have developed many practical innovative solutions to a variety of energy problems. Living with our own energy conservation modifications, Grumman has had the unusual opportunity of assessing the practicality and compatability of these modifications with the day-to-day operation of a complex manufacturing facility. Monitored energy consumption, reflecting the impact of the accomplished modifications provides a check on our original analytical energy saving projections.

Included in Grumman's operating plant are high energy consuming facilities such as research laboratories, electronic development laboratories, computer centers, data acquisition and analysis centers, assembly plants, propellant handling systems, altitude chambers and engine test stands, as well as ordinary office buildings. In 1973, Grumman Energy Conservation Services developed, and the Grumman Corporation adopted, a four-phased approach to energy conservation for its facilities. This program consists of an Energy Appraisal or Audit, a Detailed Survey and Analysis, an Implementation Phase (Design and Installation) and a Monitoring or Verification Phase.

The initial energy appraisal phase was conducted for the total Grumman facilities to determine where the prime targets and the large energy consumers were located. This was followed by the detailed survey and analysis phase covering the individual plants selected as being the highest energy consumers as identified during the first appraisal phase. This analysis phase identified both the simpler, low costs quick-return modifications for immediate implementation by our operating personnel and the longer-term modifications with their associated implementation costs estimates and economic analysis. Due to the varied functions of the Grumman facilities, the survey and analysis phase for

each plant was tailored to the specific operating conditions and problems of that facility. The systems analysis approach was used to determine how, where and why each type of building, facility, process or equipment's energy usage is related to the function it is performing. A thorough systems analysis of the entire operation of each facility identifies many opportunities where energy can be saved, reduced or possibly recovered. For each conservation opportunity, a practical solution is developed and an economic analysis is performed to determine that proposed modification's payback period. For those modifications having favorable economic payback periods, implementation plans are formulated. At the present time many of these conservation modifications have been carried into the implementation (third) phase where designs, specifications, drawings and installation of equipment have been completed.

All of the Grumman plants and facilities are in various stages of energy conservation retrofit and all are being monitored and tracked (the fourth phase) for their performance as the conservation modifications are completed. At the present time new and innovative modifications are becoming more appropriate, since the first pass modifications have been mostly completed.

In all of these four phases, the operating engineers along with the test engineers or the manufacturing engineers are made part of the energy conservation team. This insures that institutional, manufacturing or testing operations can be modified using the most efficient equipment for the job size without impairing the required manufacturing or building operations. To date, these efforts have reduced Grumman's energy consumption 20% since 1972 and the cumulative savings are equivalent to 157,000 barrels of oil.

The achievable and cost-effective energy savings found in Grumman's own facilities also exist in other large buildings and facilities. Based upon the experience gained from its in-house program, Grumman has offered its energy conservation services to a spectrum of government and commercial clients.

As a result, over sixty studies have been performed for such clients as school districts, universities, industries, banks and federal, state and local government agencies.

The benefits of high technology applications to conserving energy are especially evident in technical and industrial facilities. Government research and production facilities (wind tunnels, nuclear production plants) yield large energy savings when new high speed data acquisition systems, automated process control systems and other modern equipment is introduced into the test and production cycle. Energy savings run as high as 35% to 45% of the energy previously consumed, while the modifications pay for themselves within 3 to 5 years at current energy rates.

In the Federal Government sector, Grumman has completed or is in the process of performing energy conservation studies for many of the complex technical centers, production plants and research facilities throughout the United States.

Grumman has completed a number of energy conservation studies for the industrial facilities of a diverse group of commercial, industrial clients involving different types of equipments, processes and disciplines, including chemical, mechanical, electrical, electronics, computers and thermodynamics. Industries represented include bread baking, chemical manufacturing, paper manufacturing and heavy equipment production.

Each client's production or process line is analyzed to determine the necessary amount of energy required for proper operation, and then the best methods are devised to reduce, load match, or recover excess energy. In most cases relatively uncomplicated conservation equipment and techniques were available for the solution, while in others new and unique approaches utilizing computer simulations, organic rankine cycles or steam recovery recompression equipment had to be investigated and designed to stay within justifiable

economic payback guidelines. Several of these solutions are being implemented by our industrial and process clients. All of Grumman's industrial clients are large and well-staffed companies who have always been pursuing more efficient operation of their processes. In spite of this, it is of interest that Grumman has been highly successful in showing substantial energy savings in a variety of diversified product areas. In process energy conservation work, analyzing operations from an overall systems point of view, unprejudiced by a "we have always done it this way" and "can't possibly be changed" attitude, has produced energy conservation recommendations that may be overlooked by those too close to the process.

