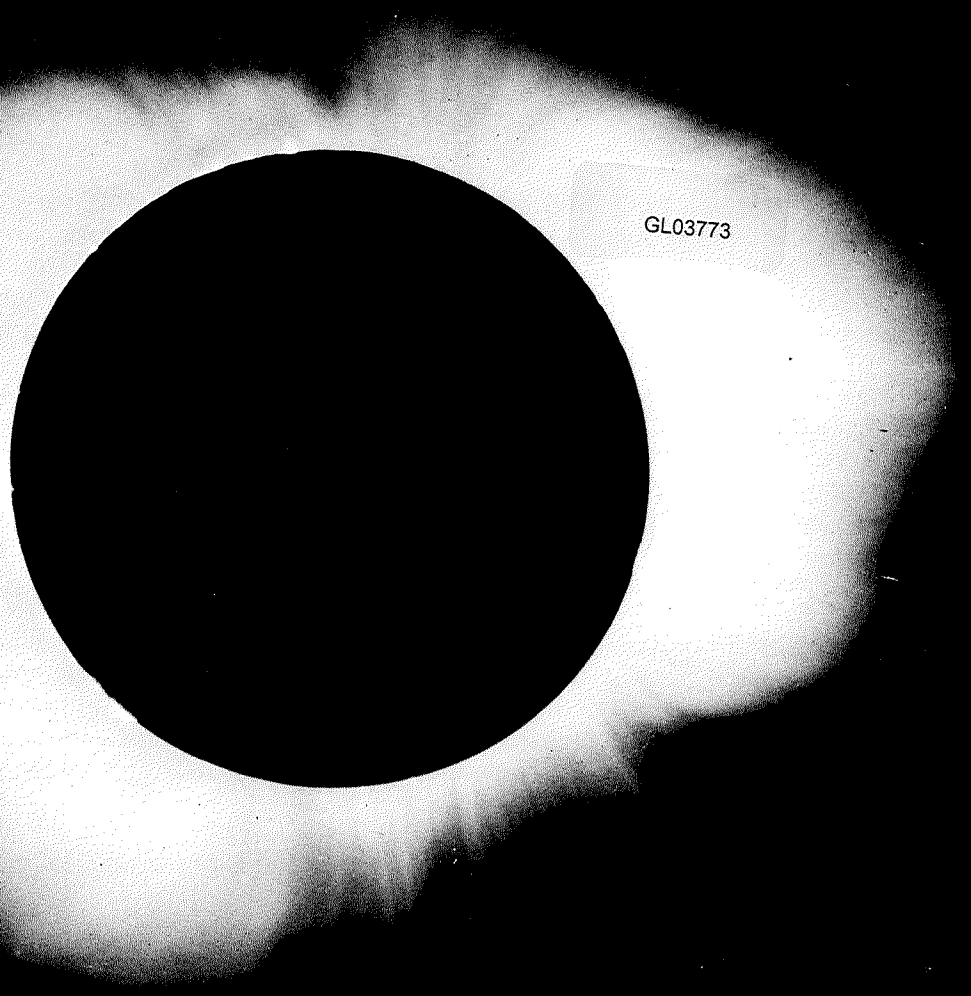
Energy

1978 Special Annual Issue

A Look Back—A Look Forward



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Editorial

Energy highlights

We have talked about it for a long time. And finally here is our first Special Issue of Energy. One of the problems with a quarterly such as ours in a rapidly moving field is that we cannot cover everything, and we cannot be as timely as we would like. Also, we do not usually have the opportunity to look back and sum up. There is just too much to publish, and we do not have the available pages (that is, enough pages within our economic framework) to do all that we would like and how we would like to do it.

Well, we are trying this on for size: our first Special Annual Issue. We hope that it gives you a good look back and as good a look forward as can be expected. We look at a lot, but we cannot look at everything, of course. Included are stories on politics, environment, DOE, petroleum, coal, OPEC, nuclear, and natural gas. However, we also left out a great deal, including such topics as conservation, solar, biomass, wind and other sources generally called alternate energy sources; nor did we get into some of the high technology items, such as fusion, MHD, and photovoltaics. And we could go on. But, we highlight what is most important. Our table of contents (see next page) is impressive, even if we say so ourselves.

By the way, part of our objective here is not to show what we are not doing, but to show that it is not easy to publish the "complete" energy magazine. But, we give it a damn good try. We highlight the major energy concerns in our regular issues in the course of the year. Also, we intend to emphasize all or at least most of these "other" items in our upcoming issues, as well as our 1978 Second Annual Energy Conference, to be held in Washington, D.C. in November. Needless to say, we will be offering additional information on our conference in the near future.

So for this year, we have a "quarterly" that comes out five times a year—a "quintessence."

Louis Naturman
Editor and Publisher

Energy magazine's 1978 Special Annual Issue
'77-'78 A Look Back — A Look Forward

featured in this issue

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Cover: Solar corona photographed at the total eclipse of June 8, 1918, Green River, Wyoming. Photo: courtesy of Hale Observatories.

Secretary of Energy Looks at the National Energy Plan

Adapted from remarks by
James R. Schlesinger, Secretary of Energy
before the Conference Board, New York City, December 7, 1977
and the
AFL-CIO Convention, Los Angeles, California, December 9, 1977

The problem that we face is the moral equivalent of war reflected as an intellectualized perception of our energy problems that do not necessarily carry with them the clear and unequivocal signal for national action such as that represented by Pearl Harbor. Nonetheless, our problems are no less serious, but they have become chronic—they are not acute. When we refer to an energy crisis we are not talking about something that will occur the day after tomorrow. It is a continuing crisis. And in order to underscore that, I go back to 1972 when I picked up the projections of the National Petroleum Council. The council at that time estimated that by 1980 the United States would be importing as much as 10,000,000 barrels of oil a day. I adjusted those numbers in accordance with some pessimistic conclusions regarding the pace at which the country could absorb coal and the speed with which we were deploying nuclear power plants and came up with the number of 16,000,000 barrels a day import.

"If we are to take advantage of the time available, it is desirable that industry, after the passage of this legislation with the rather attractive incentives for conversion that will be incorporated in that legislation, begins to move as expeditiously as possible towards these alternative sources of energy (coal). If we do that and we do that successfully, the enterprise system in the United States will continue to flourish towards the close of this century and well into the next."

The problem has grown

Given the volatility of the Middle East, the foreign policy problems associated with that, at that time I thought that that led to some pessimistic conclusions. I referred to our old friend, the balance of payments, in 1972. It was in rather fragile health at that time. One of the continuing phenomena of American life is the fragility of the health of the balance of payments. The only miscalculation in that period was that I assumed the price of oil would be about $3 or $3.50 a barrel, and we came to the conclusion that the United States could not support an extra $15 billion on its balance of payments expenditures.

Obviously, that is all changed now except for the generic character of the problem. We face exactly the same set of circumstances that were predicted in 1972, given the trends in domestic production of petroleum, and given trends in domestic energy use and the failure at that time effectively to move towards alternative sources of supply. That was our problem then, that is our problem now, and the time has come to do something about that problem rather than simply to talk about it.

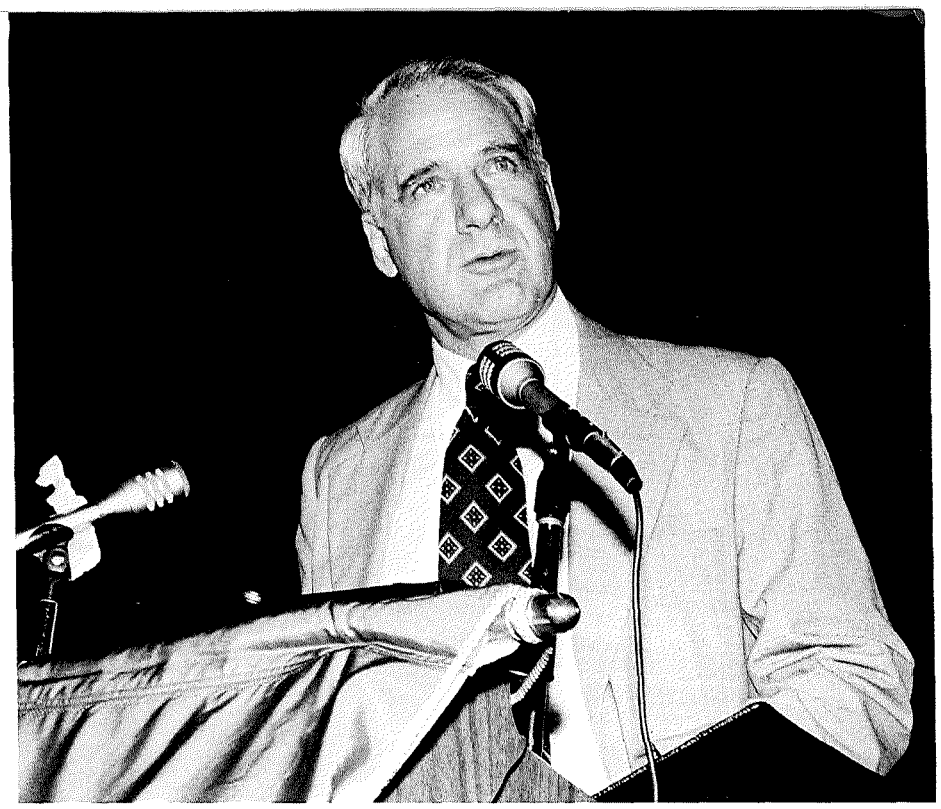
We must get serious about it

We all know what we must do with respect to the energy problem. The fundamental question is not knowing what to do, the question is getting serious about it. At the same time that one looks at the short run energy future, one must also look at the longer run. And in the longer run, we shall have to shift increasingly away from oil and gas as our principal sources of energy supply. The leadership in moving away from oil and gas should be provided by those energy users for whom the penalty of shifting away from oil and gas is least, and that refers to stationary sources or stationary facilities. As our supplies, particularly of fuel liquids, diminish relative to total demand, we shall want to see an increasing proportion of those fuel liquids flowing into the petroleum sector for which there is no easy substitute for fuel liquids—and for which the penalty of attempting to get by with something else is far greater. And we want stationary facilities increasingly to move towards those fuels which are relatively more abundant and for which the penalty in shifting is less. There is a penalty attached, and one of the purposes of the National Energy Plan is to eliminate at least the financial penalty associated with shifting toward other sources of supply. We recognize that unless there are financial inducements to move away from oil and gas towards coal or coal-based fuels, industry will resist. There are statutes on the books now telling industry to move towards coal. Yet, in the course of recent years there has been relatively little movement because the financial incentives all work in the opposite direction.

