ENERGY CONSERVATION IN THE CHEMICAL INDUSTRY

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Past Henniker Conferences have provided the objective basis for policy recommendations to the Congress. Hopefully, this conference also can be of great service to our legislators and our Nation by helping us rationally address our problems. As Herman Kahn said the other day, "Everything is very complicated, " (13) and my heart goes Out to **our** representatives, who last year had to cast their votes on 800 separate occasions on extremely complicated matters. In such an environment, good advice does seem important,

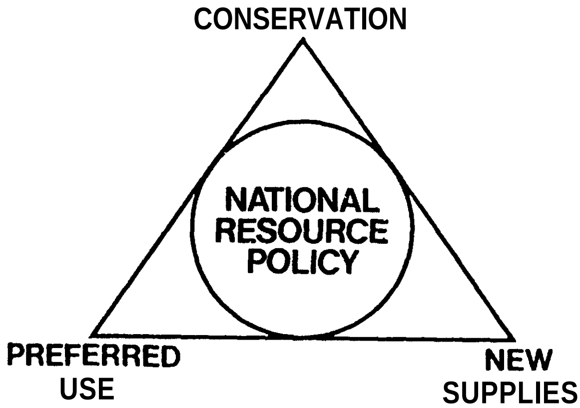
Conservation of energy is a necessary and important aspect of national energy policy. My address must be primarily practical rather than theoretical, for that's my background. It is our bicentennial year, so I hope you will take comfort with me from the words of John Dickenson at the first Continental Congress when he said, "Let experience be our guide, for reason may mislead us."

In that vein, my remarks will seek to describe the attitudes and policy position of the chemical industry on "energy" and energy conservation in particular; the nature of the political interface that currently exists in this area; the industry's and other views on the potentials for conservation; what industry is doing about it; and, last, what I believe are some sensible policy directives which the Congress might adopt to encourage better performance,

The Petrochemical Energy Group (PEG), is an ad hoc group of some 23 independent manufacturers of petrochemicals. By independent is meant they are not integrated back to oil and gas; they are not oil companies. As a basis for their efforts to influence public policy with respect to feedstocks for petrochemicals, they have developed an overall policy position, which I quote–

"The Petrochemical Energy Group (PEG), an organization of independent petrochemical companies, believes the U.S. energy program should consist of three different, but concurrent, approaches (figure 1):

FIGURE 1.—Approaches to U.S. Energy Program



- energy conservation,
- expansion of all domestic energy resources, and
- the preferred and best use of energy resources.

"For the short term there seems to be no way to meet the demand for petroleum and natural gas in the United States except through imports, The current decline in domestic oil and gas production, coupled with Government policies designed to make the United States independent of foreign energy supplies, suggests that some products now based on these hydrocarbons may not be manufactured or that some energy requirements may not be met, In a free market, this dilemma would be resolved by pricing petroleum and natural gas much higher–forcing markets which could not afford the increased costs to turn to other alternatives, However, many kinds of Government restrictions on the free market will probably keep the free market from functioning effectively.

"Thus the United States is probably facing a period of 'energy management' for some years to come, How this management will he achieved is a continuing debate. Whatever mechanism is chosen— taxes, rationing, or prohibition of certain uses–- the Nation must consciously protect its resources for their preferred uses. "

The PEG policy position accepts the fundamental purpose of Project Independence without endorsing its expression. That is, it is necessary to assure U.S. freedom of action in international affairs by establishing a secure resource base for energy. It goes without saying that similar concern exists with respect to other raw materials basic to an industrialized society.

It is a measure of the maturing congressional appreciation of the problems of the Nation that there are attempts to address these matters today, compared with the initial reaction of the legislators in 1973 and 1974 to divide up the shortage without increasing the supply,

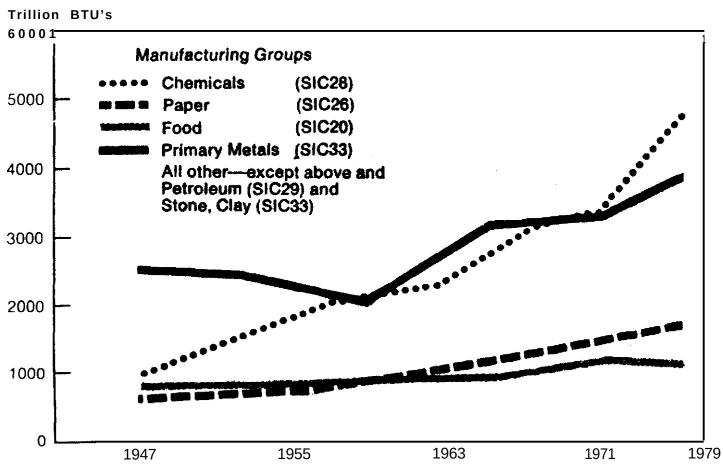
PEG's prime concern is the preferred use of resources doctrine–that is, to reserve the clean fuels which are also feedstocks for that superior use, and not to burn them as fuels. The distinction has been made between feedstocks and fuels effectively enough that the Federal Energy Administration and Federal Petroleum Congress do discriminate against synthetic natural gas plants based on naptha and LPG, for example, and a high priority for natural gas as a feedstock and process fuel is maintained in the FPC statement of priorities for natural gas use. Public policy on energy conservation generally distinguishes between fuel and feedstock uses, on the presumption that the conservation potential for feedstock is limited. That is a satisfactory working assumption for the short term, but it is probably not valid over a time span long enough to permit replacement of current processes by more efficient ones,

In early 1974 the PEG companies advised the Manufacturing Chemists Association (MCA), which comprises about 189 members producing over 90 percent of the U.S. chemicals (outside of fertilizers), that an industrywide approach to energy conservation should be initiated. Shortly thereafter, the Department of Commerce and the Federal Energy Administration asked 26 major chemical companies (both independent and integrated) in a series of workshops to define the subject matter further. The effort culminated on October 10, 1974 in a commitment to a 15 percent reduction in energy consumption per unit of output by 1980. My impression of the occasion is that the 15 percent number was a compromise reached under the threat of missing lunch, but represented a consensus among those companies who saw no way to achieve so high a result, and those who had visions of much better results than 15 percent. As additional information has been gained since then, both conservative and optimistic views are justified, depending on the different chemical processes involved. It is the mix of business which influences the average.

Other industries such as steel, aluminum, cement, petroleum, and paper undertook similar commitments at the same time, ranging from 5 percent to 15 percent. It is surely true that none of these industries has anything approaching the complexity of product mix that the chemical industry does, nor such a variety of processes or level of process complexity.

What is the level of energy consumption of these industries? In figure 2, note not only that the top six, of which four are shown, equal all other manufacturing, but also the rapid growth rate of chemicals versus others in the 1947-1975 period, particularly primary metals. This illustrates a long-term impact on the Nation's economic health, as well as a potential for apparent conservation as the manufacturing component of GNP increases in less basic industries, while the more basic industries grow relatively little. It is well known that new investment in U.S. industry lags well behind its proportion of existing world investment.