Following are some examples of the accomplishments of Grumman Energy Conservation Services in the field of industrial energy conservation for both government and industrial clients:

- o A large heavy equipment manufacturer contracted with Grumman to apply its energy systems skills and its facilities management experience to perform an energy conservation study for their facility located in mid-west United States.

The facility which was studied consisted of ten buildings containing approximately 2.6 million square feet. The facility including a wide diversity of process equipment and building heating, ventilation and air conditioning equipment. Among the equipment studied were the boiler plant; heat treat furnaces; washing processes; hydraulic assembly room; heating, ventilation and exhaust systems; air conditioning; welding processes; paint booth operations; and lighting.

The facility had previously instituted an energy conservation program of their own. The program had consisted of resetting thermostats appropriately for the season, light reduction in office areas,

and turning off lights and equipment during periods of non-use.

The additional energy conservation measures recommended by Grumman were estimated to save 8.1×10^6 KWH annually and decrease fuel (primarily natural gas) consumption annually an amount equivalent to 215×10^9 BTU. This amounted to an 8.1% reduction in electric consumption and a 21.1% reduction in fuel consumption from the previous baseline usage. Ninety-five percent of the electrical energy and sixty-three percent of the fuel savings would be realized by conservation measures that show a cost payback of less than two years. When all the measures were implemented, an estimated cost savings of \$342,000 per year would be realized.

As a part of its work for the Federal Government, Grumman surveyed a plant located in far-west United States.

The plant consists of 93 single and multi-story buildings of poured concrete, concrete blocks and fabricated metal construction. Several of these buildings are located underground with their roofs at ground level.

The FY '77 consumption was 1260×10^9 BTU's (site energy) made up of purchased electricity and steam produced from oil and natural gas.

The function of the plant involved metallurgical operations, machining and welding which would be conventional machine shop operations were it not for the radiological and toxicological nature of the material.

Grumman's energy conservation survey identified eight different potential energy conservation projects with the following results:

- o Total Energy Savings = 120×10^9 BTU's/Yr. (site energy)
 - o Total Implementation Cost = \$1,118,200
 - o Total first year energy cost avoidance = \$373,010
- The average E/C ratio is $\frac{120 \times 10^9 \text{ BTU (site)}}{\$1,118,200} = 107.3$

million BTU's (site) per \$1000 of investment

The average simple payback is $\frac{\$1,118,200}{373,010} = 3 \text{ years}$

In addition, five other projects were recommended as part of a planned retrofit program which included upgrading the High Efficiency Particulate Air (HEPA) filters in five (5) buildings. These five projects had a cost avoidance of \$1,393,000 with an implementation cost of \$1,883,000, a total energy savings of 118×10^9 BTU's (site energy) per year.

The average E/C ratio of these projects = $\frac{117.78 \times 10^9 \text{ BTU's (site)}}{\$1,883,800}$

= 62.5 million BTU's (site) per \$1000 of investment

The simple payback = $\frac{\$1,883,000}{\$1,393,000} = 1.4 \text{ years}$

- o Grumman is currently performing an energy conservation survey for the Department of Energy. The facilities are located on a 364 square mile site in southeast United States. There are 78 major buildings having a total floor area of 3.34 million square feet. The CY '77 energy consumption was $17,391 \times 10^9$ BTU (source) in the form of 435,000 tons of coal, 1.26 million gallons of No. 2 fuel oil, 598×10^6 KWH of purchased electricity. Electricity co-generated on site using coal was 499×10^6 KWH.

The facility is one of the key installations in the special nuclear materials production and research program under DOE. Their mission includes energy research and development; production of plutonium, tritium, and other nuclear materials for national defense as well as related environmental research activities. The processes contained are of an

extremely complex and critical nature. Grumman's energy conservation study when completed will include virtually all the major energy using systems at the site. These systems include the heating, ventilating and air conditioning and lighting systems in administration laboratory, machine shop, process and fabrication facilities; reactor facilities service systems including primary, secondary and back-up water cooling systems, emergency and back-up power systems; steam, chilled water and electric power generating and distribution systems.