The move to coal must happen

In 1945, the Nation was primarily dependent upon coal and we moved away from it. Oil and gas were chosen for good and sufficient reason—they were more convenient, they were cleaner, they were easier to use, they did not bear the risk of an annual soft coal strike. The problem was that we were unable to continue to expand the supply of oil and gas, particularly domestically, in such a way as to accommodate a steadily increasing demand for fuel. Now, in order to better optimize our use of fuels, industry will have to switch increasingly towards coal. I think that underscores one of the concerns that is mentioned with regard to the consistency of Government policy or perhaps the perception, right or wrong, that Government policy oscillates, if not vacillates.

Let me underscore that there will be a major, consistent, persistent ele-



ment in Government policy, to wit, the movement of stationary sources away from oil and gas and towards coal. That is the longer run projection; it is also the shorter run projection. Over the course of the next 10 to 15 years, industry will have to move predominantly towards coal and in the shorter run one will experience the early aspects of that movement.

And the short run?

Let me underscore that in the short run, in the next two years, there will not be the kinds of technologies available for coal to be burned more or less freely. Many industries will be shifting away from oil and gas towards increased use of electric power. But for direct use of fuel there will be an increasing movement in the early 1980s towards fluidized-bed boilers and towards low Btu gasifiers. In the near term, we will not have that much of a shift and the near term prospects are for reasonably stable oil prices, somewhat rising natural gas prices, the gradual diminution of the availability of natural gas for industry, as opposed to a longer term diminution of the availability of oil for industry.

In the near term all that implies is that you will be doing much the same as what you are doing today. And the Nation as a whole will continue to be dependent to a considerable extent upon imported oil, presumably coming in at relatively constant prices, and a continuation of severe balance of payment problems which it will be our responsibility to cure. In the longer run, however, there will be this obligation to move increasingly towards coal and to take advantage of those technologies which permit industry and stationary facilities to burn coal in a way consistent with environmental standards.

What about the longer run?

In the longer run, we are not going to have petroleum available as we have had in the past. In 1985 there will be little if any more petroleum available, either domestically or worldwide, than we anticipate in 1980. Sometime around the early 1990's the world will probably peak out in terms of petroleum production. From that point on we will be on a long slide downwards with diminishing production of oil and an increasing proportion of that oil being used for petrochemicals, for non-fuel uses. Increasingly the value of oil and of natural gas will be for non-boiler purposes. It is more or less inevitable. Today the world is producing about 60 million barrels of oil a day. World oil production will probably never reach beyond 80 million barrels a day and perhaps not that far. In the middle 1980's, at the latest, we will begin to face ascending prices as the industrial nations and the lesser developed countries tend to bid against each other for restrictive amounts of oil available. By that time the natural forces of the marketplace will have begun to point against making use of oil and of natural gas. The price of gas will move more or less correspondingly with oil.

The National Energy Plan

A purpose of the National Energy Plan is to help the market anticipate these conditions that inevitably will develop four, five, seven or ten years out. The less we do today, the more rapidly will those conditions develop. We can anticipate the oil stringency of the 1980's and we have a choice in our country. We can take advantage of the available time to begin to adjust our capital stock in a way that is both more fuel efficient and less oil dependent than it presently is, in a relative sense. Or we can go on willy-nilly and continue to drift in accordance with existing tendencies, with the consequence that in the middle 1980's we will face very severe economic problems because of our failure to take advantage of the time that we presently have available.

It takes a considerable period to adjust the capital stock of our economy without major disruption of the flow of goods and services to our standard of living. For example, it was in 1975 that Congress mandated that the automobile industry would produce, on an average, more fuel efficient cars and that gradually the efficiency would rise until in 1985 the average car being sold would obtain 27½ miles per gallon. At the time the legislation was passed, the average mileage being obtained by cars in the national fleet was something like 13½ miles a gallon. By 1985, when the legislation takes full effect, the average of the cars in the fleet will be something like 20 miles a gallon. It will have taken a decade to increase the fuel efficiency of automobiles by 50 percent. By 1990 or 1992, the average of the fleet will be 27½ miles per gallon. It will thus have taken better than 15 years to double the fuel efficiencies. And similarly with our entire capital stock, since investment is slow and time consuming, if we want to change the fuel efficiencies of our entire capital stock, we must work gradually overtime.

The alternatives are very grim

That is the underlying premise of the National Energy Plan. If we take advantage of the time that is available to us, we can avoid some severe economic traumas in the 1980's. If we fail to take advantage of that time, we will inevitably suffer severe economic trauma of the sort that we have not

witnessed in this country since the Great Depression. If we do nothing now and our entire economy continues to become more oil dependent, the consequence will be that when we strike that oil stringency in the middle 1980's on a worldwide basis—and there is no more supply available and prices start to move up rapidly—we will discover that we have more massive unemployment in this country than occurred after 1973 and the embargo. We will discover that inflation again tends to accelerate and that we will face balance of payments problems so massive and so intractable that we could not acquire the oil overseas even if it were available, which it will not be. I mention these prospective or potential economic problems because economic problems are associated with the effectiveness of our social organization. And if we have rising unemployment, accelerating inflation and these severe balance of payments problems, the consequence will be that the American people lose confidence in our existing system. There would be political consequences flowing from those economic difficulties that would transcend in importance the economic difficulties themselves. And I think that is the fundamental point to be kept in mind about this energy transition that we now face.

The National Energy Plan includes, as all of you are aware, tax credits which will ease the financial pain of making that shift away from oil. It will ease some of the difficulties in terms of moving from what is familiar to the unfamiliar. That I believe is an indispensible element. But we must recognize that we are moving into the unfamiliar area, that we do not have extensive experience with low BTU gasifiers or with fluidized-bed combustion and that, consequently, in order to make this painful adjustment as quickly, effectively, and smoothly as possible, that there will be some grappling with unfamiliar technologies in order to provide the energy that industry must have.

In order to keep this society flourishing, we must continue to have an expanding economy, we must create additional jobs each year in order to have something approaching full employment. We must have rising productivity and increasing production. In drawing up the National Energy Plan that has been axiomatic, and it will continue to be the priority in Government policy in the years ahead. In any conflict between conservation goals holding energy growth down to two percent and the necessity for continuing to permit economic expansion, the goal of economic expansion remains axiomatic.

Therefore . . .

In a free society, we will not be able to maintain the rudiments if we fail to have economic expansion and the associated expansion of employment opportunities which undergird the political and social stability of the society. In making out the plan, we have laid maximum stress upon utilizing the price mechanism because we do not want to get into a position in which we are attempting to ration, to allocate from Washington to establish a form of political economy. That would be sacrificing too much. We want the decisions, given the proper governmental signals, to be made by individuals and corporations. We must be more abstemious, more fuel efficient with regard to the total consumption of fuel, and we must move, if the society is to flourish, towards more abundant fuels as our ability to produce increasing amounts of oil and gas wanes. The outcome is preordained. Whether or not we achieve it depends in large degree, and particularly in the short run, on the willingness of the American business community, of American industry, to embrace enthusiastically something that is not entirely agreeable, the shift of energy sources away from oil and gas towards coal. It is not entirely agreeable but it is necessary, both for national health and for the long-term well-being of the Nation's businesses. As you create new plants and equipment, you are creating them for 35 or 40 years. □

Some Philosophy and Morality

Recognize that the transition away from oil and natural gas for industrial use will be painful in many respects, but it is a decision and a change that must be faced courageously and without timidity. If we go back to World War II, it did not take us three, four or five years to begin to adapt to the necessities that history imposed upon us. We began to adapt quickly. Some are questioning whether or not the United States could produce 1.2 billion tons of coal in 1985. In the early weeks of November, we were already producing in excess of 16 million tons a week, which means that we already have capacity in this country to produce 850 million tons of coal a year. Thus, we have to expand our capacity between now and 1985 by little better than four percent annually.

In this connection, I point to the necessity for the avoidance of shortsightedness by the business community. The business community, indeed the political community, has tendencies which will not serve our highest needs if they are exhibited: the tendency not to look beyond the next profit and loss statement, or the next general election. We have a budding crisis, a crisis that is real even though it is invisible.

Since 1973, the worldwide market for petroleum has been cartelized. Until 1973, there was no discussion of the virtues of the international free market by members of the oil and gas industry. They all thought that American industry was being destroyed by a flood of cheap foreign oil from the Middle East. As a result of cartel actions, the price of oil internationally has increased sixfold. And that has a certain virtue to it, at least in the eyes of the industry. There are virtues now to be uncovered in following the prices established by the cartel. The establishment of the cartel seems to be some kind of promised land for the producers. But it is the President's intention not to allow large-scale windfall gains to accrue to the producers of oil and natural gas in this country simply as a consequence of the cartelization of the international oil trade.

The industry sometimes has this habit of confusing itself with the deserving poor. That is at best misinterpretation, at worst self-pity. So we must proceed with this shift, this transition which will be difficult, in a way that is equitable to the American people, that does not result in windfall gains for any class of producers, that maintains a standard of living for all while encouraging an expansion of jobs in new areas, in the new sources of supply.

Department of Energy: Its Basic Structure

On October 1, 1977, the Department of Energy became the 12th Cabinet agency. With about 20,000 employees and a first-year budget of $10.4 billion, DOE, under Secretary of Energy James R. Schlesinger, brought together energy programs from the Federal Energy Administration, Federal Power Commission, and Energy Research and Development Administration (these three agencies will be dissolved into DOE), plus energy functions from Interior, Defense, Interstate Commerce Commission, Commerce, and the Department of Housing and Urban Development.

A key feature of the organization of DOE is the fact that new or emerging technologies will be grouped at the Assistant Secretary level by their stage of development (research, development, application) rather than by fuel type, such as solar, fossil, nuclear, etc.