FIGURE 2.—Gross Energy Consumer by Manufacturing Groups



Source: Refcrence # 14.

To bring this history up to date, the voluntary energy conservation programs of Federal Energy Administration and Department of Commerce now include reports from some 32 industry associations, and probably 36 more are today planning to enter. The Manufacturing Chemists Association program report will this September include 107 companies of the MCA membership, with another 15 also involved but reporting through other industry associations (fig, 3). The industry also reports its total energy usage (fig. 4).

Under the Energy Policy and Conservation Act of 1975 (EPCA)–the voluntary programs may remain intact when the bill's provisions come into force on January 1, 1977, but there are many uncertainties. Efforts funded by FEA to satisfy the bill's

FIGURE 3. – Manufacturing Chemists Association

Energy Efficiency Table	1972	1975
production (10^9 lbs)		423
Btu's (10^{12})	3065'	2941 •*
Percent improvement Over Base Year (on gross Btu consumption)	Base Year	4.0
1980 Goal is **15 Percent**		
Energy Consumed to Meet Current OSHA and EPA Requirements (10^{12} Btu)		27.8
Energy Consumed to Meet OSHA and EPA Requirements (Percent of Current Consumption)		.9

Source "Voluntary Industrial Energy Conservation Progress Report, " April **1976.** Dept. of Comrnerce. FEA.

FIGURE 4, – Energy Consumed in Chemicals Processing (Calendar Year 1975)

The wide variety of fuels and the quantities consumed in the processing operation of the **107 reporting companies** are as shown below. The companies represent over 80 percent of the industr^y sales,

Distillate Fuel Oil. gallons	411 x 10^6
Residual Fuel Oil. gallons	1079 X 106
[.iquified Petroleum Gas (LPG). gallons	14 x 10^6
Natural Gas, scf	1305 x 10^9
Other Gas. scf	25 X 10^9
Coke. tons	354 x 10^3
Coal. tons	11.3 x 10^6
Purchased Steam. lbs	88.5 X 10^9
Purchased Electricity, kWh	**68.9 X 10^9**
Propane. gal Ions	**64 X 10^6**
Other Llquids. gallons	**50 X 106**

Source '"Voluntary Industrial Energy Conservation Progress Report, " April **1976. Dept. of Commerce.** FEA.

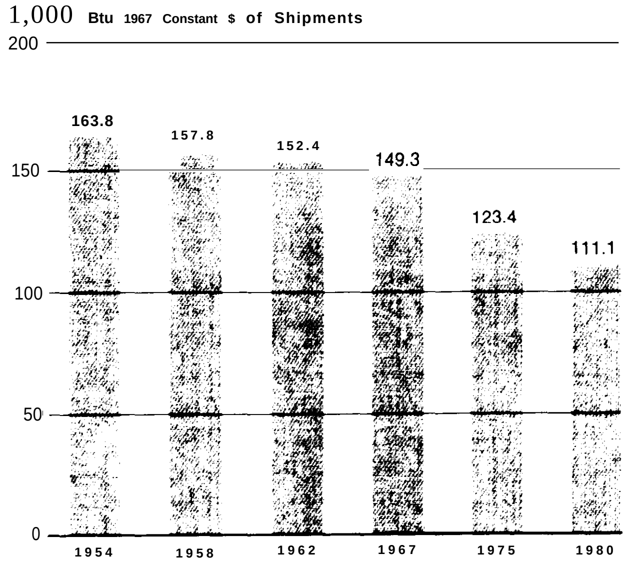
provisions include defining the top 50 companies in each two-digit, SIC code segment, and establishing by technical and economic analysis appropriate targets for energy conservation by such code for January 1, 1980. I will speak more to the question about potential savings in a moment. It is already apparent, however, that definition of the chemical industry by two-digit, SIC code raises more questions than it answers, and it is abundantly clear that taking the top 50 companies in each industry SIC using

I trillion Btu/year or more will yield a very spotty appraisal of energy intensive industry consumption.

Few people are pleased with EPCA, not particularly for its conservation provisions, but for many others, so we can expect a continuing flow of new bills covering various aspects of the energy situation. The picture is continually changing from the regulatory and legislative standpoint.

The definition of conservation currently in force in industry reporting is Btu's/unit of output (or, for the refining industry, per unit of input). This definition is not inconsistent with some economists' preferred definition on the macroscale of Btu's per unit of deflated GNP (Btu/$1976 or Btu/constant $ shipped), which suggests that through 1967, at least, manufacturing was increasingly efficient (fig. 2). The Conference Board has a forecast of continuing trend (fig. 5).

FIGURE 5.—Energy Utilization for Heat and Powcr per Unit Shipped



Source: Bureau ot the Census. *Census of Manufactures;* The Conference Board.

However, there are many more viewpoints to be heard from in the area of energy conservation. Denis Hayes, in WORLDWATCH PAPER No. 4, suggests the conflict between disciplines and jargons (11). I quote—

"Yet 'waste' can mean different things to different people. Waste signifies one thing to a physicist, and another to an economist; it has wildly differing meanings for philosophers, engineers, and politicians. In fact, all energy policy discussions bear this curse of Babel; they are plagued by ambiguous terminology and consequent misunderstandings. A new and eclectic field, energy policy, involves so many diverse disciplines that a common language and set of definitions could hardly be expected. But many conflicting claims might well be reconciled if only their respective proponents were talking about the same thing.

"Few energy economists, for example, have any background in thermodynamics. Few know that energy has a qualitative dimension, that the Second Law of Thermodynamics— which states that the quality of energy declines as it is used—is just as absolute as the First Law which states that the quantity of energy in the universe is constant. Most studies of energy use have dealt only with the quantitative dimension of energy. Most have considered the flow of energy units (Btu's, calories, or joules) used in a given process, but have not distinguished between the relative entropy levels (i. e., levels of organization and quality) of these quantities. Most have thus ignored the most important aspect of the energy flows they have been analyzing.

"While physicists thus argue that energy use in the United States is only 10 to 15 percent efficient, many economists believe that there is no significant waste in our present energy budget, By their own standards both camps are correct, The physicists failed to examine the economic cost of increasing the physical efficiency of energy use, Nor did they examine systemic alternatives (e.g. substituting van pools or public transit for automobiles). Theirs was a purely technical study of the efficiency of use of free energy in current technologies. Most economists, on the other hand, disregard the physical and technical phenomena their idealized marketplace purportedly represent. They take for granted that pricing mechanisms have assigned appropriate dollar values to all possible purchases, Since fuel buyers act in their own economic self-interest, and since the total economy seems to be operating reasonably efficiently, these economists argue that our current level of fuel consumption cannot be considered economically wasteful.