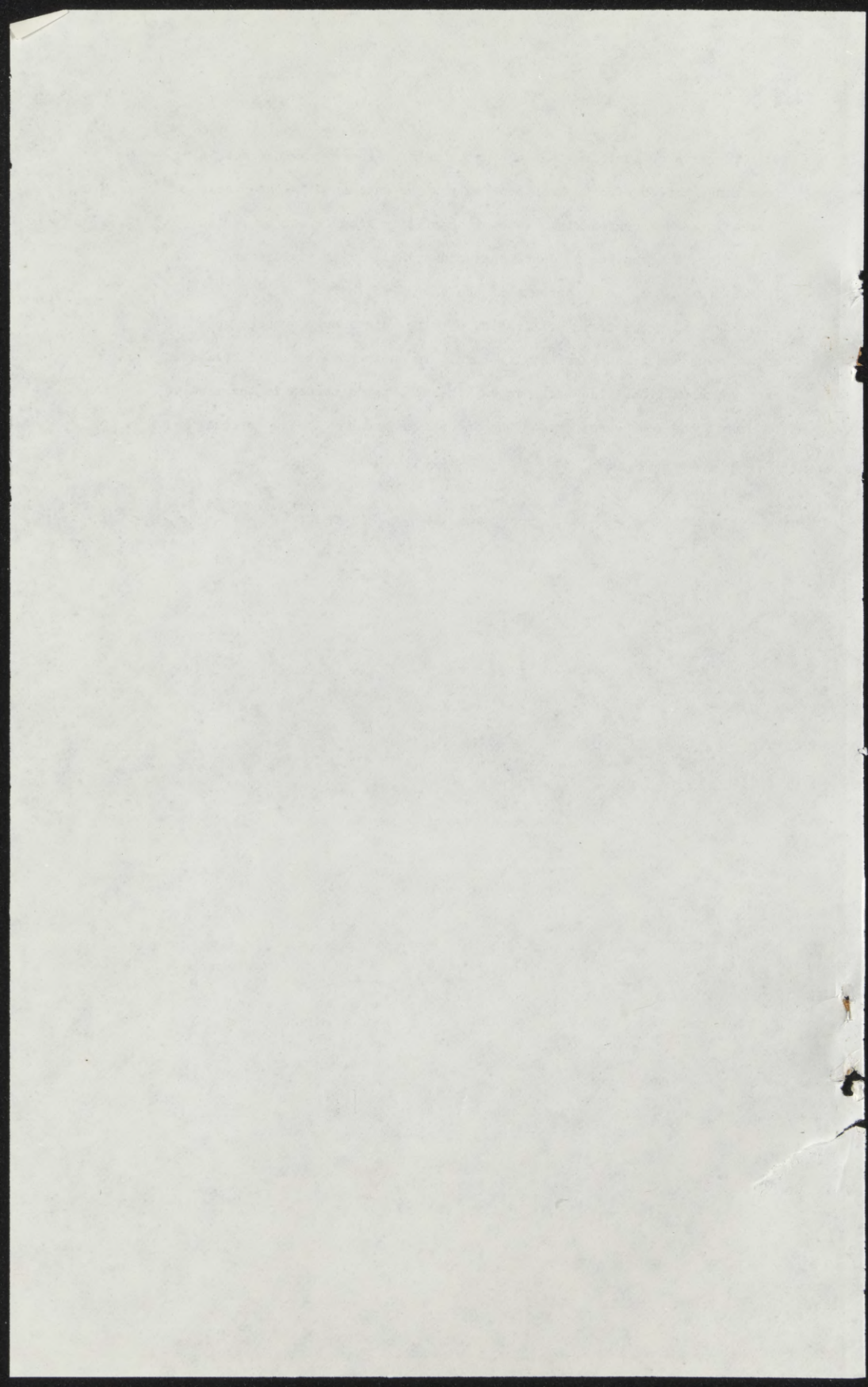
To date a total of 17 projects have been generated with the following results:

