Forbes

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August 27, 1979

Dr. Elias P. Gyftopoulos
Massachusetts Institute of Technology
Room 24-109
Cambridge, MA 02139

Dear Dr. Gyftopoulos:

Please let this letter serve as an explanation to any readers of FORBES who question the propriety of our placing the word "advertisement" on top of the special section on Energy in our September 3rd issue.

As I explained, any special section which charges a premium to cover such things as merchandising and outside text material, must be labeled "advertisement." This is at the direction of the U. S. Postal Service. It should in no way be interpreted that the writer has paid FORBES Magazine for the publishing of their text. This is simply not the case.

FORBES in it's special section activities, quite often contracts for outside writers, to gain a broader scope and to give more in depth coverage on specific subjects, in order to be of greater reader and advertiser service.

I hope this will clarify the situation.

If you have any questions or problems in the future, please don't hesitate to call me.

Cordially,

H. Duncan McMillan

H. Duncan McMillan
Director, Special Projects

HDM:jg

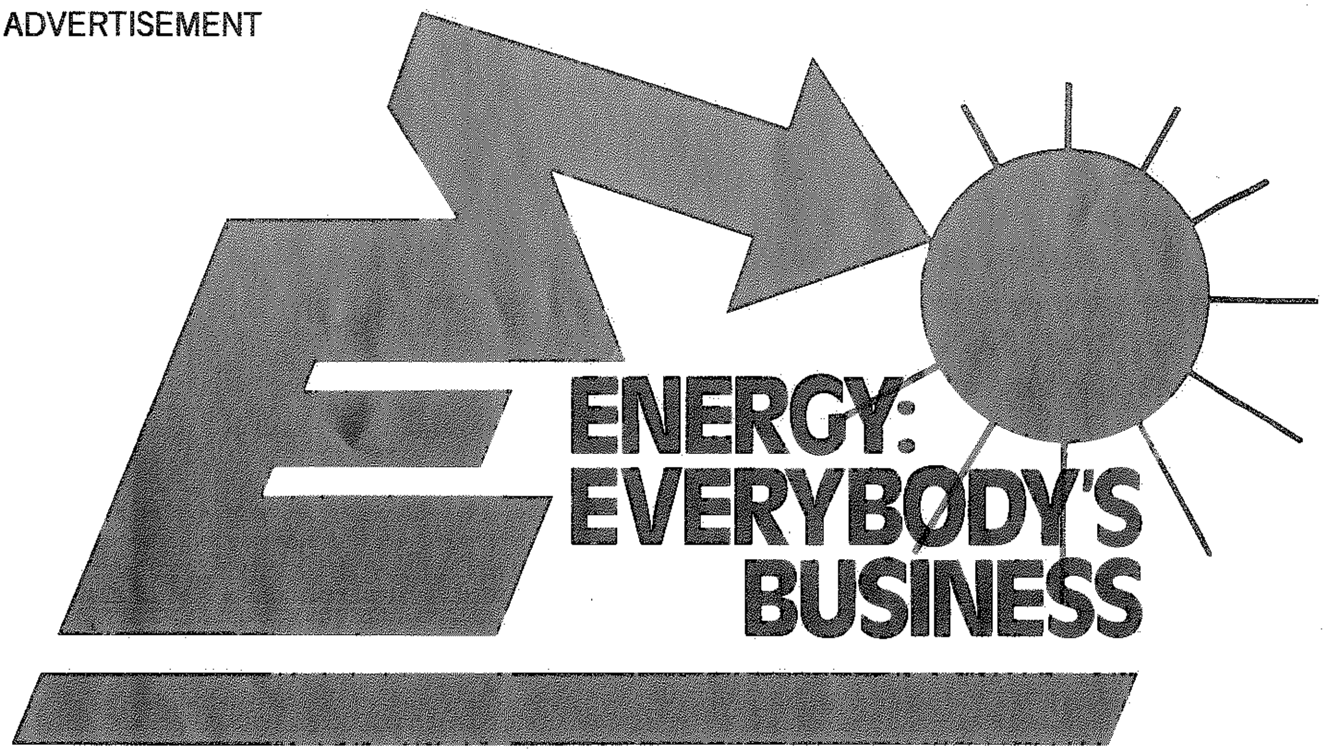
P.S. I should add that we at FORBES are extremely pleased with your contribution and feel that you were instrumental in the success of our Energy section.

SEPTEMBER 3, 1979

ONE DOLLAR FIFTY CENTS

Forbes

FALLON OF EASTMAN KODAK THE FUTURE COMES INTO FOCUS



LESS OIL AT HIGHER COST • RESERVES: HOW MANY BARRELS • SUNPOWER AND NUCLEAR POWER • COAL, SHALE OIL AND SYNFUELS • UNLOCKING THE HIDDEN RESOURCES • COGENERATION • ENERGY-EFFICIENT TECHNOLOGIES • LONG-TERM ENERGY PRODUCTIVITY • STEAM-RAISING

Elias P. Gyftopoulos
Massachusetts Institute of Technology
Dr. Gyftopoulos is Ford Professor of Engineering at MIT and former Chairman of the Faculty.

The number of nominees for energy scapegoat is plentiful. OPEC and its monopolistic actions; the oil companies and their oligopolistic power; the Administration and its ineffective leadership; the industrial establishment and its bigness; the Ayatollah Khomeini and his religious fervor; and Americans and their wasteful habits are all high on the list of proposed culprits.

No doubt these and others may either be contributing, or failing to respond effectively, to the spiraling price of energy. But the real causes of high energy prices are more fundamental and require much more than corrective or punitive action for their cure. Briefly, the true culprits are the exhaustion of our finite store of fuels at an alarming rate, especially in their liquid and gaseous forms, the very high cost of possible replacements, and the long lead-times required both to bring to the market large quantities of new energy at a price we can afford and to improve our consumption habits without destroying our economic and social well-being. The cure is investment in energy supply and demand. And as all investments, this one also needs deferment of today's benefits for a better tomorrow.

LESS OIL AT HIGHER COST

Since the end of the second World War, energy consumption has been increasing faster and faster, especially that of oil and gas. In 1977, it was at a rate equivalent to about 125 million barrels of oil* per day, about two thirds in the form of oil and natural gas, and one third coal, hydropower, and nuclear fuels.

With about 5% of the world population and 30% of the world products and services, the United States consumes about 30% of the world energy production. This consumption consists of about one-half oil, one quarter natural gas, and the remainder coal plus small contributions from hydropower and nuclear reactors. About one quarter is satisfied by imports, primarily in the form of crude oil and refined petroleum products. Oil imports have been steadily increasing over the past 30 years with the attendant consequences on foreign payments and reliability of supplies.

The rapid growth in liquid and gaseous fuel consumption in the past few decades in understandable. Such fuels were being discovered at rates higher than production, and at a relatively low cost. Reserves were doubling every 5 years whereas extraction was doubling every 10 years. The cost of extraction of a barrel of oil was only a fraction of a dollar. Exploitation methods and conversion processes were continuously improving. The economies of industrialized nations were booming, especially since they were fueled by readily accessible and cheap energy. The cost and price of energy were falling. For example, from 1950 to 1970 the real cost of energy used in U.S. manufacturing diminished by 1.7% per annum.

Around 1970, however, the eu-

* One barrel of oil is equivalent to 6000 cubic feet of natural gas, one-quarter of a ton of bituminous coal, and the energy required to generate 600 kilowatt-hours of electricity.

ENERGY
OUR HIDDEN RESOURCES
They abound in nature and science, but to exploit them we must defer immediate benefits for long-term investment.

ENERGY: EVERYBODY'S BUSINESS

phoria about abundant and cheap oil and gas took a dramatic downturn. In the United States, discoveries of new reserves were not coming on stream as fast as the growing production required. In the 1950's, 1¼ barrels of oil were being discovered for each barrel extracted, but by the mid 1970's this had dropped to about ½ barrel. Capital investments in new finds were much higher than those expended in the past. The investment in the North Sea was of the order of $10,000 per daily barrel of capacity compared with the investment in the Middle East of only a few hundred dollars for the same capacity. Projected costs of alternatives to oil, such as shale oil and gaseous and liquid fuels from coal, were three to four times higher than those of North Sea. No major energy supply could be brought to the market fast enough to effectively compete with oil. For the first time in our history, the replacement cost of all energy sources jumped above the average price paid by consumers.

Awareness that oil is a finite resource and the accompanying concern over its future availability have become topics of public interest. Usually, however, the interest is heightened only when the lines are long at the gas pump. And even then, the interest is misdirected.

RESERVES: HOW MANY BARRELS

The task of defining crude oil reserves, though subject to considerable uncertainty, has been undertaken by a wide spectrum of industry, academic and government specialists throughout the world. These investigations suggest that the ultimate world recoverable oil is about 2,000 billion barrels. To date, the cumulative production is about one fifth of the resource base. With a modest rate of growth in demand, the remaining oil would be exhausted sometime during the first half of the next century.