"If both perspectives are 'correct, ' both have shortcomings. In economic terms, technical opportunities tor conservation mean little if they are prohibitively expensive. On the other hand, the purely economic perspective may be even more deficient. Its guiding principle– that a dollar should be invested wherever it will bring the highest return —is sensible for many purposes, However, at present it almost completely disregards such 'externalities' as environmental quality, occupational safety and national security. Moreover, it_ ignores the needs of the next guy in line. On a planet with rapidly depleting, finite resources, future generations can't fend for themselves; the economic principle must be tempered by humanitarian constraints. But economics is an analytical tool, not a system of ethics.

"Combining the insights of both physicists and economists, this study considers energy to be 'wasted' whenever work is performed that could have been completed with less or lower quality energy and without incurring higher total social or economic costs. By this definition, the United States consumed about twice as much fuel in 1975 as was necessary, The major areas in which significant savings could be made are transportation, heating and cooling systems for buildings, water heating, the food system, electrical generation, industrial efficiency, waste recovery, recycling, and lighting."

So there are several definitions of conservation which can be applied, as well as standards of performance to use in evaluating results.

It does seem to the chemical industry that there is great merit in changing the dependence of the Nation on oil and gas toward coal, oil shale, oil sands, nuclear power, and such renewable energy sources as the solar, wind, and sea tides. That is the route to energy independence in supply which will be furthered by free market pricing of energy sources. The problem in the world, and in North America in particular, is not really lack of fossil resources for the foreseeable planning period (fig. 6), It is that regulated pricing of energy sources now inhibits development of coal, and later of oil shale and tar sands. About one-third of the reputed North American reserves are coal, with very questionable availability assigned to the oil shale and tar sands, which comprise all but some 8 percent of the balance.

While higher prices will create a better allocation of investment toward more available indigenous resources than oil and gas, it is also clearly the accelerator required to promote energy conservation, and it is an effective one, more so possibly to industry than to other sectors.

It needs to be stated that the profligacy in U.S. energy use which is so roundly criticized is clearly much more a function of lifestyle than industrial inefficiency. I find the Institute of Gas Technology data on correlation of spendable income and energy use interesting in this regard (fig. 7).

Other reports tend to support the view that to the American consumer convenience and comfort are and continue to be more important than vague concepts of national independence. The

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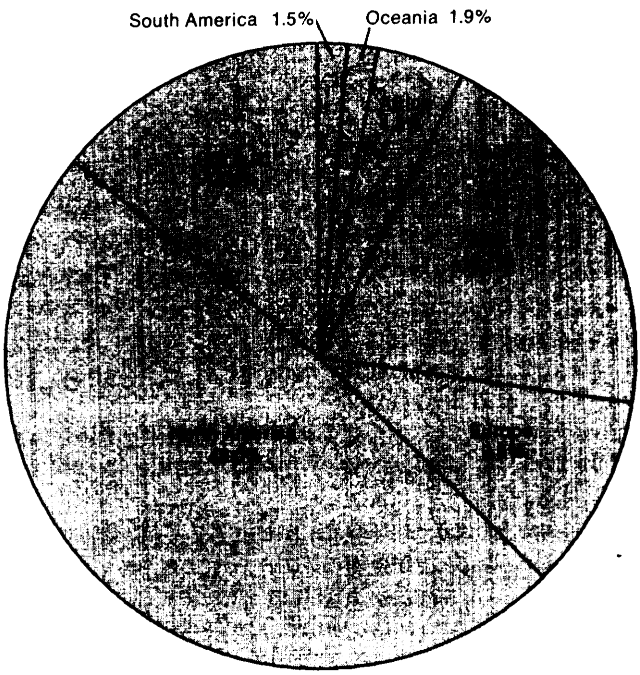
FIGURE 6.—Wor]d Recoverable Energy Reserves
(Quadrillion Btu)



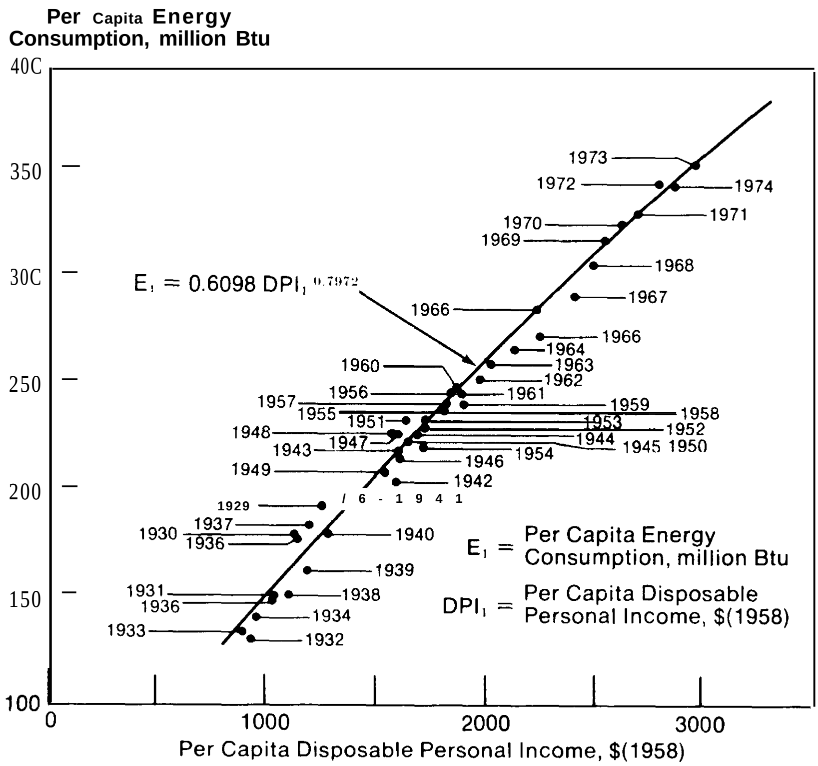
Source: Survey of Energy Resources, World Energy Conference, 1974.

American home is reported to use three times as much electricity in 1975 as it did in 1965, and gasoline use is up again in 1976, in what the New York Times calls a bicentennial driving binge. And why not? My own old 1972 Pontiac station wagon cost me 35cents/ mile to operate, inclusive of depreciation, insurance, and other costs, of which gasoline was 6cents. The economic incentive of gasoline price increases is minor relative to other costs.

Figure 8 illustrates the 13-year trend in net energy consumption by sector, and points out that the residential, commercial, and transportation sector outpaced the industrial in increasing use. FPC data on 25-year electrical use corroborates the data in figure 8, and incidentally illustrates the high-load factor of this customer class (fig. 9).