Basic research will be performed and coordinated by an Office of Energy Research. When projects reach a later stage of research and development they will be grouped under an Assistant Secretary for Energy Technology. When the concept approaches the commercial stage, it will be transferred to either the Assistant Secretary for Resource Applications, or the Assistant Secretary for Conservation and Solar Applications. These last two offices will be specialists in business and marketing questions; the other two in technology. Overall coordination will be by an R&D Coordination Council, composed of each program Assistant Secretary. Major outlay programs are described.

Conservation and solar applications

Solar commercialization programs are grouped with conservation because they are means of reducing energy demands on central power sources, and involve the same links to the building community. Functions of the office will be to develop and implement conservation programs in all sectors, including assigned regulatory programs, apply conservation and solar technology. Programs transferred from other agencies:

- *From ERDA:* Industrial Energy Conservation; Buildings and Community Systems; Transportation Energy Conservation, including electric/hybrid vehicle systems; agricultural and industrial process solar heating; solar heating and cooling of buildings; and fuels from municipal solid waste.
- *From FEA:* Utility rate structure demonstration; Office of Consumer Services; Federal Energy Management Program; consumer product efficiency; weatherization; solar commercialization; auto mileage guides; industrial energy conservation reporting/monitoring; state EPCA/ECPA grants; and Federal building solar demonstration programs.
- *From Commerce:* Industrial energy conservation and small scale technology.
- *From HUD:* Efficiency standards for new buildings and conservation/renewable resources demonstration program.

Resource applications

Commercial development of newly available energy supplies of all types will be, for the first time, consolidated into one department. Existing Federal energy resources will also be administered by this office. Programs transferred from other agencies:

- *From ERDA:* Uranium enrichment; uranium resource assessment; fossil energy development, including alternative fuels commercial demonstration; geothermal energy development and loan guarantee program.
- *From FEA:* Coal loan guarantee program; Indian resource development program; materials allocation program; and strategic petroleum reserves.
- *From Interior:* Power marketing administrations (Bonneville, Southeastern, Southwestern, Alaska); power transmission and marketing functions from Bureau of Reclamation.
- *From Defense:* Naval petroleum reserves and oil shale reserves.

Energy technology

Research and development, including technology demonstration, for all energy areas, including fossil, nuclear, solar and geothermal, is the developmental step, between basic research and commercialization. Responsibilities include conservation projects still in the developmental stage. Programs transferred from other agencies:

- *From ERDA:* Solar electric applications; solar technology support and utilization; fuels from biomass; geothermal energy development; hydroelectric power programs; hydrothermal technology applications; coal liquefaction; coal gasification; advanced coal power systems; direct coal combustion; magnetohydrodynamics; in-situ coal gasification; oil shale; enhanced oil and gas recovery; petroleum and natural gas drilling, exploration and offshore technology; petroleum and natural gas processing and utilization; R&D on production technology of solid fuels and coal preparation; electric energy systems; improved conversion efficiency; energy storage systems; water-cooled breeder reactors; gas-cooled thermal and breeder reactors; space nuclear applications; nuclear energy assessments; light-water reactor technology, facilities and fuel storage; advanced isotope separation technology; breeder reactors, including Clinch River demonstration plant, Flux Test Facility; naval reactor development; nuclear fuel cycle R&D, including waste management facilities; and magnetic fusion.

Environment

This office is responsible for seeing that other Departmental programs are consistent with environmental and safety laws, regulations and policies. Programs transferred from other agencies:

● *From ERDA:* Overview and assessment; biomedical and environmental research; life sciences research and biomedical applications; and light-water reactor safety facilities.

Energy research

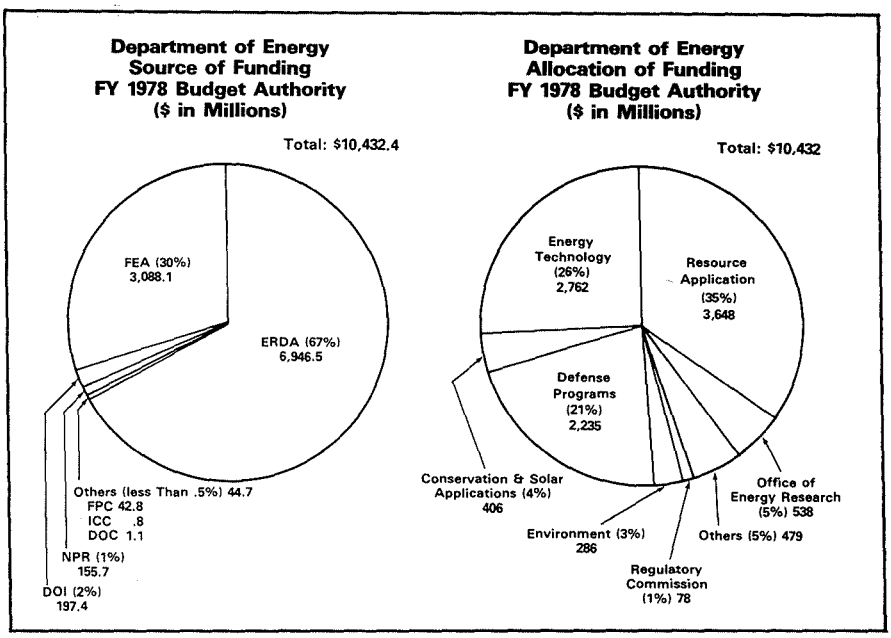
This office is responsible for basic energy research. The director advises the Secretary on physical and energy research programs, the use of multipurpose laboratories. Financial support of outside research is handled through this office.

Defense programs

Nuclear weapons research, development, testing, production and surveillance will be the responsibility of this assistant secretary. Nuclear materials safeguards and security program will also be administered by this office. Laser fusion development program will also fall here.

Economic Regulatory Admin.

This office will administer regulatory programs other than those of the Federal Energy Regulatory Commission. These will include oil pricing, allocation and import programs formerly administered by FEA, conversion of oil- and gas-fired utility and industrial facilities to coal; natural gas import/export controls; natural gas curtailment priorities; emergency allocations; regional coordination of electric power system planning and reliability of bulk power supply; and emergency and contingency planning.



Energy Information Administration

This office will bring together data-gathering systems previously operated separately. These include data on energy reserves, financial status of energy-producing companies, production, demand, consumption. This office will be responsible for long-term analysis of energy trends, including analyses of competition, financial structure and interfuel substitution. Energy Information Administration will develop a national reserves system to determine the best estimates of fuel reserves and a financial reporting system for energy-producing companies.

Federal Energy Regulatory Commission

An independent, five-member organization within DOE, but not subject to direction from the Secretary of Energy, this commission is basically the old Federal Power Commission, with some functions taken over from the Interstate Commerce Commission.

It will: license hydroelectric power projects; establish rates for sale of electricity and of natural gas; issue certificates of public convenience for construction and abandonment of facilities and services; establish curtailments of natural gas; and regulate mergers and securities acquisitions under the Natural Gas and Federal Power Acts. □

Key Department of Energy Officials (as of Jan. 1, 1978)

5 James R. Schlesinger, Secretary
5 John F. O'Leary, Dep. Secretary
5 Dale D. Myers, Under Secretary
6 Roger D. Colloff, Special Asst.
5 Phillip S. Hughes, Asst. Sec. for Intergov't and Instit. Relations
5 Alvin L. Alm, Asst. Sec. for Policy and Evaluation
5 Harry E. Bergold, Jr., Asst. Sec. for International Affairs
1 Donald A. Beattie, Acting Asst. Sec. for Conserv. & Solar Applic.
2 Thomas Noel, Acting Asst. Sec. for Resource Applications
3 Robert D. Thorne, Acting Asst. Sec. for Energy Technology
1 James L. Liverman, Acting Asst. Sec. for Environment
1 Donald M. Kerr, Acting Asst. Sec. for Defense Programs
5 Charles B. Curtis, Chairman and Member, Federal Reg. Comm.
1 Joseph Seltzer, Acting Inspector General
6 Raymond Walters, Exec. Secretariat
4 Eric J. Fygi, Acting Gen. Counsel
5 David J. Bardin, Administrator, Economic Regulatory Admin.
5 Lincoln E. Moses, Admin. Energy Information Administration
5 John Deutch, Dir., Energy Res.
6 William S. Heffelfinger, Director of Administration
7 John D. Young, Acting Controller
6. Michael J. Tashjian, Director of Procurement of Contracts Mgmt.
Marion A. Bowden, Acting Director, Equal Opportunity

1 Acting in this capacity until someone is nominated and confirmed.
2 George McIsaac has been nominated for this position but is not confirmed; Thomas Noel is acting in the meantime.
3 Robert Thorne is nominated for this position but is not confirmed.
4 Lynn Coleman is nominated for this position but is not confirmed.
5 Nominated and confirmed.
6 Nomination and confirmation not needed; these people are firm for their respective positions.
7 John Young is acting in this position until someone is appointed.

Energy Projections: Good and Bad

Energy projections abound. And then there's the National Energy Plan–totally unrealistic–among many others. Is it time for NEP-II?

World oil will run short sooner than most people had been predicting. This is WAFS' basic conclusion. Demand in the non-Communist world will probably overtake supplies around 1985 to 1995. This will be true even if energy prices rise 50% above current levels in real terms. However, other "experts" maintain that there is no real oil shortage, rather an oil rig shortage.

But other WAFS findings do not brighten the picture:

1. Demand for energy will continue to grow even if governments adopt vigorous policies to conserve energy, making imperative the finding of substitutes for oil.
2. Since such alternatives will require five to fifteen years to develop, the race will be lost unless alternate energy projects get under way.
3. Nuclear power could be the answer, but the state of public acceptance makes it appear doubtful now.
4. Coal could be the answer if increased production efforts get under way now.
5. Natural gas reserves can meet projected demand if extensive and costly intercontinental transportations are encouraged by price incentives.
6. Such alternate energy resources as oil sands, oil shale, solar, wind power and fusion, are not likely to make significant contributions in this century according to most analysts.
7. Energy conservation should be a key element.