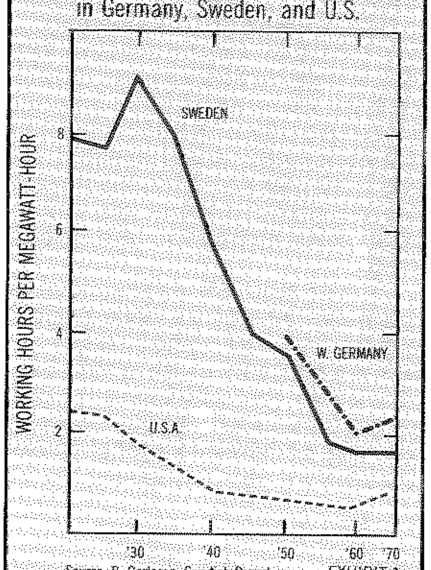
Recently, a dissenting view has emerged suggesting that recoverable oil resources may substantially exceed the 2,000 billion barrels consensus figure. B.F. Grossling of the U.S. Geological Survey estimates the recoverable world oil to be between 2600 and 6500 billion barrels. He argues that Latin America and Africa have not been drilled as densely as the U.S. and perhaps they could be as productive. If correct, Grossling's projection would extend the oil era. But with expanding demand, the extension would be at most only a few decades.

ARTIFICIAL LIMITS

For a few years, the tempering influence of Saudi Arabia and the commissioning of the Alaskan and North Sea supplies have kept oil prices under control. Recently, however, another factor is feeding the expanding price spiral. Over a short period of time, petroleum exporting countries, especially in the Middle East, accumulated immense petrowealth. They attempted to use this wealth for rapid modernization. But experience showed that a rapid rate of change is both socially disruptive and economically wasteful. In response to this experience, OPEC members have been setting in motion programs to limit production rates and adjust them to levels at which oil incomes can be productively invested.

With modest rates of economic growth, oil demand in the late 80's is estimated to be about 80 million barrels per day, compared to 60 in 1976. Of these 80, OPEC is expected to cover between 40 and 50 million barrels per day compared to the present 35. As stated at the International Energy Agency meeting in Paris in May, however, it is now very doubtful that OPEC will exceed its present rate of production. Events since then bear this out. As one member of OPEC agrees to increase production for political or economic reasons, another threatens to cut back on precisely the same grounds. These offsetting forces within the cartel point to the likelihood that foreign supply will stay sufficiently below demand to perpetuate the price spiral from that quarter.

WORKING HOURS PER UNIT OF ENERGY in Germany, Sweden, and U.S.



Source: B. Carlsson, Swedish Report EXHIBIT 1

Even a relatively small reduction in the rate of production can have a large effect on oil prices. The Iranian experience is a case in point. Prior to the revolution, Iran produced about 6 million barrels of oil per day. It interrupted production for a few months and then restarted at the rate of about 4 million barrels per day. The old rate cannot be reached without additional investments. The relatively small Iranian perturbation has had a large impact on the oil market. At the end of 1978 OPEC oil was priced at $14.50 a barrel delivered to U.S. refineries. Now it is priced over $20 a barrel.

RISING COST-PER-KILOWATT

Add to this that the cost of electricity has also been rising very fast because of safety, environmental and regulatory requirements.

In 1968 the average cost of two 1200 megawatt nuclear plants for 1976-78 operation was estimated to be $230 per kilowatt including $70 per

"This may be the only computer center where one of the job hazards is seasickness."

The Hollis Hedberg, Gulf's own floating computer center

"This computer center happens to be on the *Hollis Hedberg*," says Gulf Research Geophysicist John McDonald. "It's the only research vessel in the industry that has complete data processing right on board. And that makes all the difference.

"The typical oil exploration ship is equipped only to record raw data from whatever equipment it has on board to detect oil deposits under the ocean floor. Usually they

"On-board computers help you learn a lot more, a lot faster."

have seismic sounding gear, occasionally magnetometers and gravity meters. The raw data gets sent to an onshore computer center for analysis, and by the time analysis is complete, the ship could be a thousand miles away.

"By contrast, the *Hedberg* has a full complement of recording equipment, including hydrocarbon 'sniffers,' and with computers right on board, we can make a preliminary analysis immediately. If it looks good, we go back for a second look at that location.

"It could take five or six years between the time you find an oil deposit and the time you actually start drilling for oil, so any time we save in exploration puts the country that much closer to a new supply of petroleum.

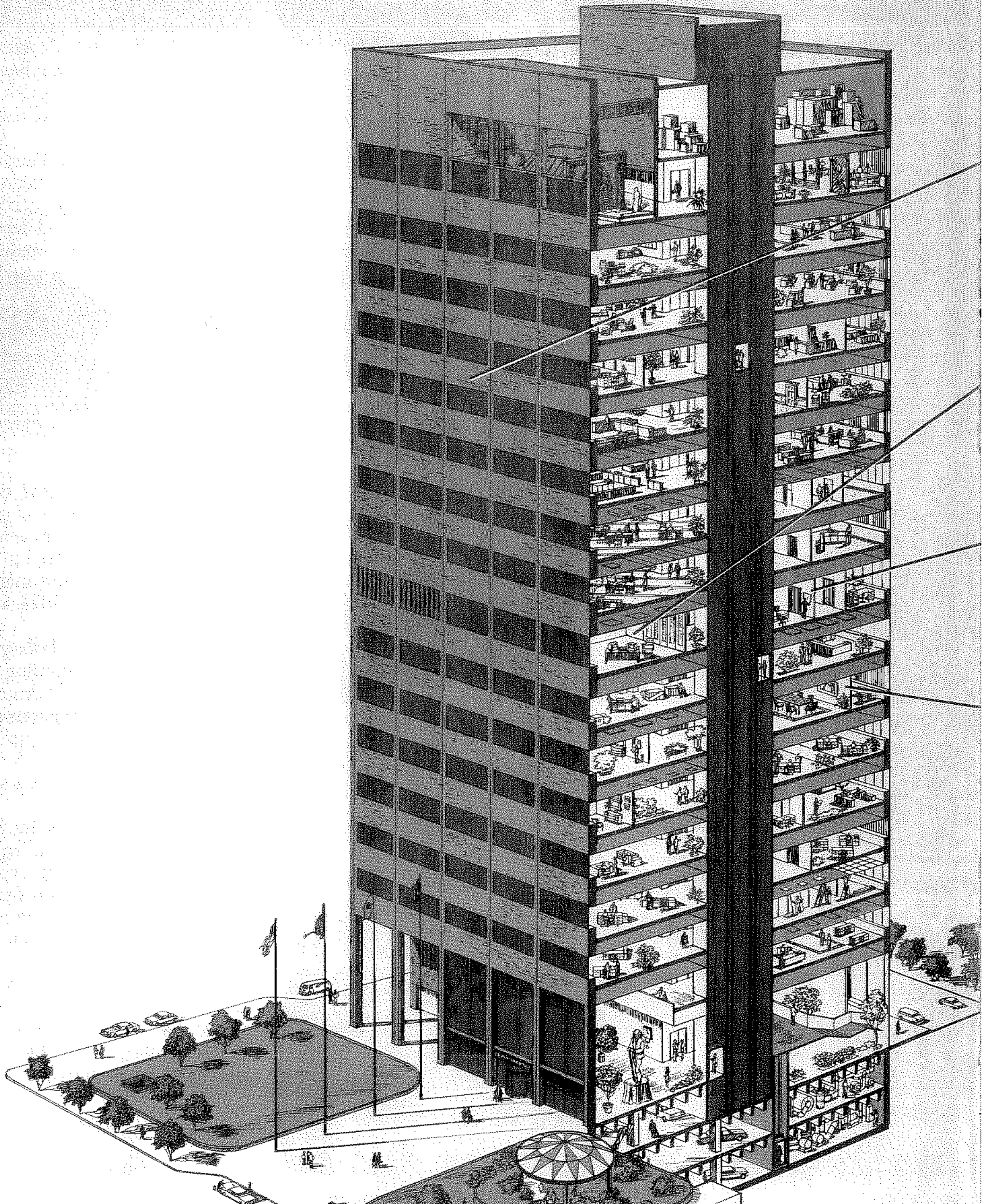
"It's a real challenge, trying to find that invisible spot under the seabed that's likely to produce oil. But the *Hedberg* is one of the best ways there is of finding it."

Gulf

Gulf people: meeting the challenge.

Gulf Oil Corporation

How Johnson Controls gives Jim Markin



total control of Benj. Franklin Plaza.

Tell us about your building, Mr. Markin.

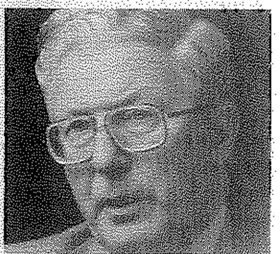
We have a commercial building, four years old. It has 20 stories above ground and three below. All told, 391,000 square feet. Rental space is divided among 50 tenants. The main tenant— that's us, Benj. Franklin Federal Savings & Loan—moved in during November, 1975. Our executive offices are in the building. It's a lot to keep on top of. But as owners and operators we must have total control over every square foot.