The trends in electricity consumption by sector reflect the realities of cost for this energy form versus other energy forms. It is at minimum three times as expensive a source of thermal

FIGURE 7.—Correlation of Annual Energy Consumption Per Capita with Disposable Personal Incorne Per Capita for the United States

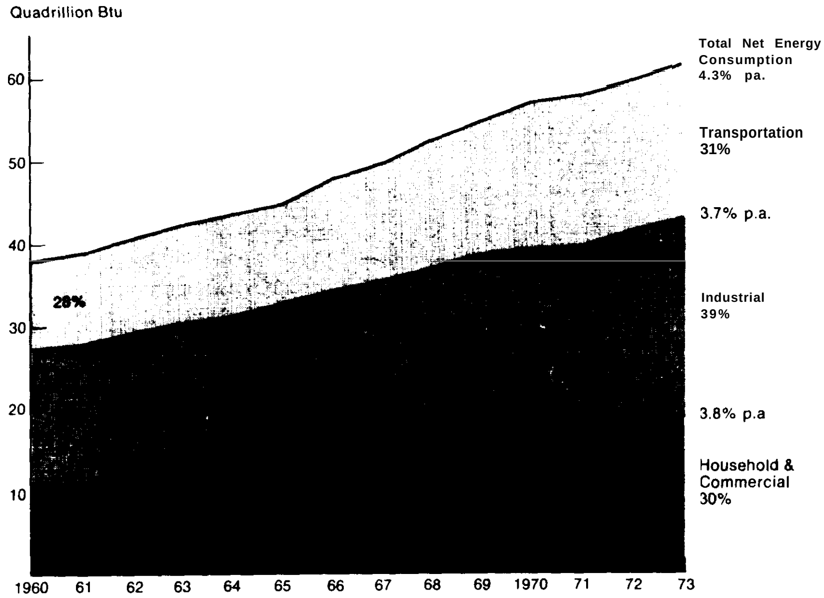


Source: Reference #8.

energy for the lowest priced user as the next cheapest alternative, and hence is and has been most efficiently used by industry. Of course, it is used in quantity only for electrochemical processes and mechanical application for which it is uniquely fitted. It is obvious from the recent congressional hearings on electric rate reform that the economic basis for charging the high-voltage, high-load factor users a lower rate per kWh than the low-voltage, low-factor users is not understood, Indeed, I was informed in those hearings that industry was “ripping off” the residential, and was wasteful of electricity because of low “promotional” rates to industry. Figure 10 was used by the Electricity Consumers Resource Council at the House Subcommittee on Energy and Power hearings in April 1976, in pointing out the illogic of that allegation,

Unfortunately some generally responsible consulting firms have reinforced this erroneous impression, The June 1976 report

FIGURE 8.—U.S. Net Energy Consumption, by Final Consuming Sector, 1960–73

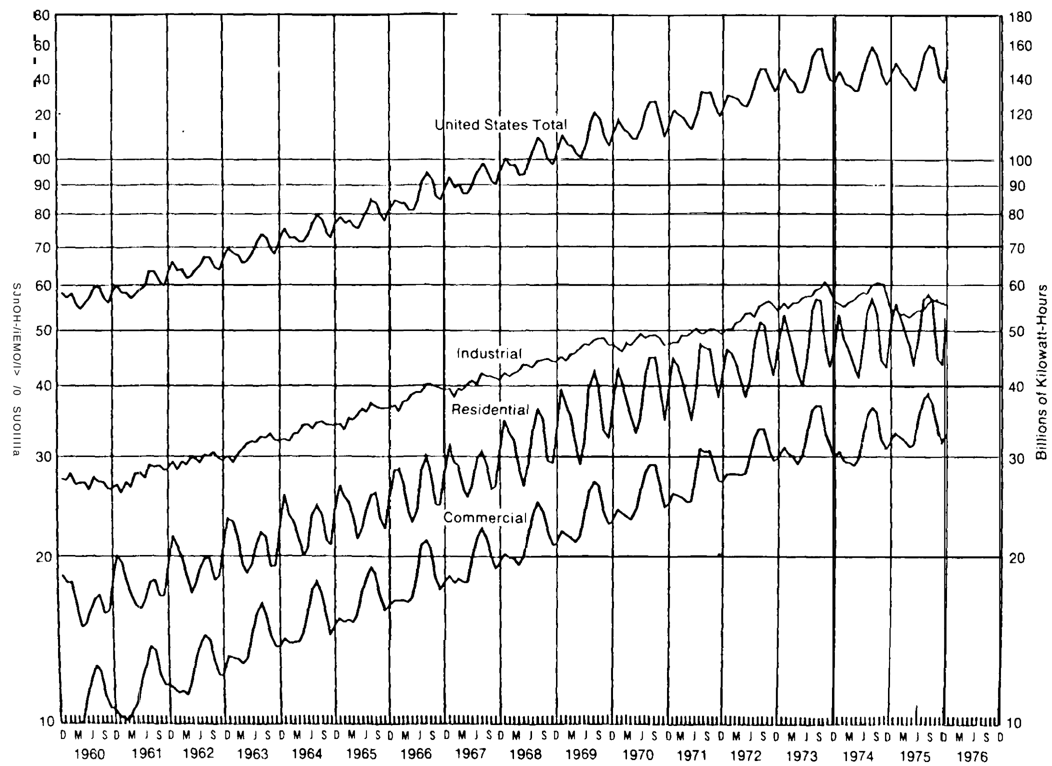


Source: U.S. Bureau of Mines, **1974.**

by the Stanford Research Institute, "Electric Power–The Cost to Industry," (9) suggests that utilities price power such that industrial customers are in effect being subsidized, principally by the residential sector. Analysis of all rate-of-return studies made for utilities, public service commissions, and industrial users over the last 5 years by two major consultants in the field, indicates that in about 80 percent of the cases the industrial class provides a higher rate of return than does the residential class. In no case were rates below cost. It is ironic, of course, that almost universally the commercial class provides a higher return than either. As a policy, major industrial users would be pleased to see utilities so price electricity as to gain an equal rate of return from all classes.

To summarize, it seems there is reason to believe that, on the macroscale, increases in energy consumption have been a function of lifestyle and personal income, Further, the residential and commercial sectors have contributed more to the growth in

FIGURE 9.—Monthly Residential, Commercial, and ndus rial Sales of Electricity in the United States, 1960–1975



Source: Reference #20.

FIGURE 20.—Purchased Energy Costs at Several ELCON Member Plants $/Million Btu's [1975j

	GAS	OIL	ELECTRICITY
California	1.23	None	4.93
Maryland	1.61	2.44	7.32
North Carolina	.87	2.55	4.83
Texas	1.13	None	2.93
Texas	1.50	None	6.44

Source: Reference #6.

energy usage than has industry, particularly in electricity. There is reason to believe that industry, and the energy-intensive industries in particular, are more sensitive to price signals on a continuing basis than are the citizenry in general,

What potentials for savings in energy use exist? The literature of the last few years is not overly instructive. Various consultants, largely at the behest of the FEA, have sought to quantify the industrial savings potential by comparing the United States with supposedly similar societies such as Sweden and West Germany and by thermodynamic analysis,

Comparison of Sweden and West Germany with U.S. energy use was developed because the GNP/capita is similar, hence the relative energy use might suggest potential for savings. It is clear that there are gross differences between the societies in their energy use, but it is not certain that U.S. industrial use of energy is less efficient than in the countries compared **(11).** One finds that Swedish energy use per capita is 6 percent of the United States. However, Swedish industrial use per capita is slightly greater than in the United States, In the particular case of the chemical industry comparison between the countries, the report shows a U.S. use, measured in kWh per dollar shipped, of 73 percent of the Swedish use (fig. 11). The German study (fig. 12) does suggest materially lower energy consumption than in the United States per unit of industrial output.