WAFS, considering economic growth and energy prices, projected that demand for oil would fall in the range of 2.6-3.4% growth per year in the 1975-85 period and 1.5-2.6% from 1985 to 2000, both well below the 6% rate of the decade before 1973. It put ultimately recoverable oil reserves at two trillion bbl., 75-80% outside Communist parts of the world. It set up two levels of discovery of new reserves: a high of 20 billion bbl. per year and a low of 10 billion bbl. per year (historical rate is 18). It then developed an oil production profile based on oil production meeting oil demand until a technical production limitation was reached: the reserve/production ratio of 15/1. (10/1, that is, not producing more than 10% of a field's oil in one year, is the worldwide average limit in terms of using the field's natural pressure to get the maximum recovery from a field. However, new fields take some years to get into production, so the figure 15/1 was used.) As new discoveries slow down, the ratio will decline toward 10/1.

What about OPEC?

A further factor is whether OPEC countries will choose to limit production to a low level (Government announced possible limits add up to 17.2 million bbl/day), or will let it increase to meet demand as long as the R/P ratio is at least 15/1 (R/P ratio in OPEC is now about 45/1).

Without an OPEC production limit, world oil production would, WAFS says, probably peak at 86 million bbl/day sometime between 1995 and 2000, and then decline sharply. If OPEC limits production at 45 million bbl/day, it would fail to meet demand and would peak in the late 1980's, then decline slowly until the second decade of the 21st century when decline would become sharper. If OPEC limits production at 33 million bbl/day, production would fail to meet demand in 1980, and it would peak at just under 60 million bbl/day in the mid 1990's, with the decline slowing into the 21st century. Thus a lower OPEC production rate would preserve supplies longer, giving a more gradual decline curve, but would move the date when oil supply failed to meet demand closer; too close, probably, for anyone to be able to do anything about it.

These dates and numbers assume a high economic growth rate, rising energy price, vigorous Government response to energy problems, coal as the principal replacement fuel, and gross additions to oil reserves of 20 billion bbl. per year—WAFS's favorite possibility of a number it mapped out. However, although the timetable would be different, the principle would remain the same: limiting production now would stretch out oil supplies but would hasten the day alternatives are needed.

Other people are making other projections as to when and at what production level oil supplies will fail to meet demand. Mobil Oil says that there is now a supply-demand balance of 47 million bbl/day, leaving a 6 million bbl/day surplus in OPEC.

- In1985, Mobil says, there will be a 65 million bbl/day supply-demand balance with no surplus.
- In 1990, there will not be enough oil available to meet a demand of 74 million bbl/day.
- These figures are for the non-Communist world. For the U.S., Mobil projects U.S. demand at 52 million bbl/day in 1990, up from 1976's 36 million bbl/day. Oil and gas will supply 61% of U.S. energy needs in 1990, Mobil says, against 75% in 1976.

NEP energy supply and demand

In January, the Federal Energy Administration forecast that U.S. energy demand would grow 2.5% a year to 1985. Over this period, consumer energy costs will increase 2.4% a year, says FEA. Natural gas would be the critical supply area. These assumptions were used as a basis for the National Energy Plan.

Before the 1973 Arab oil embargo, U.S. energy demand was increasing 3.5% a year. The plan assumes that new energy consumption by industry will go up about 4.7% a year; by residential and commercial, up about 1.1% a year; by transportation, 1.1%/yr.; and by electric utilities, 4.4%. Implicit in these numbers is the importance of conservation.

Against these demands, domestic crude supplies are expected to increase to 10.4 million bbl/day by 1985 from 1976's 9.7 million bbl/day.

- Natural gas production will be down to 16.6 trillion cubic ft./year (equivalent to about 8.2 million barrels of oil per day) from 1976's 19.9 trillion cubic ft./year. But gas production in 1985 may reach 21 trillion cubic feet in 1985 *if* prices are decontrolled.
- Coal production will hopefully reach 1 billion tons/year (12.2 million barrels of oil equivalent per day).
- Nuclear is slated to account for 23% of total electricity generation and this seems generous.
- Alternate energy forms, such as solar, geothermal, wind power, etc. are expected to provide about 10% of

Is there an oil shortage?

The short-term realities seem to indicate that oil supplies will not grow short in the near future, provided that there is no blockade, which does not seem very likely. OPEC does not want it and the big western oil consuming nations are less likely to tolerate such a move these days. Conservation, especially in transportation (more fuel efficient cars), which itself can reduce consumption by two to three million barrels per day, slower worldwide economic growth (a very mixed blessing indeed), seem to be doing more than most of us expected. Although NEP predicted a 7-8 million bbl./day oil import level (initially pronounced incredible by most of the energy industry), we now see industry calculations that suggest that imports may even be in the range of 9 million bbl/day.

Most worldwide (excluding Communist) countries' demand forecasts have also been lowered to as little as 61-64 million bbl./day from prior forecasts which have approached the 68 million plus bbl./day range. Most of these new estimates call for OPEC shipments to range between 25 and 35 million bbl./day, and non-OPEC shipments to grow from 20 to 25 million bbl./day by 1985. Of course, the arithmetic is easy. If OPEC cannot or will not deliver 36 million bbl./day, the Western World is still in trouble, unless alternate sources are found. In any case, the vicious circle of high oil prices and slow economic growth must be considered before the shortage hits.

total energy. And this is optimistic.

- Oil imports are predicted to be anywhere from 5 to 10 million bbl/day, depending on price and policy according to NEP. By inference this will not be enough. Without more oil imports, we just will not make it. LNG imports are slated to reach 1.1 trillion cubic ft./year in 1985 and 2.3 trillion cubic ft./year in 1990—almost all from OPEC; GAO, among others, believes that the LNG import policy has not been thought out well enough.
- In 1985, U.S. oil production will rise to 10.6 million barrels/day. But by 1990 it should fall off to 9.3 million bbl/day. The increased 1985 U.S. oil production will include 2.8 million bbl/day from new oil field enhancement techniques; 1.2 million bbl/day from new offshore oil. Alaska will provide 2.4 million bbl/day.

Table
National Energy Plan Fuel Balance

Fuel Balances by Sector

[Million barrels of oil equivalent per day]

	1976	1985 without Plan	1985 with Plan	1985 Plan plus additional conservation
Demand	37.0	48.3	46.4	45.2
Residential and commercial:				
Oil	3.5	3.2	2.7	—
Natural gas	3.9	3.8	4.1	—
Electricity	6.3	9.1	8.4	—
Coal	.1	—	—	—
Total	13.8	16.1	15.2	—
Industry:				
Oil	3.2	7.0	4.0	—
Natural gas	4.4	4.5	4.5	—
Electricity	4.2	7.2	7.1	—
Coal	1.9	2.7	5.0	—
Total	13.7	21.4	20.6	—
Transportation:				
Oil	9.2	10.6	10.2	—
Natural gas	.3	.2	.3	—
Total	9.5	10.8	10.5	—
Electricity:				
Oil	1.6	2.0	1.3	—
Natural gas	1.5	.9	.5	—
Coal	4.9	8.2	8.3	—
Nuclear	1.0	3.6	3.8	—
Other	1.5	1.6	1.6	—
Total	10.5	16.3	15.5	—

Investment? Conservation?

U.S. energy investments will come to $650 billion (in 1975 dollars) over the next ten years, if not more. Of this, $370 billion will go for oil and gas; $250 billion for electricity; and $23 billion for coal.

Roger Sant, former energy conservation chief for the Energy Research and Development Administration, projects another kind of energy investment: a new $500 billion energy conservation industry, producing in 1985 the equivalent of 17 million bbl per day of oil, a third of U.S. needs. The key to this would be increasing the price of all energy to the level of the cost of incremental additions to energy supply. The consumer is now paying about $3 per million Btu's, Sant says, where the cost of marginal energy production (the kind which new supplies represent, whether from new technology or new exploration) is about $5 per million Btu's.

Until 1970 the marginal cost of energy additions was less than the current price. In 1976 the marginal cost became about twice the consumer price. By Sant's estimates, an energy conservation investment of $520 billion could keep energy demand from increasing 3.5% a year to 110 quadrillion Btu's in 1985; instead it would remain constant at 75 quadrillion Btu's, a saving of 35 quads.

FEA later estimated that conservation will save 21 quads per year by 1985. The discrepancy resulted mainly from Sant's failure to consider the cost of producing insulation and other conservation work. In any case this high level of conservation is also optimistic. It seems clear that when, where and if the cost of new energy passes the cost of new energy conservation, investment on a per Btu basis will have an influence on the amount invested in producing new energy, on the amount of energy needed, the cost of energy, as well as on the international energy trade, and when and where energy shortfalls may come. □

OPEC: The Cartel Still Stands

In December 1976, in a meeting in Qatar, eleven of the thirteen OPEC members agreed to increase their petroleum prices 10% on January 1 and by another 5% on July 1. These were countries which needed all of the oil revenue they could get because of large populations, major development programs, high military expenses: Qatar; Venezuela; Kuwait; Libya; Algeria; Nigeria; Ecuador; Indonesia; Iran; Iraq; and Gabon. Two OPEC members, Saudi Arabia and the United Arab Emirates, had more oil revenues than they knew what to do with (actually more than they really wanted), and decided to raise their prices only 5% in January and not at all in July.

Long-term, all energy strategies, from development of coal gasification processes to adding insulation to the house, base their economies on continued high petroleum prices from OPEC.

The beginning of the strain

In an effort to push other OPEC members back down to its own pricing level, Saudi Arabia threatened to increase its oil production to accommodate more of the oil purchasers drawn by its lower price. In other words, it was prepared to take business away from other OPEC members, a move which seemed calculated to put at least an emotional strain on the ties which bound the organization together. If the lost business hurt the "ten percenters," as the upper price-tier members were called, they would begin selling at lower prices, bringing the overall level of OPEC prices down toward the Saudi-UAE level. It might also begin OPEC disintegration. Oil producers with surplus oil might begin making secret under-the-counter deals with purchasing oil companies at prices below the agreed upon floor. The oil companies would be able to play producers against each other, sending prices spiralling downward as suspicion overwhelmed the trust necessary to keep OPEC together, the classic way cartels collapse. Thus went the theory.

The ten percenters raised their prices $1.19/bbl, rather than try to increase by 10% each of the various product prices. This increased the base price to $12.70/bbl. With a 5% increase, the base price from Saudi Arabia and UAE was increased to only $12.08/bbl. Companies had been stockpiling oil in anticipation of the price increase, buying about 4 million bbl/day more than the normal total of about 30 million bbl/day from OPEC. This extra buying had already forced the price up 5-6% above normal, so the Saudi increase was, in effect, no increase at all. Saudi Arabia began almost immediately to increase production from 8.5 to 9.8 million bbl/day, with a further increase to 11.8 million bbl/day at year's end. At the same time, because of the stockpiling, demand for oil from OPEC fell during the first quarter while the oil companies were working off their stockpiles.