And do you have total control?

We built a Johnson Controls JC/80 computer right into this building. It was the first totally automated building in the Northwest. Heating, ventilating, air conditioning are all controlled by the computer. Our lighting, our security, including a card access system for the elevators after hours, is controlled by the JC/80. And not only is the building protected by sprinklers, but our JC/80 can locate a fire, call the fire department, and give evacuation instructions, too. I'd call that total control.

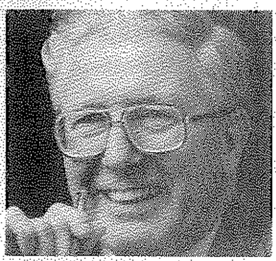
How much does the JC/80 save you?

We've always had the JC/80, so I have no previous figures to compare to. But I can tell you this. Rental rates are based largely on operating costs, and last year our rates went up less than 4%. That's a lot less than the rise in utility charges. And all systems are carefully monitored, 24 hours a day, by the computer, our building engineer, or his assistant. He doesn't even have to be at the console. The computer asks for him if there's a problem. This *has* to be a major savings in manhours. And we have new programs, new savings in the works.



New programs, new savings?

Take our meeting rooms. Things are happening there maybe three nights a week. Or maybe a tenant wants to work late. Used to be we had to heat or cool the whole building to use a floor after hours. But now we've programmed the JC/80 to deliver air to each floor individually. And added a start-stop program to save steam. And a demand-limiting program to cut electric bills. It's too soon to give you hard savings, but we estimate $950 to $1000 a month. I'll have to revise these savings upward, because I've heard our electric rates are going up 21.2%. Anticipated payback for these capital modifications is less than two years.



James Markin
Building Manager
Benj. Franklin Plaza
Portland, Oregon

Do you have a service agreement with Johnson Controls?

We do. Johnson Controls is capable of handling all or any part of control maintenance, but we do a lot ourselves, because the computer frees up our building engineer. Johnson Controls is responsible for maintaining the vital legs of the computer system. They have the experience, the people, and the tools to do this job best. So we just leave it to them.

JOHNSON CONTROLS

The total control company

Johnson Controls has the experience, the people, and the tools to design and install a total building automation system for your building. For information on how to get total control through automation, fill in this form and mail to:

Mr. Ron Caffrey, Vice President, Marketing, Ref. G-139
Johnson Controls, Inc., Box 423, Milwaukee, Wisc. 53201

NAME____________________

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CITY__________ STATE______ ZIP______

kilowatt for escalation to the operating dates. The estimated cost of three 800 megawatt coal-fired units for 1976-78 operation was $180 per kilowatt including $60 per kilowatt for escalation. The corresponding costs of electricity were 0.8 and 1.1 cents per kilowatt-hour for the nuclear and coal-fired plants respectively.

In 1978, the average cost of two nuclear units going in service in 1988-90 was estimated to be $1,650 per kilowatt including $740 for escalation. The three-unit coal plant for 1988-90 service was estimated to cost $1,270 per kilowatt including $630 for escalation. The corresponding estimates of the electricity costs were 6.4 and 6.5 cents per kilowatt-hour for the nuclear and coal fired units respectively.

The increases in plant costs between the two estimating dates are due primarily to statutory and regulatory requirements (about 78%) and to a lesser degree to inflation (about 22%).

Save for a miracle, it does not seem likely that we will ever return to an era of low-cost energy. From now on, we will be paying an ever increasing fraction of our income for our energy needs and, therefore, at a fixed rate of productivity, our standard of living will be going down. Can we arrest this fraction at some new plateau without turning the clock back to the "good old days" that in actuality were terrible for most people? No one can give a sure and simple answer to this question because no such answer has been found. One thing is certain, however. No amount of rhetoric can talk the problem out of existence. Instead, long term but nonetheless profitable commitments must be made to increase both energy supplies and energy productivity. The path is long and painful but less so than any other solution.

INDUSTRIAL ENERGY USE
In Relation To Value of Shipments For the U.S. — W. Germany '72

Industrial Sector	10^3 Btu/$ of Shipments U.S.	10^3 Btu/$ of Shipments W. Germany	W. Germany as % of U.S.
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: Federal Energy Administration, Energy Conservation Paper No. 33

EXHIBIT 2

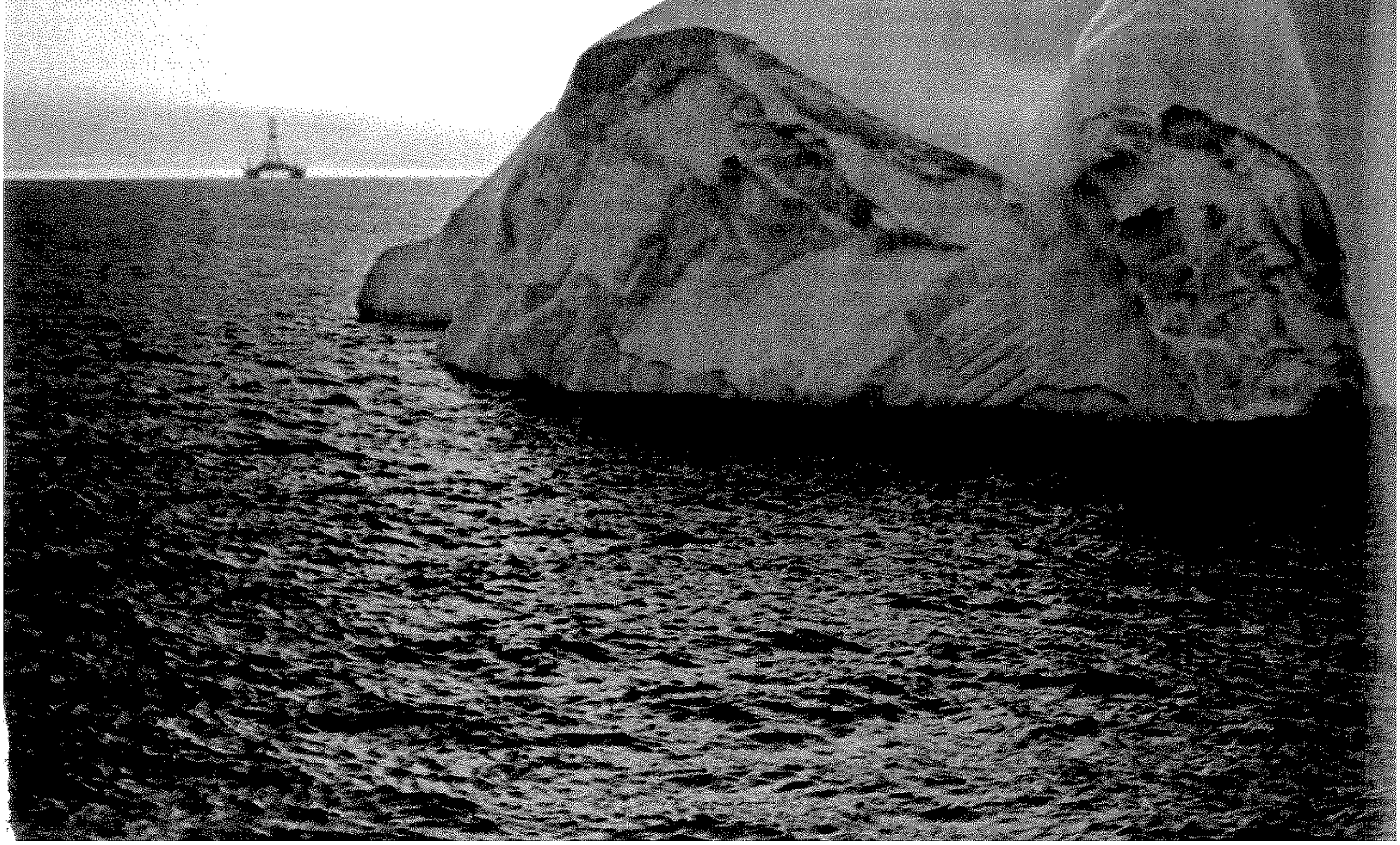
SUNPOWER AND NUCLEAR POWER

For the long term, extending well into the next century, at least one entirely new major energy source must be developed. By then all forms of energy currently in use will be inadequate. Only three possibilities exist: the sun, nuclear fusion, and nuclear fission with breeding. Each of these possibilities has its own set of scientific, technical, economic, safety and political problems and uncertainties. As a result, none is a sure bet at the present time. All three must be researched and developed concurrently with the anticipation that, 40 to 50 years from now, at least one will become the winner.