Some of my colleagues in U.S. industry who have reviewed these reports and interviewed the London office of the consultant who did the German study criticize it on various grounds. In my opinion the outcome is not unlikely, in view of the generally more modern German steel, chemical, and refinery plants reconstructed after World War 11; the much higher level of processing of U.S. food; the imports of wood pulp by the paper industry in Germany; and the notably lower fuel costs enjoyed by the U.S. petrochemical industry on the Gulf Coast,

FIGURE 11 .—Energy Consumption in kWh/Capita for U.S. and Sweden in 1971

	United States kWh	Sweden kWh
Transportation	24.025	7.350
Commercial	9.600	7.375
Residential	13.500	14.150
Industry	28.900	29.450
Feedstocks	5.600	2.500
Utility Losses (actual)	14.200	3.700
Actual Consumption	95.825	64.500
Energy Embodied in Foreign Trade	1.800	-4.600
Net Consumption	97.625	59.900

Source: L. Schipper (Energy & Resources Group) and A. J. Lichtenberg (Chairman. Energy and Resources Group). University of California. Berkeley. Calif.

FIGURE 12.—Comparison of Industrial Energy Consumption in Relation to Value of Shipments for the United States and West Germany—1972

Industrial Sector	10^3 Btu/$ of Shipments: United States	10^3 Btu/$ of Shipments: West Germany	West Germany as Percent of United States
Food	11.9	8.3	70%
Paper	104.0	38.6	37
Chemicals	71.8	40.8	57
Petroleum and coal products	112.0	56.0	50
Stone. clay. glass. and concrete products	75.3	54.8	73
Primary metals	97.0	77.6	80
Total for six energy-intensive industries	61.2	42.4	69
Other manufacturing	9.4	7.1	76
Industry total	34.8	25.1	72

Source: "Comparison of Energy Consumption Between West Germany & the U.S." R. L. Goen & R. K. White. Stanford Research Institute—June 1975.

Going beyond comparisons, **A.** J. Appleby constructs **a** scenario of a nonfossil-fuel economy after the year 2000, with dramatically higher energy prices impelling **a** reordering of society and industrial organization to force conservation (17). For the year 2025 he would have industrial energy use overall at one-third of 1971 energy consumption per $1 of GNP, measuring energy use in tons equivalent of crude oil (fig. 13). He assumes an overall potential savings of 27.2 percent of primary energy use per GNP unit. Made up by a series of savings, these would include a reduction from the present industrial total of 33 percent

FIGURE 13.—*Potential Energy Savings in the U.S. and EEC Economies*

	% of total energy consumption	Present top/ $1000 of GNP (1971)	Primary savings (%)	Method of saving	Secondary savings (%)	Method of saving	Final energy (% of current total)	Future top/ $1000 of GNP (1971)	Future total (%)
USA									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		15.0	0.23	39.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Electricity considered primary energy.	9.6	0.15	25.0
Industrial	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Waste heat use.	14.6	0.21	36.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	0.59	100.0
EEC									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		12.4	0.14	28.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		14.3	0.15	30.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		18.5	0.21	42.0
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		45.2	0.50	100.0

Source: "Energy Costs and Society" by A. J. Appleby, ENERGY POLICY, June 1976.

in process steam and direct heat, with emphasis on retrieval of waste **heat from electric powerplants; cutting primary** metals demand for energy in half; reducing present inorganic chemical industry consumption by one third, and so forth.

His argument is based on the intolerable burden of future energy costs and capital demands which he sees placed on society by the generation of that energy. However, what kind of capital cost and technological development needed to replace current industrial, transportation, and housing to satisfy these ideals is not adequately understood, The measures required will be Draconian. This is a splendid example, I trust you will agree, of "Reason misleading us. "

"The FEA-funded studies by Battelle and Gordian Associates published thus far seem to me to be closing in on the subject of conservation potential without actually providing either a measure of potential or a rationale for approach. The thermodynamics studies at Battelle (16) cover seven energy-intensive industries, including four major plastics, and calculate the fuel requirements for the polymerization steps and the imputed thermodynamic efficiency of those steps (figs. 14 and 15).

FIGURE 14.–Fuel Use for PJastics per 'l'on of Product

	Total Industry Fuel Used[(a)]	Fuel for Polymerization[(b)]	Fuel Value of Monomer[(c)]
	(10^6 Btu/ton of product)		
Low-density polyethylene	45.8	15.3	44.8
High-density polyethylene	37.2	13.2	45.7
Polystyrene	18.5	8.0	37.3
Polyvinylchloride	23.8	7.1	17.9

(a) Includes monomer production (but not fuel equivalent of feed stocks) are inefficiencies in steam and electrical generation.

(h) Fuel equivalent for steam and electricity required for polymerization process analyzed.

(c) Fuel equivalent of monomer feed stock. not included in Columns I and 2.

Source: Battelle Columbus Laboratories. "Evaluation of the Theoretical Potential for Energy Conservation in Seven Basic Industries," prepared for FEA **7/11/75.**

The Gordian Associates study (18) on these same plastics assigns the energy consumption from raw material acquisition to final product ex-reactor, and is therefore useful in focusing on which of these steps offers the biggest targets (fig. 16).

As time has elapsed, more sophisticated approaches involving direct participation by industrial groups have been initiated, and I

~FIGURE **15.–Plastics Production Efficiency**

Polymer	Polymerization Efficiency, Percent	Entire Industry Efficiency, Percent
Low-density polyethylene	67	45
High-density polyethylene	66	49
Polystyrene	79	64
Polyvinylchloride	62	37

Source: Battelle Columbus Laboratories. "Evaluation of the Theoretical Potential for Energy Conservation in Seven Basic Industries," prepared for FEA 7/li/75.