The demand fall-off was worst for high-sulfur heavy oils used for heating and electric generation. These oils had been in oversupply before the price increase and countries which produce the heavy oils, most notably Venezuela and Kuwait, were already unable to keep the OPEC floor under the price. Heavy oils are also where Saudi Arabia had its surplus capacity, which it began to make available to the market. Exxon and other purchasers began to shift their purchases of heavy oil away from Venezuela and Kuwait toward Saudi Arabia. Also expected to lose a portion of their market were Iran and Iraq.

An increase of Saudi production by 2.5 million bbl/day and of the UAE by 300,000 bbl/day (both comfortable increases) would cut into the market of the other 11 by about 15%. Aramco members (Exxon, Mobil, Standard Oil Co. of California and Texaco), allowed to buy at the lower price, would reap about a $2 billion windfall over the year. Saudi Arabia, of course, would not be able to replace its OPEC partners as oil suppliers. Before the price rise, Saudi Arabia and UAE provided about one third of OPEC's oil; under the new circumstances, it might produce just under half.

Before the stockpiling began prior to the January price increase, Saudi Arabia and UAE produced 10.5 million bbl/day out of an OPEC total of 30.2 million bbl/day: 34.8%. Current capacity for OPEC is 38 million bbl/day; capacity for Saudi Arabia and UAE is 14.1 million bbl/day: 37%. However, if OPEC's total sales remain at 30.2 million bbl/day while Saudi Arabia and UAE move to capacity production of 14.1 million bbl/day, their share would be 46.7%. As a matter of fact, most industry analysts do not expect any increase.

More activity, no collapse

A number of things happened during the six months of two-tier pricing, but break-up of OPEC was not among them. Some ten percenters tried to hold oil companies to supply contracts. Iran threatened to blacklist any company failing to honor a purchase agreement. Kuwait made efforts to get British Petroleum to honor agreements, which it has. But the agreements were sufficiently flexible so that BP could go ahead and buy cheaper oil when it could get it.

The major oil companies had an interest in not openly breaking with their old trading partners for a small price advantage. Since the nationalization of most oil properties in OPEC, the major producers have been left with preferred access agreements where they once had ownership positions. These agreements permit them exclusive access to as much of the oil as they want with a discount from official prices—as much of a trading advantage as the oil com-

Table 1
1976 Oil Production by Organization of Petroleum Exporting Countries

Country	Million bbl/day
Saudi Arabia	8.5
United Arab Emirates	2.0
Iran	5.8
Iraq	2.6
Venezuela	2.4
Kuwait	1.7
Nigeria	1.9
Libya	1.9
Indonesia	1.5
Algeria	1.0
Qatar	0.5
Gabon	0.2
Ecuador	0.2
TOTAL	30.2

panies really need. However, as indicated above, shifts did take place in sources of supply. And some of the 11 ten percenters offered some grades of oil at a lower than official price. Lighter oils, such as those produced in the African countries, generally took the full $1.19 increase, but heavier oils generally failed to take the increase. (Saudi Arabia did not even increase its heavy oil price by the 5% it had promised.)

But OPEC did not fall apart, and the most significant thing that happened was a flight around the OPEC world by Venezuelan President Carlos Andres Perez, in an effort to eliminate the two-tier pricing. It worked. In May Saudi Arabia and UAE agreed to raise their prices on July 1 by 5%, to the level of the other 11. At the same time, 9 of the 11 agreed to forego their promised further price increase of 5%, so almost all OPEC production was back at the same official price again.

The two OPEC members not agreeing to forego the price rise were Iraq and Libya. Neither particularly worried the oil community. Iraq had always been a renegade, quick to lower prices when business was slow, so it was not expected to offer higher prices in practice. Libya has very low-sulfur oil which has always sold at a premium, particularly to air pollution-conscious countries, such as the U.S. Therefore, its price increase might simply reflect market realities.

OPEC Historical Highlights

1960 OPEC was formed in reaction to an attempt by a group of major oil companies, led by Standard Oil Co. (New Jersey), now Exxon, to reduce the official price of oil by 4-14¢/bbl. The first OPEC meeting, in Baghdad that September, forced a retraction of the decreases.

1971 The Teheran Agreement was made, in which the producing countries, working as a group, and the oil companies jointly established price changes. Closing of the Suez Canal, shutdown of a major pipeline to the Mediterranean, and production cutbacks by Libya pointed to a crude oil shortage, making the price agreements stick. Revenues to producing countries increased 30-50%.

1973 In October, OPEC met in Kuwait following collapse of talks in Vienna with the oil companies, and increased posted prices by 70%. Saudi Arabia's take from a barrel of crude rose from $.99 in January to $3.43 in October. The next day the Arab nations ordered production cutbacks and an embargo on oil shipments to the United States, the Netherlands and other nations. This was in retaliation, they said, against positions taken by these countries in the Arab-Israeli war then under way. In December, Iran, Iraq, Kuwait, Saudi Arabia, Qatar and Abu Dhabi announced in Teheran a doubling of crude prices, effective January 1. A few weeks later OPEC as a whole made this price increase universal.

1974 The crude price continued to increase during the year with adjustments in taxes and royalty rates, and as nationalization of oil-producing properties proceeded. In June, Saudi Arabia blocked an attempt to raise oil prices by several dollars a barrel. OPEC agreed to increase government take through royalties by 2%, adding 10-15¢/bbl. to the price. The primary aim was to reduce profits of oil companies. In December, OPEC met in Vienna and raised prices by 38¢/bbl, moving at the same time away from posted prices toward more realistic expressions of fees. Again, OPEC spoke of the increase as primarily an attack on international oil company profits.

1975 Meeting again in Vienna in May, OPEC, after tense disagreements, raised prices 10%, bringing the price of Arabian light crude to $11.51/bbl, an increase of $1.05. The primary disagreement was between Iran, which wanted a 28% increase, and Saudi Arabia, which wanted 5% or less. In Bali, Indonesia, OPEC (bowing to demands by Saudi Arabia) froze crude oil prices. A worldwide recession was probably a larger influence than the Saudis in the decision. Uncertainty over how to price the more than 40 different grades and forms of crude produced by member nations was also a factor: Saudi Arabia wanted a new formula.

1976 Meeting in Qatar in December, eleven members agreed to raise prices 10% on January 1, and a further 5% on July 1. Saudi Arabia and UAE agreed only to raise their prices 5% on January 1 with no further increase.

1977 OPEC's Vienna headquarters announced that 9 of the higher-priced 11 members (all but Iraq and Libya) had cancelled the July 1, 5% increase. At the same time, Saudi Arabia and UAE agreed to make a 5%, July 1 increase, thus bringing all OPEC official prices back in line again. World oil glut and world recessionary conditions promoted an end-of-year de facto price freeze, as led by Saudi Arabia and Iran.

1978 A price hike is expected—maybe.

More strain, but Saudi Arabia leads

Since the Saudi's interest in taking more of the market with a lower price was not commercial (it presently has no need for additional revenues), it was able to bend its price policy toward its aims of preserving and dominating OPEC, and keeping petroleum prices from overwhelming the economies of the industrialized world. (The latter aim becomes stronger as more of its surplus funds are invested in this industrialized world.)

Meanwhile, sluggish world economic growth; a relatively mild early winter; new supplies from the North Sea, the North Slope and Mexico; and conservation measures have forced OPEC to cut back production. There is also some evidence that the Saudi oilfields have been seriously damaged by salt-water corrosion in the pumps and pipelines, and drops in oil pressure. The Saudis also may have been overstating their exports.

So, the end results of OPEC's first 1977 maneuvers were:

- An initial 10% increase in the price of OPEC oil.
- A final December de facto oil price freeze, initiated by Saudi Arabia and Iran.
- A showing that OPEC was able to weather its worst threat since it found its strength at the end of the 1973 Arab boycott.
- A good indication of just how much influence Saudi Arabia can bring to bear on its OPEC partners: enough to keep them from running wild, but not enough to hold them strictly in line.

If OPEC oil becomes relatively less important, however, OPEC will be under still greater pressure. We believe that OPEC will be strong enough to hold prices, albeit with fewer and smaller increases. □

The Politics of Energy

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As it is currently the locus of the energy debate, the logical place to begin a consideration of the politics of energy is the Congress. There are a number of traditional ways of looking at Congressional divisions. For example, one might think in terms of the House versus Senate, or of Democrats versus Republicans. In the case of energy, however, the most important division lies along regional lines. Basically, it is one of energy-consuming states versus energy-producing ones. This is particularly clear when one considers who the main political actors are on either side of the issue. On the House side, the major actors all tend to be from consuming states, while in the Senate the opposite tends to be the case. A situation such as this was bound to lead to the sorts of differences found in the House-passed and Senate versions of the energy bill. It is these differences which are causing such trouble for the conference committee currently considering the proposals.

There is an oft-quoted truism which holds that there are only two real issues in politics: bread and butter, and war and peace. In the future, however, it is likely that this political axiom will be replaced with one asserting that there is only one issue: energy.

Congressional divisions?

House Speaker Tip O'Neil has been the major force behind the President's proposals. He enjoys a number of advantages over his Senate counterpart Robert Byrd. First, the House has always been far more amenable to following the suggestions of its leadership than has the Senate. Also, many of the committees most concerned with energy are chaired by members from consuming states. Take for example, John Dingell, Chairman of the House Commerce Subcommittee on Energy and Power. Dingell's subcommittee considered a number of the major provisions of the energy bill, including those dealing with natural gas pricing policy and utility rate reform. Dingell represents Detroit, and as such, is deeply concerned with both the maintenance of the viability of the automotive industry, and the continuing supply of cheap natural gas for his constituents. It should not be surprising that Mr. Dingell was a major force pushing for the continued regulation of natural gas prices and against various measures intended to enforce stricter pollution control and efficiency standards for automobiles.