The sun is a universally available and inexhaustible source of energy. Whether in the form of insolation, wind power, or temperature difference in oceans, this energy is free for capture and use almost every day, almost everywhere. The technology for the capture and conversion of solar energy is generally known. But the cost of most of this technology is presently prohibitive. The research and development effort in the United States (about $1 billion per year) and abroad is directed primarily to reducing costs. Among the methods under investigation are improving the operating characteristics of devices and equipment, developing mass production techniques, and adapting the quality of the energy required by end-uses to the quality of insolation so as to avoid the need for expensive conversion equipment. Solar energy experts are optimistic but not certain that the required cost reductions will be achieved.

Nuclear fusion can become an immense source of energy. It is based on fusing together nuclei of light elements such as deuterium (heavy hydrogen) at very high temperature, about 100 million degrees. It is the same process as that which generates the energy of the sun. Deuterium is contained in the oceans and can be extracted at reasonable cost. Controlled fusion experiments have been carried out in laboratories in the United States, the Soviet Union and other countries during the past three decades. Intensive research continues. Presently the United States spends about $0.5 billion per year. Excellent progress has been made in understanding the scientific aspects of the process. A few years from now, this understanding may be sufficient to allow systematic work on the development of the technology of large-scale fusion reactors. Many difficult technical and economic problems must then be resolved. If all goes well, fusion reactors will become an important energy source sometime after the first quarter of the next century. No one can say for sure that all will go well.

Nuclear fission can become a source of energy for several thousand years. In its present state of development, nuclear power uses as fuel a material called Uranium-235. This materi-



al is only a small part, about 0.7%, of natural uranium. The remainder is another isotope called Uranium-238. Unless methods are developed for using the abundant Uranium-238, the cost of nuclear power will become unattractive some decades from now. Uranium-238 (and thorium) can be transformed into a fissionable fuel in a so-called breeder nuclear reactor. The technology of breeder reactors is fairly advanced but not completely developed. More work is required before breeders can be commercialized. Nuclear power faces serious opposition, especially in the United States. The opposition is based on concerns about proliferation of nuclear weapons, the safe disposal of long-lived radioactive wastes and the consequences of major accidents at nuclear power plants. Though it had no effect on human lives, the Three Mile Island incident has heightened these concerns. Proponents argue that at least in its present form, nuclear power is the cheapest and environmentally most benign practical source of electricity known to date. They base this assessment on the record of the nuclear industry over the past two decades. They are optimistic but not certain that the same will be true for breeder reactors. At the present time, the development of breeders in the United States has been postponed indefinitely.

COAL, SHALE OIL AND SYNFUELS

During the transition to a new major energy source, principal supplies that can substitute for oil are coal (directly or in the form of synthetic fuels), gas, nuclear energy from present generation reactors (light water reactors), oil from shale and tar sands, solar energy for low temperature end-uses, and a number of other resources (i.e., geothermal energy). Each of these alternatives has its own combination of technical, economic, environmental and institutional issues—to name the most prominent—that can and must be resolved. The list of issues and controversies is too long to analyze here. Three points, however, need stressing.

(1) Prices of all forms of energy should be allowed to find their competitive levels in the market. It is counterproductive to artificially price at historical cost a commodity as valuable as energy. For this discourages the adoption of more expensive alternatives such as solar energy, as well as energy-saving investments such as better insulated buildings. Undoubtedly, deregulation of the energy sector would result in inequities. It is preferable, however, to address inequities on their own merits and demerits rather than to use them as an excuse for not adopting an effective energy-pricing policy.

(2) During the transition to a new energy supply, none of the alternatives can by itself make a sufficiently large contribution so as to overshadow all the others. All are essential. Foregoing the use of one or more of them makes the response to the energy problem that much harder.

(3) The resolution of the issues and controversies surrounding energy should be balanced. For instance, it does not make sense to be exclusively concerned with one issue, such as nuclear reactor risks, and yet be indifferent about many related issues, such as the environmental and social consequences of burning and exhausting hydrocarbons and coal.

UNLOCKING THE HIDDEN RESOURCES

The deployment of additional energy supplies is only one-half of the response to the need to limit the spiraling price of energy to a reasonable new plateau. The other half is hidden in the demand side of the energy equation. Its importance and magnitude are not as widely recognized as they deserve.

For each task in the economy, resources should be allocated so as to maximize the benefits. For example, energy and other inputs should be used in such proportions as to achieve the same products and services at the lowest cost.

During the past decade of rampant inflation, all prices have been rising. But energy prices have been rising much faster than those of labor, capital goods, and materials. Further the trend of energy prices rising faster than those of everything else most likely will continue for a long time to come. Hence the question: "Is it possible to reoptimize energy end-uses so as to satisfy the same societal needs at equal or lower overall cost while consuming less energy?" Asked differently: "Is it possible to achieve cost-effective energy conservation or increased energy productivity?" If the answer is positive, we will be able both to reduce the impact of high energy costs and control future energy-price rises. For low-cost energy produced by increased productivity will be competing against high cost energy from new supplies and against arbitrary price increases by oil producers.

Some analysts see no hope in reducing energy demand. They argue that energy savings can come primarily from belt-tightening measures. But lowering thermostats, reducing speed limits, rationing fuels, and consuming less manufactured goods provide only temporary

ENERGY SAVINGS BY COGENERATION
Electricity/Process Steam

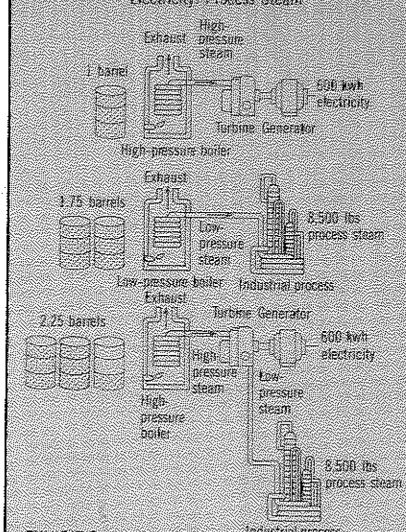
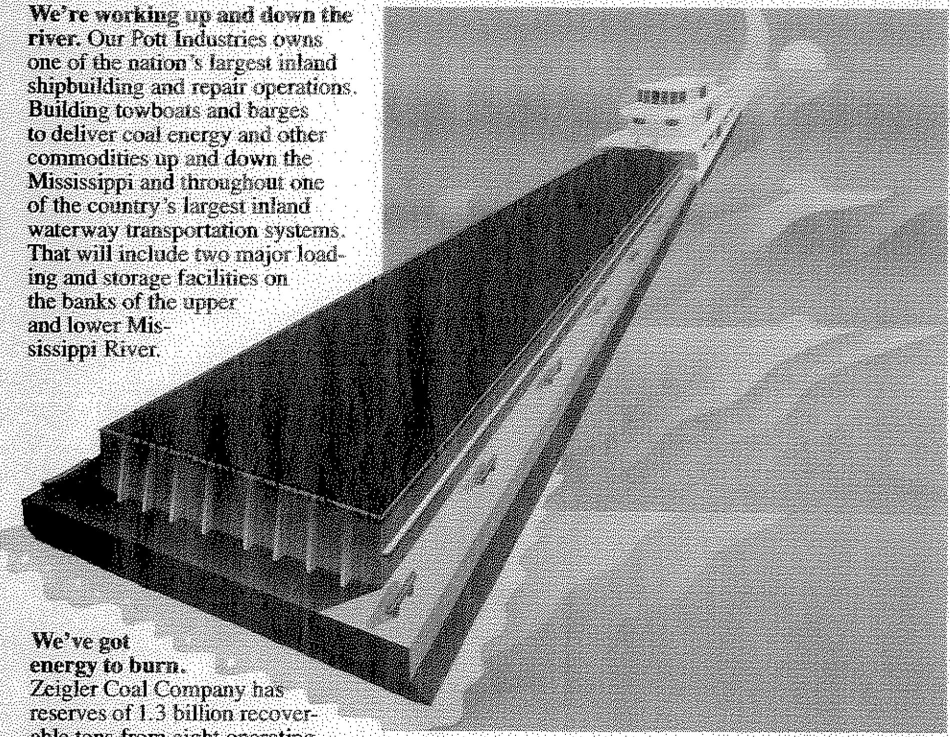


EXHIBIT 3

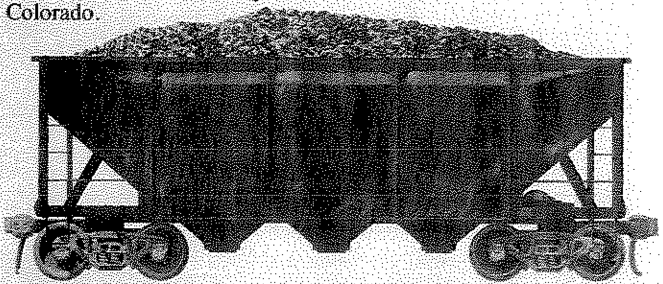
We're selling energy down the river.