FIGURE 16, **–Percentage Breakdown by Operation of Total MMBtu of Primary Energy Consumption** for Production of Selected Plastic Products in the United States in 1970

Primary and Ancillary Production Operations	LDPE Resin	HDPE Resin	Poly - styrene Resin	Polyvinyl- chloride Resin
Natural Gas Processing	15.3	16.2	4.0	7.5
Production of Oxygen	—		—	1.4
Production of Ethylene	63.3	66.8	16.3	30.8
Production of Acetylene	—	—	—	9.4
Production of LDPE Resin	21.4		—	—
Production of HDPE Resin	—	17.0	—	—
Production of Aromatics	—		49.3	
Ethylbenzene by Superfractionation	—	—	3.1	—
Production of Styrene	—	—	20.5	—
Production of Polystyrene			6.8	—
Production of Chlorine		—	—	18.1
Production of Vinyl Chloride	—		—	12.7
Production of PVC	—	—	—	20.1
Total	100.0	100.0	100,0	100.0
Total Primary Energy Consumption, MMBtu/ton	93.49	86.64	117.42	82.92

Source: Energy Conservation Paper No. 9 prepared by Gordian Associates.

must say it is high time. It is not necessarily suggested that greater competence exists in the industrial groups than can be found in the consulting community, but much better access to current practice and the potential for technological advance can be expected. Probably most important, an evaluation of the reinvestment arising from anticipated growth rates of various product sectors can be expected to be applied, and this is certainly the most important influence on achieving conservation potential. In the chemical industry, we have, as a rule of thumb, anticipated twice as much energy efficiency improvement from new capital formation as from housekeeping and retrofit activities.

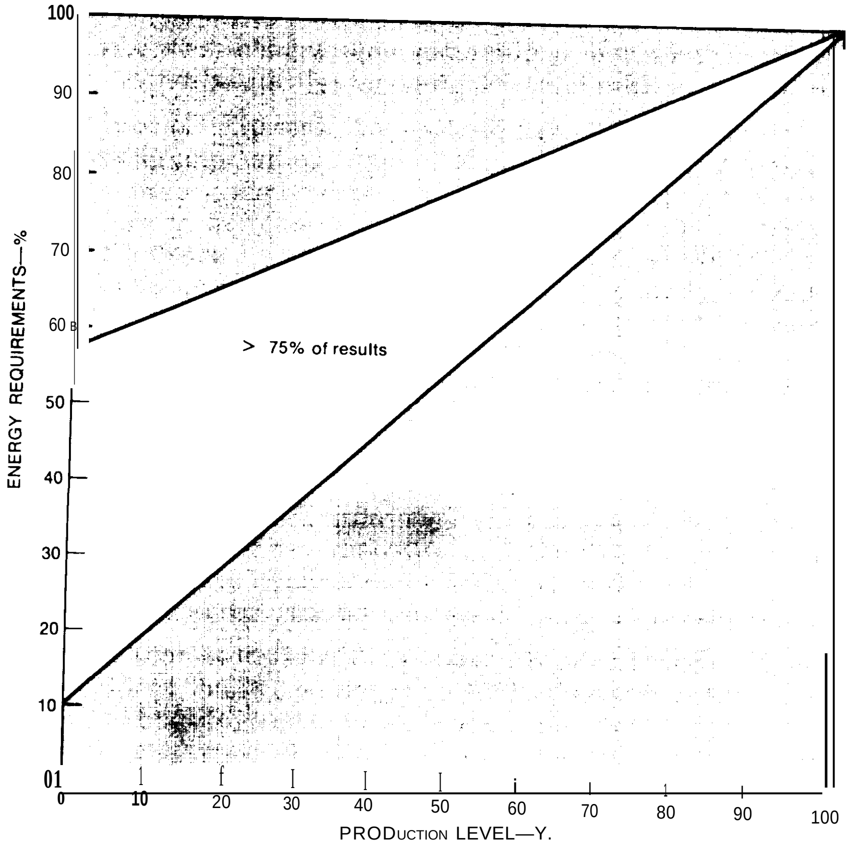
Under the auspices of the National Research Council, there is currently under way a study to appraise the appropriate future role of nuclear power among alternative energy systems, As an aspect of that study, a demand/conservation work panel is addressing the question of industrial energy conservation potential through the year 2010. The work statement of the group was reviewed recently with the Manufacturing Chemists Association task force, It seems to the MCA group that the study offers both theoretical and practical potential over that extended time span, tempered as it promised to be by realistic forecasts of population and economic growth, lifestyle changes, and technological advance,

The timetables currently governing the study would suggest that it should be finished in 1976, and will be in my opinion the first industry comment with adequate depth and scope to justify confidence in the forecast for the industry sector.

In the shorter term we have the FEA effort to define industry conservation targets for 1980, a program mandated by EPCA. The Battelle-Chem Systems study is likely to be published in September 1976. Under the urging of the MCA, an open communication by the chemical industry to consultants has been realized. Since the results have not been released yet by the FEA, and since they will be the subject of open hearings, it is impossible to offer comments on the results derived. The MCA Committee has organized a parallel study using industry experts in each SIC code area to develop an independent target number, properly weighted by the energy intensivity of the product sectors and the anticipated growth rates of each.

It becomes apparent in the MCA studies why the industry is reluctant to be bound to a high target at any time. Two technical reasons dominate, First, the extent of capacity utilization at any given moment has a profound effect on energy use per unit of output (fig. 17). Within the shaded portion lies 75 percent of the some 100 processes evaluated by the industry task force. You will note in these energy-intensive processes that at the origin the median energy requirement is 35 percent of full capacity energy. Or, on that median line, 30 percent of capacity required 50 percent of maximum energy utilization, The chemical industry operated at 74 percent of capacity in 1975, but the most energy inten -

FIGURE 17.—Energy Requirements Versus Production



Source: Manufacturing Chemists Association.

sive portions, such as olefins manufacture, ran at below 60 percent for a large part of the year.

Second, the SIC code approach mandated by law (and the only one seemingly feasible in light of currently available data) creates statistical problems for the chemical industry analysis. The problem is that SIC determination is by principal product shipped from each establishment, Given that, in the typical chemical complex, the sequential flow of intermediator to products is in several steps, these data shed little light on the effect of process steps involved. For example, my own company in its chemical operations produces 2-1/2 to 3 pounds of products and intermediates for each pound of product it sells. Less integrated operations will, of course, have fewer processing steps.

There is no question, however, that our own internal studies give great confidence that voluntary programs in the chemical industry will lead to savings greater than 15 percent by 1980 versus 1972, provided the economy justifies an economic utilization of capacity at that time. It is premature to publish specific predictions of savings for that time period. In plastics, synthetic rubber, fibers, BTX, and organic chemicals, increases in efficiency above 15 percent are considered feasible. On the other hand, the electrochemical and industrial gas sectors, dependent on electricity, offer much less savings potential overall, and along with the inorganic pigments and other inorganic serve to bring down the weighted average forecast.

It seems that energy intensivity declines markedly with each step in the value added. This has a most beneficial effect on management attention to energy conservation, since in the chemical industry the lowest value products have been most impacted by rising energy costs.