One interesting effect of this regional division was to create some rather strange alliances. For example, Representative Bob Kreuger of Texas, a moderate Democrat, found himself co-sponsoring a natural gas deregulation bill with Representative Clarence Brown of Ohio, a conservative Republican. Tim Lee Carter, a nominal conservative, found himself voting with Representative Wirth, who would hardly be considered one. The differences become even more pronounced when comparing the House with the Senate.

White House and Senate policy

In all fairness, it should be pointed out that Majority Leader Robert Byrd had an impossible task before him. While regional differences played a major role in the development of the Senate's version of the energy bill, Senate traditions and incredibly inept White House lobbying efforts probably had even more of an impact. Further, by the time the Senate began its deliberations, it was becoming increasingly evident that the original Carter proposals contained a number of serious flaws. Chief among these was the total disregard for the development of additional supplies of energy. Had the Administration been willing to admit to this deficiency and offer some sort of compromise, the Senate might have gone along with the bulk of its program. Instead, they chose to stand fast, which may have been a fatal tactical error.

This is particularly true in light of the fact that the tax provisions of the measure, frequently referred to as the "cornerstone of the Administration's plan" had to be approved by the Senate Finance Committee. The Chairman of Senate Finance, Russell Long, is unsurpassed in the Congress in his knowledge of the workings of the oil and gas industries. He, therefore, was bound to perceive the lack of incentives for oil and gas development. Long, however, is a creature of the Senate steeped in its traditions of dialog and compromise. He, therefore, proposed a compromise which would have earmarked the collections of the wellhead tax on crude oil for the purpose of locating and developing additional supplies.

It was here that the ineptitude of the White House lobbying efforts became evident. Reports of unreturned phone calls, sharp exchanges, and refusal to compromise were legion. To what extent they are true will only be known by the individuals involved; however, the fact remains that the Senate Finance Committee ultimately voted out a measure that did not contain any of the tax provisions desired by the President. While it is true that the Senate traditionally has preferred

creating tax incentives to the imposition of new taxes, it is significant that none of the President's energy taxes were in the version of the bill the committee reported.

It should also be noted that the White House did itself no good in the manner in which it handled the natural gas filibuster. The Senate is bound by traditions; most of its members fervently believe that the maintenance of those traditions is essential to the body's ability to function. While the Vice President may have succeeded in breaking the filibuster, he also succeeded in alienating no small number of the Senate's members.

What about the policy process?

One aspect of the energy policy debate which has received relatively little attention centers on the policy-making process within the White House itself. While much effort has gone into portraying this process as the epitome of objectivity, most observers generally concede that it appears far less objective than the Administration would contend. The reason for the apparent lack of objectivity stems from the fact that a significant number of the policy makers surrounding the President came to the Administration from the environmental movement. There has, therefore, been a marked tendency to place the protection of the environment at the head of the list of policy priorities.

The high priority given environmental concerns within the White House policy-making process has led to certain contradictions within their approach to the energy situation. For example, the President has stressed the utilization of our most abundant energy resource: coal. At the same time, however, he has also endorsed and signed strict new surface mining controls, and has also endorsed the strict application of standards for air quality. The simple fact is that both of these actions are inconsistent with a rapid expansion of coal utilization; and together, they present an almost unsurmountable barrier. When one considers that as much as 85 percent of the United States may be in violation of the Clean Air Standard for suspended particulants, the scope of the contradiction becomes evident. It should also be noted that implementation of the new surface mining law will remove as much as 28 billion tons of coal from our reserve base; this is equal to more than 24 times the stated production goal for 1985.

Politics: A Guiding Force

Like it or not, we must face the reality of temporarily shrinking supplies, and all of the economic repercussions associated with serious shortages of any critical material. In a very real sense, the politics of energy will be the guiding force behind the path our nation travels for many generations to come.

Low credibility, unattainability

Contradictory and counterproductive policy positions such as these can only serve to further undermine the already shaky credibility of the President's energy plan. When coupled with the fact that nearly every major private and government analysis of the National Energy Plan has demonstrated that the goals it sets in the areas of conservation, reduction of imports and home insulation are unattainable, the weak position of the plan becomes evident. The only question which remains is: Why wasn't the plan withdrawn for further consideration?

The unattainability of the import goals set forth in the National Energy Plan is a factor of considerable consequence. The reason why this particular aspect of the Plan's shortcomings is so important is that it carries with it an implicit assumption which has far-reaching foreign policy implications. Consider the fact that the plan contains no real incentives for the encouragement of domestic production of oil and natural gas. Then consider the fact that the strict enforcement of environmental controls and surface mining regulations will inevitably reduce the ability of industry and utilities to convert their boilers to coal. The question then becomes: Where will our energy come from? The implicit answer to that question is obviously, from the Persian Gulf Oil Reserves.

However, to insure continuing supplies of Arab oil, we are going to be forced to make a number of crucial foreign concessions to the Arab nations. In fact, it is already becoming evident that such concessions are being extracted. There can be little doubt that the President's recent statements concerning the rights of Palestinians, and the status of the occupied lands were a reflection of concern over maintaining cordial relations with the OPEC countries. It can be assured, that as the level of imports from that part of the world rises, so too will the pressure on the United States. Ultimately, we may find ourselves in the position of having to give up our traditional support of our only real Mideast ally, or suffer from the economic chaos an Arab oil boycott could bring.

And nuclear energy

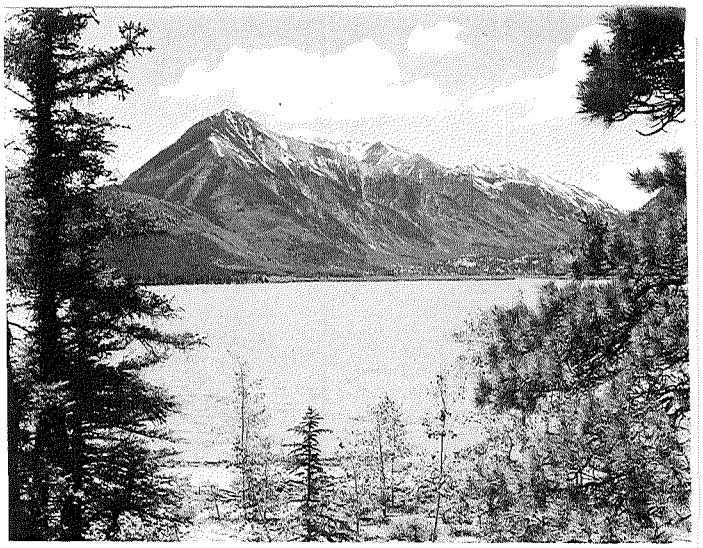
A second major foreign policy implication of the President's energy policy is concerned with issues surrounding nuclear energy. From his April 20th speech, in which he acknowledged a limited role for nuclear power, calling it a last resort, to his November 8th speech, in which he failed to mention nuclear energy as an alternative to be examined, it has become obvious that the President's opposition to the continued development of nuclear power has been increasing. The most significant aspects of his opposition have been the decision to delay indefinitely the reprocessing of spent fuels, and the veto of the Clinch River Authorization bill. These actions virtually assure that the traditional dominance of the world's nuclear energy industry by the United States will disappear.

Presently, it appears inevitable that the other developed nations of the world will rely increasingly on nuclear energy for electric power generation. France, Great Britain, Germany and the Soviet Union are all developing the Breeder Reactor. Germany is planning the commercial reprocessing of spent fuel, as is France.

Currently, the Soviet Union has two Breeder Reactors on line, and has plans for several more. They have also announced that they are moving the target date for demonstration of a hybrid fission-fusion breeder reactor up to 1981. As this particular type of unit is especially efficient in the production of fuel, it could represent a major advance. Further, at a recent conference, the Soviets indicated that they were considering the construction of reactors in the 25,000 to 30,000 megawatt range. These are far larger than anything considered in the West, and would have tremendous economies of scale. Since these reactors would breed far more fuel than could conceivably be used within the Soviet economy, the possibility of their planning on becoming fuel exporters is raised. The implications of this for the West are, of course, serious, especially since the Soviet Union is one of the few countries with large supplies of uranium. □

An Environmentalist Speaks: Where Should Energy Come from in the Years Immediately Ahead?

Michael McCloskey, Executive Director, The Sierra Club



Environmentalists advocate meeting our energy needs in the future through a maximum amount of conservation, with near-term reliance on coal; accelerated efforts to recover more oil from existing fields through tertiary techniques; and by resorting to more unconventional energy sources such as geothermal power. None of these supply sources offers a "free environmental ride." Each has its environmental costs. But the environmentalists want to be selective in picking areas and techniques to minimize adverse environmental impacts. Are their goals realistic? Is all this compatible?

The search for an answer to our national energy dilemma has been a slow and agonizing one. Three presidents have proffered solutions, which have varied widely. Each time Congress has had its own ideas, though a body of programs has gradually begun to take form. And as it has, the nature of the problem has also emerged in sharper relief: our domestic production of oil and gas is declining and will be dramatically reduced by 1990; our reliance on imported oil continues to grow, with no end in sight; and domestic use of energy continues to grow at rates which compound from year to year, though at a somewhat reduced pace.

The environmentalist's position

In responding to this picture, environmentalists have stressed the need to reduce growth rates through a vigorous program of energy conservation. They have embraced programs which would reduce growth to 2% or less per year. With such reductions, future energy needs might be cut in half. Demand would be curtailed through a combination of measures which would dampen consumption through higher prices and induce consumers to install more efficient equipment. Much of President Carter's program is directed toward such ends, though it remains to be seen how much of it will survive. At this point, one would not want to bet on much more than increased incentives for solar power and insulation, though hopefully some form of improved incentives for automotive fuel economy will also emerge.

Various supply scenarios have been drawn for future dates which reflect the thinking of environmentalists. It may be worthwhile to compare a few of them to gain some perspective on the subject. The "Zero Energy Growth" scenario of the Ford Foundation's Energy Policy Project looked forward to leveling off growth rates by the year 2000, with only a 15% increase in supply by 1985. On the other hand, a low-growth scenario, which just came out by a group at the University of Wisconsin, looks forward to the possibility of actually decreasing total energy use by the year 2000, with levels of use remaining constant through 1985. President Carter's National Energy Plan hopes to hold increases in demand through 1985 to no more than 20% above the current level of consumption. The President's plan would almost double coal production, but keep oil imports from increasing. The Ford Foundation scenario would only slightly increase coal production by 1985, but would look to tertiary oil recovery to actually expand oil production. It sees geothermal and solar energy beginning to phase-in by then, with more significant increments (7%) by the year 2000. The Wisconsin study also sees coal production almost doubling but not until the year 2000, though it sees domestic oil production declining after 1980. It sees a strong future for low-temperature solar power, wind and geothermal energy, but these contributions would only become relatively significant after the second decade of the next century. By the middle of that century, it sees almost one-third of all energy coming from such unconventional sources.