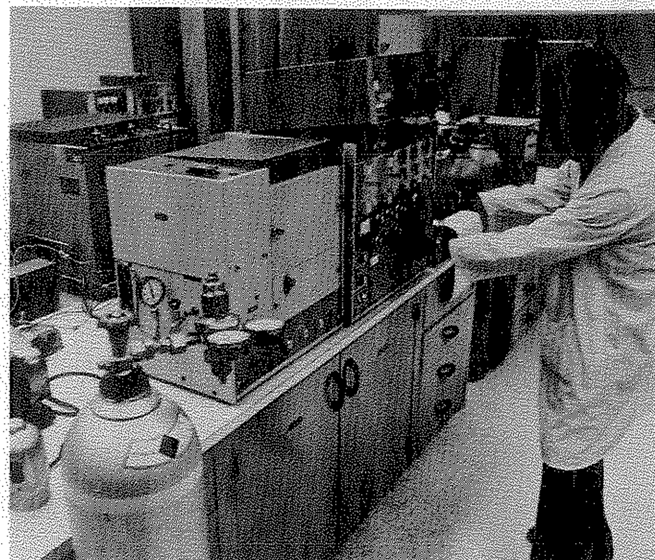
We're working up and down the river. Our Pott Industries owns one of the nation's largest inland shipbuilding and repair operations. Building towboats and barges to deliver coal energy and other commodities up and down the Mississippi and throughout one of the country's largest inland waterway transportation systems. That will include two major loading and storage facilities on the banks of the upper and lower Mississippi River.



We're going places. To meet the increased level of worldwide offshore drilling efforts, our offshore marine services division delivers marine transportation and services on a worldwide basis.

We've got energy to burn. Zeigler Coal Company has reserves of 1.3 billion recoverable tons from eight operating mines in Illinois, Kentucky and Colorado.





We're sending energy down the tubes. HNG's natural gas transmission subsidiaries operate pipelines to further ensure energy delivery to our customers. Even in extreme shortages caused by cold weather and declining supply, storage units like our Bammel Storage Reservoir ensure that we'll deliver.

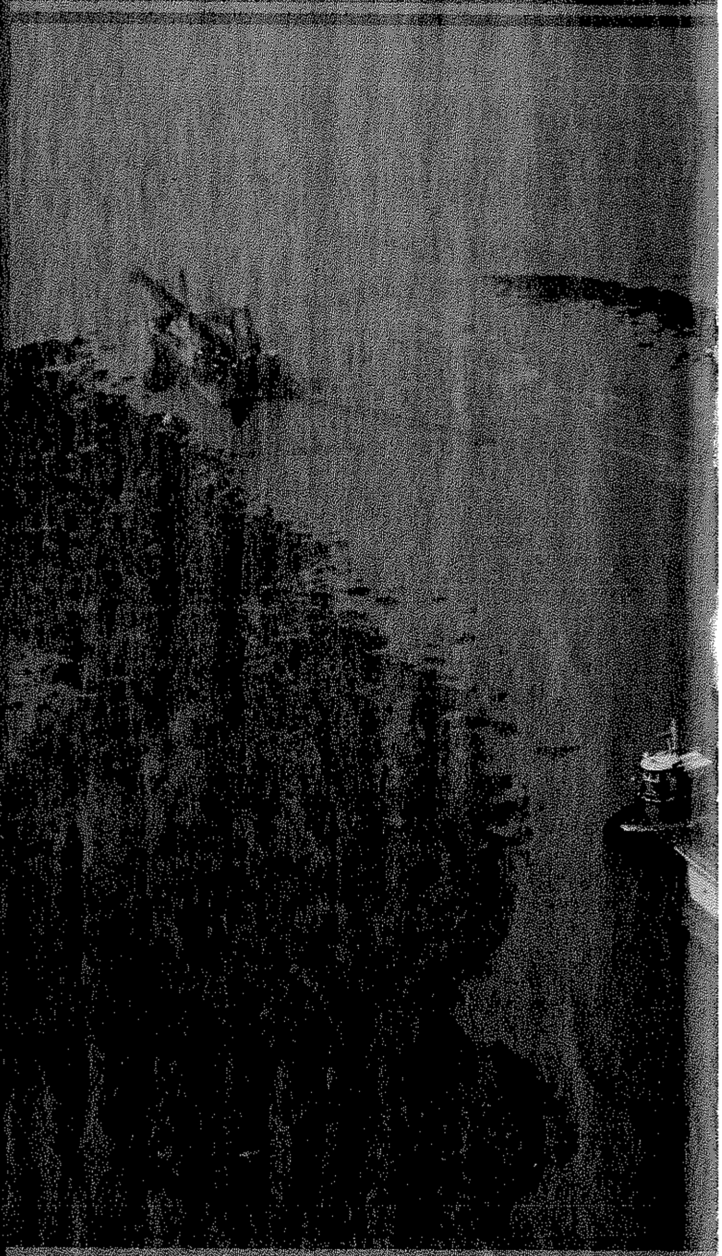
We're industrious as well as energetic. HNG provides industrial gases through Liquid Carbonic Corporation, manufacturing and distributing a comprehensive line of specialty gases for highly technical applications. This operation includes five specialty gas laboratories.

For more information on all we're doing, write our Chairman, Robert R. Herring, P.O. Box 1188, Houston, Texas 77001.

We're doing a lot of unexpected things.

HNG

New natural gas production is coming ashore.



Because Panhandle Eastern is moving ahead.

Panhandle's latest move connects our transmission systems to new gas production in the Gulf of Mexico, 40 miles off the coast of Louisiana, further strengthening flowing gas supply.

The new $60 million pipeline facilities constructed this spring tap an estimated 200 billion cubic feet of reserves–the largest single gas reserve connection in recent years.

That's good news for stockholders and for our utility customers who serve markets in Michigan, Ohio, Indiana, Illinois and Missouri. Pipeline deliveries were up 13 percent in the first half of 1979. This is another tangible benefit

Men and marine equipment complete the pipeline connection in Atchafalaya Bay, Louisiana, to bring new offshore natural gas production to millions of people.

First Half Financial Results

	1979	1978
Revenues	$951 million	$671 million
Net Income	$ 85 million	$ 61 million
Earnings Per Share	$4.64	$3.39

from Panhandle's $1.2 billion investment thus far in this decade to explore, develop and acquire new gas supplies–energy that our nation must have.

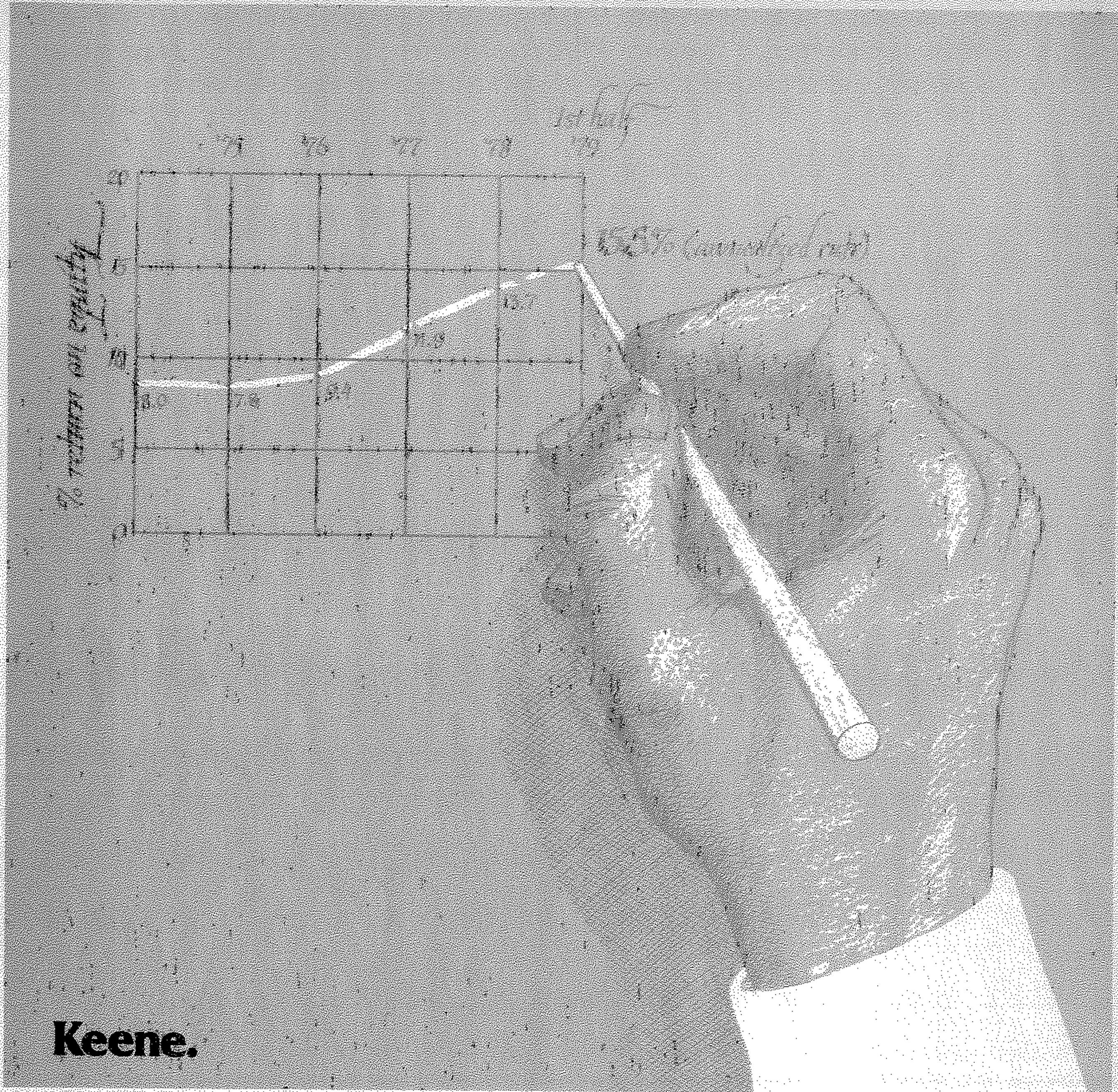
In fact, this year Panhandle's capital spending for energy will be the largest in our 50-year history–$500 million.