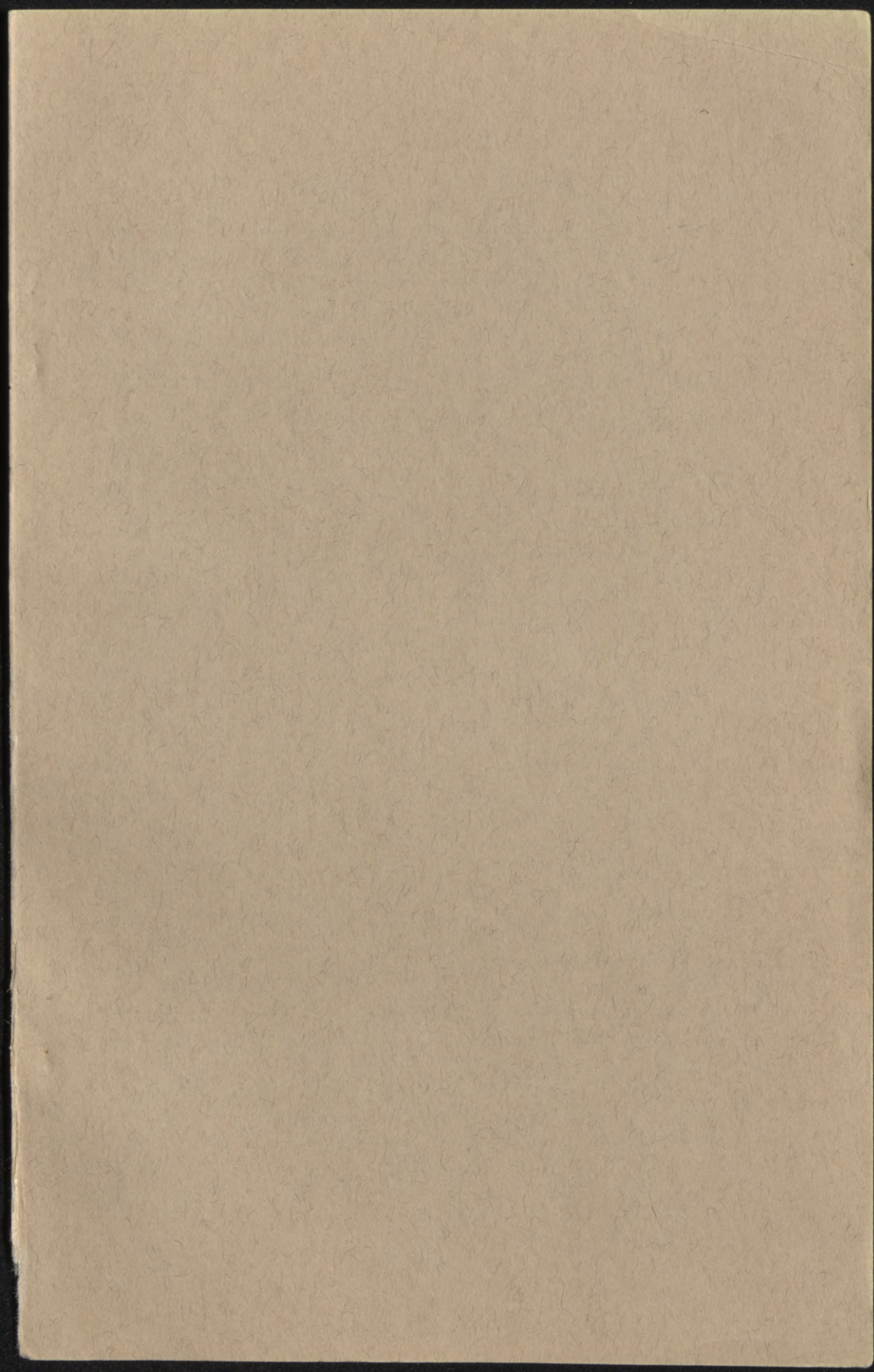
$$\begin{aligned}
 \circ \quad \text{Total Energy Savings} &= 435 \times 10^9 \text{ BTU/Year} \\
 \text{Total Project Costs} &= \$4,043,000 \\
 \text{Average E/C Ratio is:} &= \frac{435 \times 10^9 \text{ BTU (source)}}{\$4,043,000} = 107.6 \text{ million BTU's} \\
 &\quad \text{(source) per \$1000 of investment} \\
 \text{Average simple payback period:} &= 4.1 \text{ years}
 \end{aligned}$$

Grumman's experience has shown that many of today's existing buildings and industrial processes can be effectively modified to greatly reduce energy usage, at acceptable economic paybacks.

Lasting energy savings do not come about by people manually turning off lights and lowering thermostat settings, but rather by system analyses that uncover excessive uses of energy, and the development of appropriate designs for modifying heating, ventilating and air conditioning and process systems. We have found that each building or facility is different, requiring an individual approach and effort, and what might be appropriate in one case may not be right for another. The modification of existing buildings/facilities into an "energy conservation mode" requires the recognition of the uniqueness of the building/facilities involved, in terms of their operation and usage, and the types of mechanical/electrical systems inherent therein.

There is no question that the potential for energy savings resulting from conservation efforts has been badly under-estimated in the past. Having pursued energy savings in over 88 million square feet of varied facilities, Grumman has no doubt that conservation will yield energy savings in the order of 20 to 50 percent of the energy formerly used in existing buildings and processes. Utilization of alternate energy sources such as solar, wind and trash burning will result in another 5% to 10% decrease in energy consumption. The technology is here. What's needed is the resolve to commit the resources, create the incentives and develop the overall program management plans and schedules to really make it happen.







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