Obviously, anyone can play with growth rates and supply mixes to suggest any kind of energy future. No one really knows what the future holds. But it is worth noting that considerable thought has been given to low-growth energy futures, and that they feature certain common themes: increased reliance on coal; declining primary production of oil; a limited future for nuclear power; and an important future for renewable energy.

The perspective of environmentalists toward these themes arises out of their innate suspicion of nuclear power, their preference for benign sources such as household solar applications, and their realization that coal supplies are plentiful while oil supplies are limited. We will describe our perspectives, in particular, on increased coal production, enhanced oil recovery, and geothermal development as examples of the tradeoffs environmentalists seem willing to accept in their supply scenarios.

Nuclear: Source we can do without

At the outset, a word must be said about nuclear power. Environmentalists believe it represents a premature deployment of a kind of high

technology that is too socially expensive. There is still no established system to permanently safeguard radioactive wastes; experts are still divided over the safety of lightwater core cooling systems; and the world can ill afford the dangers that illegal diversion of fissile materials poses. Operating performance has been far from satisfactory, and few utilities are ordering them anymore. For most of the country, coal is competitive with nuclear power. With little more than 3% of our power coming from nuclear plants, it represents a power source that we can still do without.

Coal: We can deal with it

The problems with coal are real, and they are plentiful, but many of them are familiar problems. In any event, they are ones we will have to live with. Fortunately, we have enough coal to allow us to be discriminating in selecting the best methods to increase our production, whether it be to one billion tons or a lesser figure.

The problems involved with burning coal can be largely handled by installing scrubbers, or other equipment which represents the best available control technology, as required by law. Over 100 utilities have now ordered them. Older plants can burn low-sulfur coal. There are over 30 billion tons of it in the East, most of which can be deep-mined. Future power plants should be sited wherever possible in areas which have attained compliance with Federal air quality standards. Siting will have to be limited in areas with air quality which exceeds the secondary standards.

Coal mining is burdened with problems in all three of the provinces which can most easily expand production: the Illinois Basin, Appalachia, and the Northern Great Plains. However, there are fewer new and unsolved problems in the Illinois Basin and Appalachia than on the Northern Great Plains. Future production east of the Mississippi will be increasingly from underground sources (where 60% of the deep-mine reserves are found) as strippable reserves are exhausted. In the Illinois Basin, for instance, 40% of the strippable reserves have been mined out. Surface mining there should be focused on the southern half of the basin where the farmland is only half as productive. In Appalachia, production should be focused on deep mines south of the "hinge-line" in West Virginia, where there is less likelihood of acid-mine drainage. Surface mining generally will be less destructive in the gentler terrain north of that line, where erosion tends to be less pronounced.

Production from the Northern Great Plains should be far less than forecasted earlier because of the BACT requirement that was reaffirmed in the 1977 amendments to the Clean Air Act. It will restore the market for eastern coal. Production that does occur should be concentrated around communities like Sheridan and Gillette in Wyoming where the seams are thickest, site productivity the least, and social impacts have already been felt. A "go slow" policy on expanded surface mining in this province is indicated because of the unknowns about the long-term viability of reclamation efforts. It is not clear whether reclaimed areas can survive periodic drought cycles. Moreover, there has been almost no success to date in restoring forests of Ponderosa Pines on hills that have been mined. In addition, there are special problems in this arid region with mining that interferes with subirrigated alluvial valleys, springs, and aquifers. It is far from clear that such water systems can be restored.

Further leasing of substantial amounts of Federal coal should await resolution of these problems and testing under the new "Surface Mine Control Act." There are already 28 billion tons of Federal coal under either lease or preference right application, to say nothing of billions more under state, individual, and private leases.

Oil: Problems with offshore

Let us turn now to the subject of oil. As oil production has moved offshore in search of new oil fields, environmentalists have become increasingly concerned. In making this transition, the locus of production has become one burdened with unique problems: the ocean medium can quickly spread leaked oil; juvenile and larval forms of sea life are particularly vulnerable to injury; the oceans and the seabed are public resources; and the oil must be transported across an ecologically fragile coastal zone. The most biologically productive areas of the ocean are the surface layers near the coasts—the very ones being exploited for oil. The most pervasive problems are: (1) damage to the coastal zone through poor siting of onshore holding facilities; (2) low-level chronic leaks from offshore oil facilities; and (3) occasional blowouts.

In certain localities, offshore oil development poses conflicts because of such factors as earthquake risks, unstable geological formations in the seabed, threats to areas with special biological values such as sponge or oyster beds, or the impact of visibility on onshore communities. The absence of adequate coastal planning and management in some states, and the dearth of good baseline data, have made it difficult to deal with these problems. Hopefully, Congress will pass new legislation at last to provide a stronger mandate for environmental planning in the OCS leasing process.

The Sierra Club has not been opposed to further OCS leasing, as such, but we do want an OCS reform act passed first, and we want leasing directed toward the less vulnerable areas. Areas with conspicuous problems such as George's Banks, the Georgia Embayment, and certain waters in Alaska should be taken off the leasing schedule. Until better baseline data are used as the basis of planning sales; more research on oil pollution has been completed; and a more well-planned coastal regulation comes on line, there should be only a modest leasing program of hundreds of thousands of acres each year, not millions.

But there is a more environmentally acceptable way to increase oil production onshore in old fields through the use of enhanced or tertiary oil recovery techniques. Currently, the techniques used to remove oil from field reservoirs leave about 70% of the oil in the reservoir, with only 30% recovered. Of the 300 billion barrels of oil in place in known fields which cannot be reached by primary and secondary recovery techniques, estimates of further recovery by tertiary methods range from 7 billion to 110 billion barrels. Oil company estimates tend to run in the 15-25 billion barrel range, while estimates of Federal agencies and their consultants range between 15 billion and 65 billion barrels. Estimates differ widely because of variations in knowledge of field geology, differing perceptions about the rate at which the technology will improve, different assumptions about the likelihood of Federal incentives, and as a function of the prevailing price of oil and needed rates of return. Most projections suggest that a major expansion in enhanced recovery is not possible before 1990, which is also the date by which recovery by conventional techniques should fall to less than 2 million barrels per day

(from today's 8.2 million bpd).

Environmental problems posed by future development of enhanced recovery techniques do not appear to be severe, but require careful attention. It is well to bear in mind that enhanced recovery programs are directed at areas that have *already* been heavily developed. Emphasis needs to be placed on air pollution control devices for thermal operations and on policing abandoned fields. Oil is burned to produce steam for thermal flooding techniques. This combustion produces air pollution, with sulfur dioxide emissions posing the most challenging problem.

A number of the chemicals which may be used in enhanced recovery, particularly micellar-polymers, are toxic and may be environmental hazards if they reach aquifers or surface waters. While operators would have financial incentives to prevent loss of chemicals from a contained reservoir, nonetheless leaks may occur. The well casing may break, or there may be unknown drainage channels from reservoirs. Chemical solutions, such as micellar-polymers, will also require large quantities of water for reservoir flooding. As many as 19 barrels of water may be needed to produce one barrel of oil. Availability of this much water may be a limiting factor in arid regions.

The primary methods of oil production will probably be in massive decline by 1990. It is vital that they be offset by sharply increasing tertiary recovery output. For that to happen, a mounting level of advance investment in tertiary development must be made in the next few years. There are real problems in inducing oil companies to invest large sums of capital ($200 billion or more in the next 25 years) in front-end financing commitments for tertiary recovery which will not be recovered for long periods (6-19 years for field development). The public interest in resource conservation suggests the Federal Government should develop incentives to make sure tertiary techniques are applied in the optimum manner and with the right timing.

Geothermal power has problems too

Geothermal energy is a major energy resource in certain parts of the country, and the technology for dry steam development is clearly demonstrated. It may play an increasingly important role in our energy future, but it is not without its problems.

Estimates of potential development by 1985 range from 4000 MW_E to 132,000 MW_E, and by 2000 from 30,000 MW_E to 800,000 MW_E. The high estimates assume rapid technical breakthroughs and ample Federal encouragement. The range in estimates means that anywhere from 0.5 to 15% of the country's electrical supply might come from geothermal sources. Presently, only .1% comes from that source. In California, which has the greatest potential, the percentage could get as high as 20-30% by 2000. The average of these estimates for 2000 is around 200,000 MW_E.

Overall, environmental problems with geothermal development are not as severe as those posed by alternative supply sources, but in specific instances the problems can be severe. Development of 200,000 MW_E by 2000 would mean that about 9% of the United States' electricity would come from geothermal sources, and about 4.5% of its total energy supply. A geothermal development is a major industrial facility, and the suitable sites are often in remote areas with high natural values. As many as 8000 acres can be involved in a large complex, as well as long transmission lines, with as much as 20% of the area enduring heavy impacts which remove all or most of the ground cover. In the process, wildlife habitat is destroyed, migration routes severed, and erosion triggered.

The environmental problems stemming from such development involve basic questions of site compatibility and operational effects. Moreover, problems of a different character are posed by the various phases of development: exploration, operation, and abandonment after operations terminate. Most discussions to date focus on operational problems and ignore siting questions, as well as the damage done by random but unsuccessful exploration, drilling, and what happens in the way of rehabilitating the site once the operation closes down.

About half of the known geothermal resource areas may be burdened with problems involving the compatibility of developing the site and nearby natural values. Many sites in the West are near wilderness areas and wildlife refuges. While the Geothermal Steam Act of 1970 exempts wildlife refuges and National Parks from development, it leaves Forest Service Wilderness Areas open to development, along with Wild Rivers, National Trails, natural areas, primitive areas, and roadless areas. Moreover, development can dry up surface thermal phenomena of esthetic interest such as geysers, hot springs, mud pots, and fumaroles. The Interior Department has been slow to recognize these problems, and it has done little to collect baseline data in advance and to require slant drilling to protect surface resources.