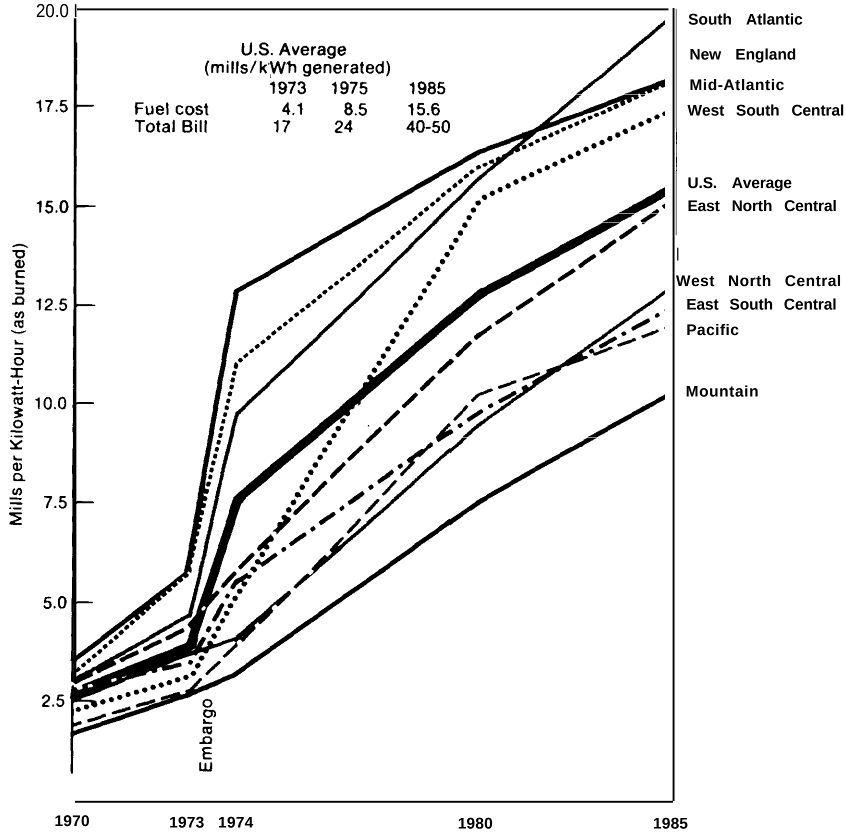
Which leads to the question, What is the impact on the chemical industry and how is it reacting in practical ways?

Lacking generalized data, I must resort here to particular examples. But I do believe the response has been very similar across the industry, in light of the reporting of some 100 companies in the industry. The conservation results reported to the MCA for transmittal to the Government indicate that the average savings per unit of output by the top 26 companies and the balance of the 100 are approximately the same.

The economic imperative created by energy dependence and sharply rising costs to save is enormous. Figure 18 displays recent fuel cost to utilities, and the total and projected U.S. average electricity costs. Since fuel cost is a major portion of purchased electricity charges for industrial users (about 70 percent in Texas Gulf Coast), the impact is greater on the industrial than the residential user for electricity. Unit electricity charges for a typical U.S. chemical company in 1975 are 240 percent of 1972. Intrastate natural gas prices are up eightfold. And oil costs are up fourfold. A basic petrochemical producer may have today 30 percent total energy product cost per dollar of sales. These relationships have directed management attention to savings of energy in many ways, with good effect and more zeal than any regulatory process can possibly command.

The industry conservation programs in my own company and others with which I am familiar have embodied all the paraphernalia required to systematically produce results. First, top management has uttered policy statements reflecting not commitments to Government agencies, but the economic necessity to be more efficient, Second, identified individuals in the organiza-

FIGURE 18.—Cost of Fuel Used for Electric Power Generation by Region, 1970-1985



Sources: Edison Electric Institute; Arthur D. Little, Inc., estimates.

tion structure have been given responsibility for results. Next, capital and expense moneys have been allocated consistent with economic and other guidelines.

Major energy-using processes are subjected to intensive audit, as are whole plants. Periodic reporting has been established, or better yet included in existing operations-improvement reporting systems, Strong internal and external employee and public relations programs have been instituted to encourage involvement and pride in results.

The published reports on the Monsanto Company represent a leading program. Under the "activity" method of reporting, they recognize a 19. I percent energy savings-per-unit output in the period of 1973-1975 inclusive, Since the production rate was low in 1975, the company purchased 15 percent less energy in 1975 than in 1974, but energy costs increased 24 percent, At the same production level as 1974, costs would have been up 45 percent.

The "activity" report concept anticipates the annual effect at reasonably high operating rates of projects instituted, and differs from the MCA report, which essentially reports the ratio of energy consumed, per pound of product produced, per calendar year, compared with the 1972 base year.

Monsanto uses a target energy cost to evaluate energy conservation investment, and that target is the energy cost in an outpost year 5 years after mechanical completion.

My own company's energy conservation savings are reported and managed through a longstanding Operations Improvement Program. That program, by the way, is given credit for our economic viability in the period 1960-1970, during which time the company's chemical price index in current dollars fell 36 percent.

Figure 19 portrays some recent history. It is noteworthy that since 1972 energy conservation savings as percent of total savings have gone from 15 percent to 37 percent of the total. About 30 engineers are dedicated to energy conservation work alone in the plants of this division,

FIGURE 19.–Energy Conservation Saving as Percent of Manufacturing Savings

Year	Energy Conservation Savings $MM	Operations Improvement Program–Overall/ Savings (l)$MM	Energy Cons. Savings as% of Mfg. Total –(%
1972	6.2	41.1	1 5,1%
73	8.4	47.5	17.7
74	9.0	47.5	19.0
75	12.8	47,3	27.1
First 76 Half Date	9.5	25.8	36.8%

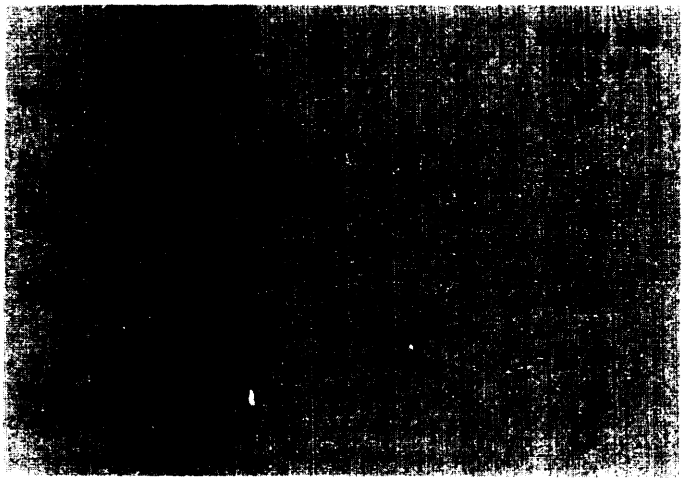
(l)– Energy Conservation savings are included in the OIP overall savings. OIP focuses attentlon on:

Energy Costs
Raw Material Costs
Period Costs
Any other (:osts not in above

Source: Union Carbide Corporation

Research and development activities are increasingly directed to process development in less energy-intensive processes. Traditionally, about two-thirds of the equipment investment in chemical manufacturing is devoted to separation equipment, largely distillation columns. Since the early 1970's, research into new and less energy-intensive separation processes has been funded, The target is obviously large (fig. 20).