With capital investment this year equal to four times 1978 net income, Panhandle Eastern is making the positive moves now to enhance future gas supply and earnings.

Learn more about Panhandle Eastern's diversified energy activities in natural gas transmission, oil and gas exploration and production, contract drilling and coal mining by writing to Corporate Communications, P.O. Box 1642, Houston, Texas 77001.

50 1979

Panhandle Eastern PIPE LINE COMPANY



In just over 3 years, our return on Stockholders' Equity almost doubled.

Between 1975 and 1978, return on stockholders' equity rose from 7.8% to 13.7%. For the first half of 1979, it rose to 15.5%. In these inflationary times, that's a very comforting figure to find.

Helping customers save energy helps keep Keene's curves growing.

For example, some of our industrial and architectural lighting fixtures save as much as 30-40% on electricity. We also make insulation that enables electric motors to perform more efficiently, as well as filtration equipment that lengthens the life of expensive lubricating oils. We're even involved with solar energy. There are solar mirrors using our bearings, and other projects which utilize our expertise in silicone. For more details on what we do and how we do it, write for our annual and quarterly reports.

KEENE
CORPORATION
200 Park Avenue, New York, N.Y. 10017

ENERGY: EVERYBODY'S BUSINESS

relief to high energy bills. Moreover, if insisted upon, they lead eventually to reduced economic activity, unemployment, and low living standards. Thus, the belt-tightening rationale is correct in its conclusions but faulty in its premises. For true energy conservation is not a matter of foregoing the benefits of products and services of an expanding economy, but one of consuming energy according to its relative value.

In every sector, there exist large margins for reducing energy consumption without strangling the economy. More importantly, if we do not take advantage of these margins then, in fact, our economic well-being and national security will be endangered. Reoptimizing energy end-uses through cost-effective technology will, of course, require long-term commitments involving restructuring of all sectors of the economy. This restructuring cannot happen automatically because of institutional barriers and economic distortions of the free market system introduced by past decisions. But these barriers and distortions are not insurmountable. They are challenging opportunities for vigorous and productive work.

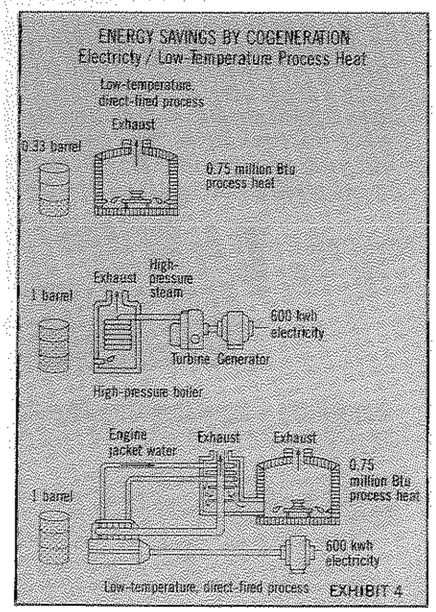


EXHIBIT 4

How much saved energy could be produced through known cost-effective technology? No one knows the answer for sure. Nevertheless, comparisons with other nations and results of many studies suggest an average of about 1/3 saved over a period of one decade.

Germany and Sweden, two highly industrialized nations, have always experienced energy prices markedly higher than the United States. Partly as a result, these two countries have been using energy more productively. For example, labor manhours per unit of energy have been higher than in the U.S. (Exhibit 1). Again, for specific industries energy use per dollar of shipments in West Germany is lower than in the U.S. (Exhibit 2). To be sure, more than energy price affects the pattern of energy consumption in a particular country. The comparisons, however, indicate that cost-effective technology for increased energy productivity exists, that it has been tried, and that it works.

ENERGY-EFFICIENT TECHNOLOGIES

Manufacturing accounts for about 40% of energy consumption in the U.S. In 1977, a study by Thermo-Electron Corporation estimated that approximately 25%—the equivalent of 4.5 million barrels of oil per day—of projected 1985 energy usage in U.S. manufacturing could be saved through conservation measures whose capital and total costs would be equal to or less than those needed to obtain comparable amounts of new energy supply.

One-fourth of the energy savings could be achieved by the generation of electricity in combination with the raising of process steam, with direct-fired, high temperature furnaces, or with direct-fired, low temperature applications.

Another one-fourth of the saving could be obtained through energy recycling and waste-heat recovery by economizers, regenerators, recuperators and waste-heat boilers, all well known techniques for capturing rejected energy and putting it to work.

One-tenth of the energy savings could be achieved through increased efficiency of electric motors, electrolytic processes, and lighting. The remainder, about 40%, would result from measures peculiar to each manufacturing process.

Because of wide differences in the efficiency of current practices, particular industries deviate substantially from the average 25% energy saving. In addition, industries will differ from each other in the mix of energy-saving opportunities with regard to fuel type, that is the fractions of savings that can be achieved in coal, oil, gas and electricity.

U.S. industry has been working at improving its energy productivity. Responding to the rapid escalation of energy prices, it has reduced dramatically the energy consumed per unit of output. Expressed in terms of energy per constant-value dollar, energy usage was cut from 59,000 British thermal units per dollar in 1973 to 46,000 British thermal units per dollar in 1978, a drop of 22%. Stated differently, from 1973 to 1978, real production of goods and services increased by 12%, but energy consumption decreased by 10%.

By conserving costly energy

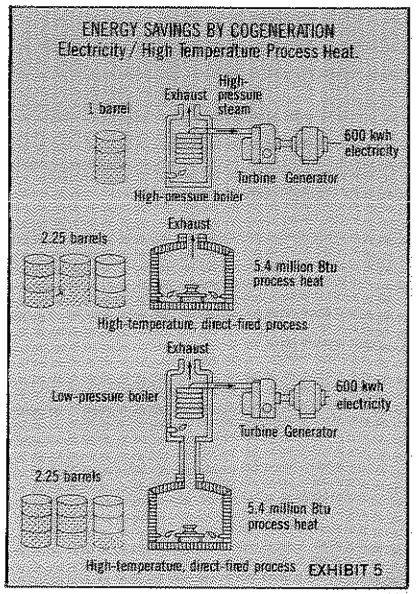


EXHIBIT 5

through increased efficiency, industry is making a major contribution to the U.S. economy. The savings in 1978 alone were $20 billion, or about $270 per household, which would have to be passed to the consumer if industry continued to operate at the 1973 efficiency.

Most of this energy saving has been achieved by costless good housekeeping, such as turning lights off in unused areas, closing windows in the winter, and not having air-conditioners and electric space heaters on simultaneously in the summer. The balance, however, has been achieved by investments in energy-efficiency with handsome payback, mostly in less than a year.

COGENERATION

Investments in energy productivity are not being implemented as fast as present circumstances warrant. The opportunity and factors that inhibit its implementation can be illustrated by considering the technology of cogeneration.

Cogeneration is the term used to describe the combined generation of electricity or motive power and process steam or heat. It can be practiced to supply the electricity and heat needs of either a community or a manufacturing plant, or both. Usually these two needs are satisfied from different units, each generating one of the two forms of energy.

Cogeneration has been used successfully in many countries. The Gulf States Utilities Company is a nonregulated business in Louisiana. It supplies cogenerated electricity and process steam to an Exxon refinery and to the Ethyl Corporation. The Dow Chemical Company produces 75% of its electricity needs by cogeneration. It also expects to purchase process heat from a nuclear power plant in Midland. Many German manufacturers cogenerate electricity in excess of their needs. They sell this excess to utilities. About 8% of the electricity distributed by German utilities is purchased from industrial cogenerators. Denmark cogenerates electricity and heat for use in district heating networks.

In manufacturing plants, electricity or motive power can be generated with low-pressure process steam, low-temperature process heat, or high-temperature process heat. That each type of cogeneration saves fuel can be easily seen in the production of process steam from the waste heat of the electricity plant, or the electricity as produced from the waste heat of a high temperature industrial heating process.

Cogeneration also saves capital because its incremental investment is less than the investment that would have been made in expensive new fuel supplies if energy were not conserved.

By the end of the next decade, cost-effective cogeneration in U.S. manufacturing could save the equivalent of up to a million barrels of oil per day, at a

America's first synthetic fuel plant

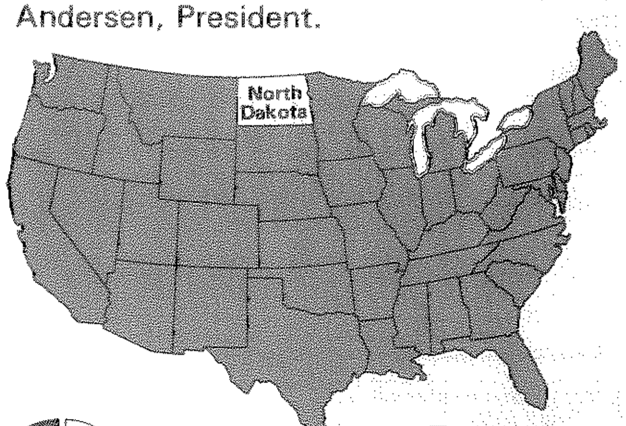
The search for energy independence led to the coal fields of North Dakota

Synthetic fuel is the only real limit to the cost of imported oil. Fortunately, America has vast coal reserves and the technology to develop gas, oil or even gasohol from coal.

The rare combination of easily reachable coal and water, and a willing work force made North Dakota the logical place to begin the search for self sufficiency through synthetic gas and oil. America's first commercial synthetic fuel plant is a short step away from groundbreaking ceremonies in Mercer County, North Dakota.

The Nokota Company, active in synfuels since 1971, is directly involved in more than one third of the lignite coal estimated to be economically recoverable in North Dakota, including the coal reserves dedicated to America's first commercial synthetic fuel plant.

Synthetic fuel is already a familiar phrase to most North Dakotans. If you'd like more information, contact Mr. Galen Andersen, President.



the nokota company

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capital cost of about $25 billion less than what would be incurred without cogeneration. The achievement of this cost-effective energy saving, however, is inhibited by several constraints; technical, economic, environmental, regulatory and institutional. The degree to which cogeneration will be implemented depends on policies that will be adopted to address some or all of these constraints.

STEAM-RAISING

The raising of process steam accounts for about 40 percent of industrial energy consumption. In many applications, process steam is used at relatively low pressure and temperature; typically 50 to 150 pounds per square inch and 300 to 350 F. The normal method of raising process steam in fuel-fired boilers is inefficient because the steam produced is at a relatively low temperature, although the heat from the combustion of the fuel is at a much higher temperature.

The use of cogeneration can improve the efficiency. Exhibit 3 illustrates how cogeneration is effected by a high-pressure boiler and a back-pressure steam turbogenerator. The combined process produces 8500 lbs. of low-pressure process steam and 600 kilowatt-hours of electricity by consuming the equivalent of 2.25 barrels of oil. If the same steam and electricity were generated in a low-pressure steam boiler and an electricity plant respectively, they would have consumed the equivalent of 2.75 barrels of oil. In the separate processes, the two tasks consume 0.5 barrels of oil more than in the combined process. Alternatively, the 600 kilowatt-hours of electricity is obtained for an incremental fuel consumption of only about 0.5 barrels, instead of the full barrel that is consumed by a modern central-station power plant.

Considerable latitude exists for varying the ratio of electricity to steam. Steam turbogenerators normally yield about 50 to 70 kilowatt-hours for each million British thermal units going to process steam. With diesel turbogenerators, electricity production rises to as much as 400 kilowatt-hours for each million British thermal units going to process steam. Incremental fuel consumption is about 2/3 of that of a central power station. With gas turbines and waste-heat boilers, electricity production is about 200 kilowatt-hours per million British thermal units going to process steam, and incremental fuel consumption is about 6/10 of that of a central power station.

For the next decade, the total potential for cogeneration of electricity and process steam is estimated to be about 1.2×10^{12} kilowatt-hours per year, or about 200,000 megawatts for 6000 hours per year. Because of technical and economic constraints, only up to one-third of this potential is feasible, corresponding to an addition to 50,000 megawatts (11,000 megawatts is already installed in various industries) and to a fuel saving equivalent to about 0.7 million barrels of oil per day.

Energy Savings & Capital Costs of Cogeneration In U.S. Manufacturing Compared With Investments In Equivalent New Energy Supplies To Satisfy The Same Energy Needs as With Cogeneration

Energy savings technology	Energy savings Capital cost (in millions of barrels of oil per day) Fuel	Electricity	Conservation (in billions of dollars)	Energy supply (in billions of dollars)
Cogeneration of electricity with:				
Process Steam	0.68	0.54	54	70
Low-temperature processes	0.18	0.18	18.5	24
High-temperature processes	0.16	0.054	3.5	7
Total	1.02	0.78	$76.00	$101.00

Source: Thermo Electron Corporation, Waltham, Mass.

EXHIBIT 6

LOW-TEMPERATURE PROCESSES

Low temperature heating processes, such a baking, drying, and curing, incur large inefficiencies because high-quality fuel is used to accomplish a task that requires only a low-grade energy supply. When the temperature requirement is very low, say 200 to 300 F, diesel or steam-turbine engines can be used to cogenerate electricity, as in steam raising. Exhibit 4 illustrates the use of the so-called topping engine in the combined process, and the fuel saving in comparison to the separate processes.

By the end of the next decade, the theoretical potential for electricity produced by using diesel engines in low-temperature processes is about 250,000 megawatts. Since many low-temperature processes are relatively small in scale and subject to intermittent operation, only about 17,000 megawatts for 7000 hours per year of this cogeneration will be achieved, mostly with diesel engines and to a lesser extent with gas turbines.

HIGH-TEMPERATURE PROCESSES

Many of the heating processes required for the manufacture of metals, ceramics, glass, and cement are carried out in furnaces at high temperatures, sometimes in excess of 2000 F. Large inefficiencies occur because high quality energy is lost in the exhaust gases and materials leaving the furnace. One method of reducing inefficiency is effected by cogeneration of electricity from the exhaust gases. Exhibit 5 illus-

Amcord Reports

AMCORD'S COAL POWER

Energy is the name of the game in the cement industry, where giant kilns consume enormous amounts of fuel to make cement.

Frankly, heavy dependency on energy could be bad news to some. But not to us at Amcord. No long gas lines for us.

A few years ago, before the 1973 energy crunch, we made a hard-and-fast, lonely decision to become self-sufficient for our fuel needs by 1980. And to avoid outright dependency upon oil or natural gas to fire our cement kilns.

So we became the first in our industry to make an all-out commitment to coal. Which, incidentally, burns "clean" in the cement manufacturing process.

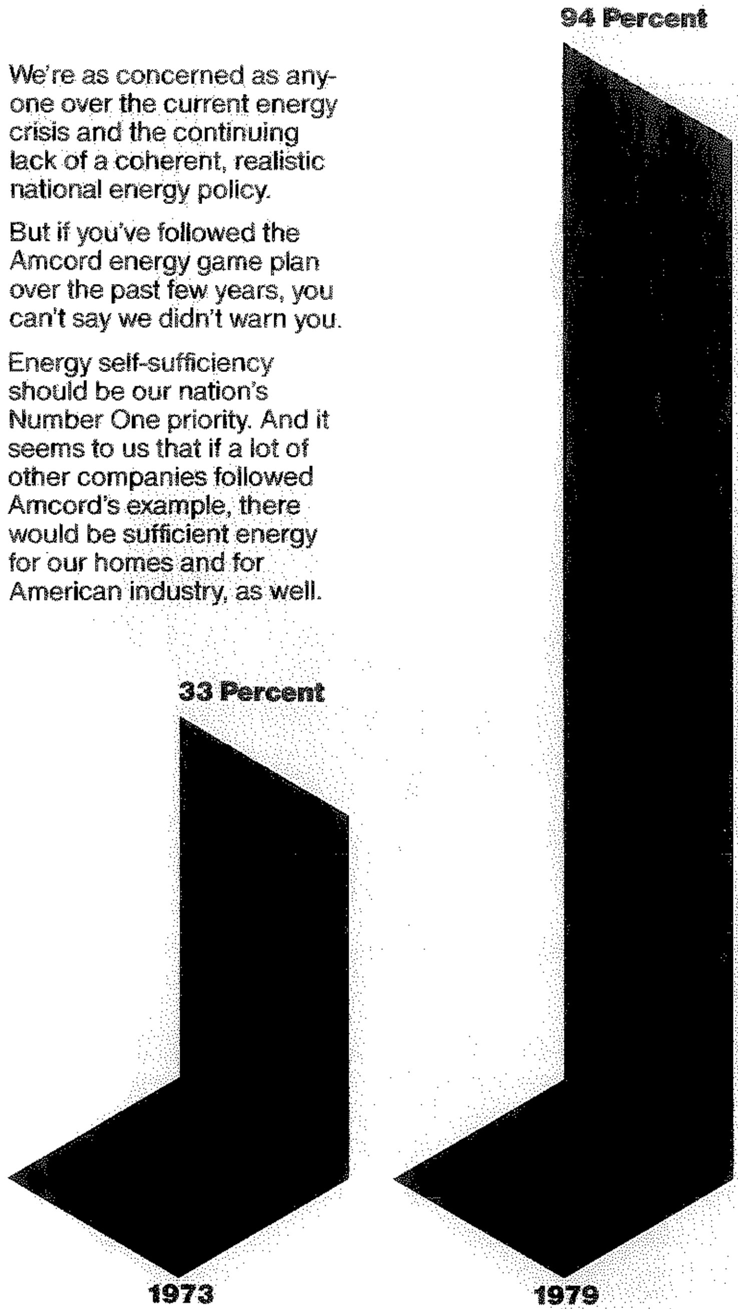
We acquired substantial coal properties in New Mexico and Pennsylvania, up-graded and expanded them, and are now supplying the majority of the total fuel requirements of our five modern cement plants in California, Arizona, Michigan and Pennsylvania.