FIGURE **20.–Fuel** and Energy Use in the Chemical Mushy by Conversion Process



Source: Reference **#21.**

The principal deterrent to faster implementation of energy-upgrading projects is capital availability, A typical priority list for investment is, first, mandatory projects for employee safety; second, projects to meet environmental commitments; third, major expansion; and fourth, energy conservation.

Typically, paybacks for approved retrofit projects of an Operations Improvement Program or energy conservation nature are very great— less than a year at the present time. This reflects both lack of capital availability and the recognition that incremental investment in obsolete facilities may have very high returns, but the fundamental non-competitiveness of such facilities relative to all new ones embodying state-of-the-art technology is usually overriding. That trend is less obvious today, since all new facilities initiated will be completed at costs greater than 400 percent of those finished in 1971, but it is nonetheless fundamental in the long term.

The engineering guidelines currently in force indicate that there is economic justification in our operation for an investment of $100,000 to save 1590 barrels per year oil equivalent. The key assumptions are a forecast of energy price in an outpost year 5 years hence, and investment costs 2 years hence,

The discussion has concentrated so far on conservation measured as increasing energy efficiency. It is also true that conservation of declining fuel resources is a particular objective that prompts investment programs to diminish use of natural gas as fuel, The priority use of natural gas for residential use is explicit, and boiler use will be sacrificed. The current Texas Railroad Commission policy in that regard is clear, and while awkward for a number of individual plants and companies it is consistent with policies they have endorsed through industry groups such as PEG. My own company aims to reduce total natural gas use 65 percent by 1980 from 1972 levels, and I believe that is typical.

It is expected that if the new Federal Power Commission price , setting of $1.42 for interstate use is confirmed after litigation by consumers, then that will tend to promote conservation in interstate pipeline customers, as well as increased availability of gas to the pipeline. Intrastate prices in Texas and Louisiana already range from $1.50 to $2.00, and in our plans are expected to reach parity with oil in the early 1980’s. A form value premium of 10 percent is very likely,

Such an economic spur to coal production is appropriate, and should suggest a more rational address to environmental costs and regulations, Environmental costs for coal should be internalized, and can in all probability be afforded if competing fuels reach more rational pricing.

It is perfectly apparent to the chemical industry that environmental obligations will have to be met fully in the areas where operations are principally located, such as Texas.

From a variety of industry sources, some forecasts of the energy efficiency of all new facilities embodying current technology at anticipated energy prices can be suggested. One source indicates that an all new olefins plant would use 35 percent less energy than a 1971 plant (22). Modifications of an existing plant would yield 15 percent. An all new refinery could achieve a 40 percent saving. Several categories of plastic plants will have 25 percent to 60 percent lower energy requirements than facilities built today (2). Realization of these potentials is obviously a function of increasing product demand for it is very difficult to justify additional new plants, no matter how economic they are, in an oversupplied market.

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A number of forecasters anticipate continued growth in the chemicals and plastics sectors at rates greater than GNP growth, albeit at half the levels realized in the 1960's. It is expected that engineering plastics will continue to replace metals on a utilized cost basis, particularly in transportation equipment. Continuing conservation potential exists there, Owens Corning Fiberglas has postulated a .79 gallon of gas saving per pound of weight reduction over the life of an automobile (100,000 miles). This sort of incentive will of course be reinforced by higher gasoline prices,

What Governmental and Regulator Policies are Appropriate to Energy Conservation ?

Beneficial results can be achieved in a number of ways, but the policy thrusts are relatively few, Seven are discussed as follows:

1. There should be more open invitation by the Congress and the energy agencies for industrial contribution to policymaking.
2. Voluntary industrial energy conservation programs should be maintained and encouraged. The economic incentives exist to prompt management attention and application of resources. The chemical industry's complexity surely calls for address within the infrastructure, not central regulation.
3. The prices of energy commodities, should be deregulated, and combined with windfall profit taxation modified by investment plow-back forgiveness for development of indigenous resources. The concept that "economic rents" created by deregulation is a social injustice does not recognize that present embedded investments are low compared with the dramatically higher requirements of new investments in energy product development and processing, Traditionally, these investments constituted about 12 percent of total industrial capital formation, but are about 25 percent today. Furthermore, the regulated low pricing of natural gas impedes the development of coal, exacerbates the misallocation of development resources, and keeps overall energy costs down, thus discouraging energy conservation investment in the United States compared to the rest of the world.
4. Capital and manpower are limited resources. Investment credit approaches are far superior to loans and loan guarantees, which impact on debt equity guidelines in many companies. A plan proposed by the Minnesota Energy Agency seems reasonable and could make many

marginal industrial energy conservation projects economically attractive. Briefly, the "Minnesota Plan" would give a tax credit of 25 percent for expenditures on plant and equipment related to achieving energy efficiency, plus a same year write-off if the company involved would certify that for every $4 of investment $1 annually of energy savings would result. The "break even" point for large and small corporations would range between 2 to 2.7 years. The Government would thus recover its cost for the program in 6 to 8.2 years,

5. Continuation and further development of Government-supported energy conservation education in smaller companies is appropriate. The EPIC manuals from the Department of Commerce get high marks from our people, and the industry seminars planned by FEA make sense, provided adequate technical content is achieved.
6. Industry-electric utility cooperation needs to be facilitated, The intrinsically wasteful thermal efficiency of electricity generation is improving in new coal-fired plants, to values like 8400 Btu/kWh from an average of over 10,000, but greater conservation potential exists in dual plants using waste heat. Industrial experience suggests that thermal efficiencies of 75 percent are practical.

   Specific areas include:

   (a) Off-peak and surplus power–some utilities offer lower cost power during off-peak hours or on an as-available basis;
   (b) Self-generation by industry with sale of surplus power to the utility or purchase of back-up power from utility;
   (c) Wheeling of power through utility-owned transmission facilities— this would involve purchase of power and self-generation outside of the serving utilities territory and wheeled over their lines;
   (d) Curtailable rate schedules–some utilities offer non-firm electric service at lower cost reflecting the higher utilization of generation facilities;
   (e) Dual-purpose industrial energy centers–these are a consortium of private industries which build and operate a central station for the production of both process steam and electrical energy;
   (f) Waste-heat recovery– this involves recovering waste heat from industrial processes and using it to generate power which is fed into the utility's distribution system, and

(g) Steam sales–purchase of process steam from electric utility. Steam sales for heating and process use are made by some utilities but the practice is not widespread,

7. A concentrated program should be started to demonstrate, and allow under law, coal mining and burning technology which is environmentally acceptable. The coal utilization in the United States today represents only 18 percent of primary energy supply, compared with 50 percent in 1950. But it is not generally recognized how narrow the market is—about 75 percent of all coal burned in the United States is consumed by 17 companies. Current strip-mining technology practiced in West German brown coal fields is noteworthy in its minimum environmental impact, and fluidized-bed coal combustion is near demonstration stage.

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