With our own coal.

We're as concerned as anyone over the current energy crisis and the continuing lack of a coherent, realistic national energy policy.

But if you've followed the Amcord energy game plan over the past few years, you can't say we didn't warn you.

Energy self-sufficiency should be our nation's Number One priority. And it seems to us that if a lot of other companies followed Amcord's example, there would be sufficient energy for our homes and for American industry, as well.



Coal as source of fuel for Amcord Cement Plants

One of America's Leading Cement Producers

Amcord, Inc.,
Newport Beach, California
92660
Listed NYSE, PSE:
Symbol AAC

AMCORD

trates the use of so-called bottoming engines in the combined process, and the fuel saving in comparison to the separate processes. Perhaps, about 5,000 megawatts for 7,000 hours per year will be cogenerated in such applications.

Estimates of the energy and capital savings that could be effected by cogeneration in U.S. manufacturing over the next ten years are listed in Exhibit 6.

The capital investment estimates are based on the following assumption: (a) new fossil fuel supply from source to consumer: coal, $4,500 per barrel of oil equivalent per day, and oil, $16,000 per barrel per day; (b) new power plants (40% coal and 60% nuclear) including fuel supply and distribution: $1,400 per kilowatt; (c) units for cogeneration with process steam: $850 per kilowatt plus cost of fuel supply; (d) units for cogeneration with low-temperature processes (mostly diesels): $700 per kilowatt plus cost of fuel supply; and (e) units for cogeneration with high-temperature processes: $700 per kilowatt but no cost for fuel supply.

SOME CONSTRAINTS

- Cogeneration may not be technically feasible for some manufacturers because the amounts of electricity and process heat needed are not in the right proportion, or because the two forms of energy are not required at the same periods of time.
- Cogeneration may not be economically attractive to some manufacturers because the price of electricity sold by the local utility is relatively low (due to historical pricing policies and subsidies of the electrical sector) whereas the price of fuels in the location is closer to replacement cost.
- Cogeneration may not be environmentally possible for some manufacturers because of regulations which classify certain air pollution districts as nondegradation or nonattainment areas.

Unquestionably, these constraints and uncertainties represent the reality of the marketplace and adversely influence decisions about investments in energy productivity. There are, however, some mitigating factors that should also be taken into account.

- Granted, the average price of energy is well below the still rising replacement cost of energy supplies. This condition, however, is likely to be only transitory. Recognition of this likelihood may reduce the cost of transition for some companies.
- The rate of return on investment required by energy-using industries is higher than that granted to regulated utilities for comparable-risk new power plants. Some companies may use this difference to attract new special-purpose capital from investors.
- Most companies set the expect-

ENERGY: EVERYBODY'S BUSINESS

ed rate of return from energy-saving investments at a level about twice as high as that for mainstream business investments. As a result, capital spending is concentrated on the latter while higher energy costs are passed on to consumers. Revision of that priority may represent a chance to increase market share for some companies.

• Federal, state and local regulations restrict the generation of electricity by many manufacturers. But these regulations are in the process of being revised, and appropriate presentations to authorities could result in advantages for some manufacturers.

LONG-TERM ENERGY PRODUCTIVITY

The estimated increases of energy productivity are only a fraction of the existing potential. Assessment of this potential requires a reliable and practical yardstick that can be used for all fuels and all processes.

The laws of physics and thermodynamics give an absolute measure of efficiency of any process that transforms a material from one form to another. This measure accounts not only for the amount of energy required and consumed in the process but also for the qualities of those energies*. Quality is an important characteristic because an amount of energy at a high temperature is more useful and more valuable than an equal amount at a low temperature. Its value can be calculated by physicists and engineers. For example, the quality of natural gas is 1.0 but that of hot gases at 1000 F is about 0.4. Again, the quality of energy required to heat metal parts to 1500 F is about 0.5, but that for raising steam for central heating is only 0.2.

Based on this scientific measure, the average energy end-use efficiency in the United States, as well as other industrialized societies, is about 10%. Some typical efficiencies of specific end-uses are listed in Exhibit 7.

It is clear that the potential margin for improvement is enormous. Of course, energy end-use efficiency will never approach 100% for real processes and devices, even in the remote future. But the present low values of efficien-

*One way to describe the measure is to use a formula in which efficiency equals the ratio:

$$\frac{\text{(quality of required energy)} \times \text{(required energy)}}{\text{(quality of consumed energy)} \times \text{(consumed energy)}}$$

Some oil people think a good investment banker needs an eastern accent.

And some don't:

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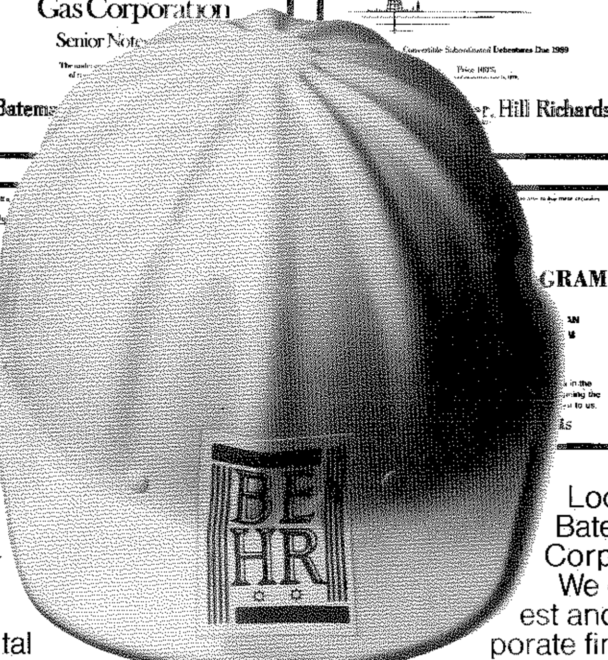

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cies emphasize the enormous opportunity for energy savings and the fact that no fundamental scientific barriers exist to prevent substantial improvements. Even a modest change, from 10% average efficiency to about 11% for the United States, today represents the equivalent of 4 million barrels of oil per day, almost the amount consumed by all U.S. automobiles. A doubling of the U.S. efficiency would provide the equivalent of 2/3 of today's OPEC production forever.

To achieve large and practical increases in energy end-use efficiency requires a long-term commitment in research and development of entirely new, cost-effective processes for every energy consuming sector of the economy. Residential and commercial activities, transportation systems, and industrial processes all have inefficiencies and all are subject to sizeable improvements in energy productivity. Such a commitment holds the promise of yielding energy comparable to that of a major new energy supply indefinitely. It should therefore be given equal priority.

A cost-effective doubling of the average energy end-use efficiency over a period of several decades is not all that remarkable or unprecedented. For example, it has been accomplished over a comparable number of decades in improving the efficiency of electric power plants. This accomplishment, of course, was the result of enormous and continuing commitments of technological resources—the same prescription suggested here for all energy-consuming tasks.

Typical Average Thermodynamic Efficiencies of Various Processes. The Thermodynamic Efficiency Accounts for the Quantity and the Quality of Both The Energy Required and the Energy Consumed in an End-Use.

Residential and commercial:	
—space heating	6%
—water heating	3%
Air conditioning and refrigeration	5%
Automobile propulsion	10%
Steel making	21%
Petroleum refining	10%
Cement manufacturing	10%
Paper production	less than 1%
Average of industrial society	10%

EXHIBIT 7

Perhaps searching for the scapegoat is popular. It provides familiar material for animated discussions. But it can neither compete with OPEC price-fixing nor shorten lines at the gas pump. Facilitating investments in additional energy supplies and energy productivity is not popular. It requires unfamiliar approaches to all aspects of the energy business. But it can gradually arrest the price spiral and secure our energy needs. It calls for concerted participation by all: leadership by the Administration and Congress, responsiveness by energy users of all sectors, and realism by the citizenry.