Geothermal fluids are produced in the millions of gallons daily in an operating field, and they normally contain toxic substances, such as ammonia, arsenic, boron and mercury. Pollution of surface waters with these fluids has been a recurrent problem at the Geysers in California. Air pollution is a serious problem because geothermal vapors can contain a wide variety of polluting gases, including hydrogen sulfide, arsenic, fluorides, ammonia, radon and mercury. These gases can be released from a cooling tower. Levels of hydrogen sulfide at the Geysers are 16 times the toxic level. Scrubbers and other control technology are needed to prevent degradation of air quality. Blowouts may also pose a danger of sudden, unexpected releases of noxious gases. Also, problems of local fogging may occur because of steam releases.

High noise levels are reached in and around geothermal developments, both in the drilling process (up to 126DB[A]) and in operations, due to periodic venting (up to 199DB[A]). This noise is caused by steam escaping at high pressures.

The withdrawal of ground fluids can lead to subsidence of the land surface. Earth subsidence can cause considerable property damage and would destroy irrigation canals in a place like the Imperial Valley where the canals depend on gravity flow. Experts hope that subsidence can be prevented by injecting fluids, but it is not known whether reinjected fluid, which will be cooler, will return to the same strata. Areas with geothermal potential tend to be located in areas of high seismic activity. Reinjection of fluids could lubricate fault planes and trigger minor earthquakes.

None of the above mentioned supply sources offers a "free environmental ride." Each has its environmental costs. But we can be selective in picking areas and techniques to minimize adverse environmental impacts. If we can find a way to make conservation work well enough, we can then gain the time, experience and knowledge to make intelligent choices in meeting energy needs in the years ahead. □

A View of the Petroleum Industry

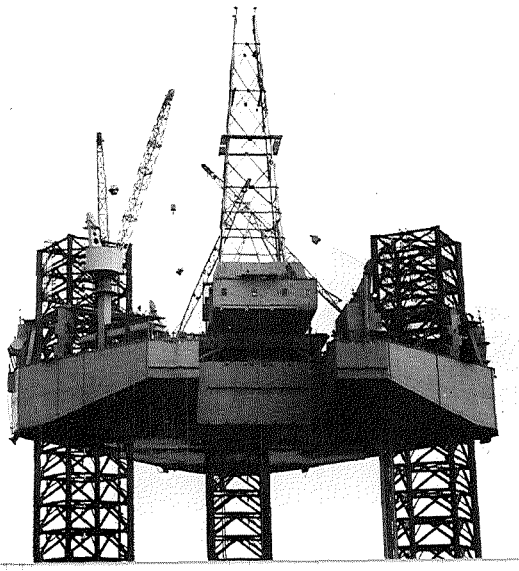
Anna W. Crull, Southwest Correspondent

It would be presumptuous to out-of-hand express the view of so large and so diverse a group as the American petroleum industry. What will be reflected are the views and interchanges expressed by petroleum industry leaders during the November 1977 meeting of the American Petroleum Institute (API) in Houston.

The petroleum industry is much more than gasoline. It is, for one thing, a large part of the American public. About one and one-half million people are directly employed in the industry. Another two million Americans are shareholders in just six large oil companies. Another 12 million Americans participate indirectly in these six large companies through mutual funds and similar investments. Millions more own interests in smaller companies within the industry or in related service companies. All of these Americans, together with their dependents, comprise a sizable segment of America. The United States petroleum industry is a lot of things. What it is not is "The Seven Sisters" skulking along in inner sanctums to dominate the consumer. Behind the intricacies of specific gravities, premium discounts and buy-backs, the petroleum industry is not without its black marks. It is also without much understanding among those that would administer the industry or by the majority of those that use its products.

Whose judgment?

The most bandied word of the API 1977 meeting was "naive", meaning "lack of informed judgment." John Swearingen, newly-elected board chairman of API, described the current Federal Administration as being "naive" about energy. James Schlesinger, Secretary of Energy, claimed the Carter energy program offered "generous incentives" for exploration of new oil and gas. Continuing he said, "Indeed in our naiveté, we had expected some grudging acceptance, even a degree of enthusiasm" from the oil industry. But there is some hope that an effort to obtain knowledge and understanding will set a new tone for national energy policy. There are some positive things to say about the United States oil industry. There is no inherent wrong in being big or with doing what you do in an efficient and profit making manner. That is supposed to be what free enterprise and "the American Way" are all about. One of the rocks thrown at oil company executives is that they make large salaries each year. So do professional athletes, movie stars, rock and roll singers in a few weeks or a few hours of effort. Of course, bigness may lead to some monopolistic excesses. It is the incipient condition that is probably the real problem.



Myth and reality

Drilling for oil is a high risk business. A shallow onshore well costs from $100,000 to $1,000,000 and many times a million dollars for an offshore well, even in the Gulf of Mexico. About two-thirds of the 9,234 exploratory wells drilled in this country last year were dry. A small derrick rig drilling in the Gulf of Mexico costs upwards of $12,000 a day just for the rig and men. Costs are typically $23-25,000 per day. Pipe for even a small well can cost half a million dollars. To get oil and/or gas out of the Gulf of Mexico costs about $1.5 million just to drill and case a well. That estimate does not include the cost of the lease, the discovery or production figures. That's just to drill. These figures are brought out by oilmen because they feel the general public and the Federal Government is "naive" about the high cost and high risk of their jobs. From geologist to roustabout, the oil game does not seem like one of "obscene profits". It takes upward of five years from the time an oil company gets an offshore lease until the first oil or gas goes ashore, if there is anything to send. That's talking about offshore Gulf oil. Oil from the North Slope is much tougher and much more expensive. Even if oil or gas is found there may not be enough to make the development a commercial success.

The phrase "commercial success" tells it all in terms of price regulations and what the oil companies think about them. The API was less than impressed when Mr. Schlesinger told them that, "The oil industry loves regulations." What the Secretary meant was that the oil industry wanted regulations that worked in the industry's favor. What he succeeded in doing was further convincing the API that the Washington bureaucratic system was unknowledgeable about the petroleum industry and the mechanics of producing and marketing petroleum products.

Mr. Schlesinger sought to destroy what he called the "mythology" surrounding Government views toward the oil industry. He said it was a myth that the people in Washington do not believe there is any more oil and gas "out there." "We read the same publications," he observed. According to Mr. Schlesinger other myths include: The Carter energy plan lacks incentives for developing additional supplies of oil and natural gas; and the people in Washington have it in for the oil industry. Instead, he suggested that the oil industry had paranoia. The last myth to be attacked was the view that the energy plan is heavily weighted in favor of conservation versus production. "This is a colossal exaggeration," said Schlesinger.

The oil industry sees most of the "myths" as "realities". What the oil industry sees is an industry that has been seeking only moderate returns on huge investments. The industry sees itself as so competitive that the largest producer accounts for less than 9% of total output; the largest

refiner has only 8% of total capacity; and the largest marketer makes only 8% of major product sales. The oil industry sees itself as a competitive business that pays wages and gives benefits well above the national industrial average.

A reality for the petroleum industry is the advance of technology. Pipelines have come a long way since the first venture in 1865 in Pennsylvania. Expertise in technology has developed a superior refining industry. In 1920, a refinery could obtain only 11 gallons of gasoline and related products from a barrel of crude oil. Today the yield is 19 gallons of gasoline on the average from each 42-gallon barrel of oil. More than 3,000 chemicals are made from oil and gas to form the basis of the plastics industry, for detergents, fertilizers, fabrics and rubber. The output of petrochemicals accounts for over half the total volume of organic chemicals manufactured in this country and requires only about 5% of domestic crude oil and natural gas production.

A reality for the petroleum industry is that the discovery and development of our nation's potential reserves of oil and natural gas will not be maximized if prices are artificially frozen below the cost of alternate fuels. The petroleum industry believes that the freezing of prices will ultimately cost the consumer more than under a realistic free market price system. Re-regulation is not deregulation and a tax program is not a sound energy development program. Natural gas price controls do not solve the natural gas shortage.

A look at Washington: An indictment

The view of the petroleum industry is that the "moral equivalent of war" has been declared, not on solutions to the energy crisis, but on the petroleum industry. The Federal Government has fostered the idea that the oil companies are a forceful foe, cunning and greedy. The oil companies have proven combat experience against the Sierra Club, the State of Alaska, and "whoever bought and paid for Texas." Oil company allies include the Arabs, 20 million stockholders and employees, Texas, Detroit, and everyone with a car. The feeling is that for Washington to obtain victory, the industry must be destroyed in order to save it.

An Energy Department has been created, and officials and employees are being hired to work there. Some 20,000 employees will be needed, some from other federal jobs, others for the first time. Clerks, lawyers, accountants and assorted "energy experts", who give the impression that they could not get jobs with Exxon or Gulf, will now gladly spend the rest of their lives telling Exxon and Gulf what to do. This will cost $10.4 billion in the first year the new Department of Energy operates. That is more than the combined profits of our country's largest oil companies. The oil companies think it is a myth when Mr. Schlesinger tells them about dismantling parts of the energy bureaucracy to "make it more efficient." Somehow they just don't think it will happen that way.

Maurice Granville, board chairman of Texaco, Inc. said, "Our industry and this institute remain ready to cooperate and consult with Government in setting a proper energy course. It is with disappointment and some bewilderment that we have not been able to establish an ongoing relationship with the Government that effectively funnels our industry's vast experience into the Administration's planning. The expertise and know how of the energy industry, which in other parts of the world is regarded as one of this nation's greatest assets, has not been put to productive use here in the United States."

Most of the petroleum industry views what is going on in Congress in the guise of an "energy bill", not as an energy bill, but as a tax bill. Estimates within the petroleum industry indicate that the price the public pays for gasoline will increase by over 15¢ a gallon by 1981. The Federal Government will tax the public about $48 billion on petroleum by 1981. This crude oil equalization tax will not yield any more oil or gas; nor will the creation of a new cabinet position.

To be sure, the petroleum industry is not going broke just yet. Maybe it is involved in some self-pity and maybe not. The agreement is that the "people in Washington" are indeed naive about energy production and utilization. It is not a myth that the mechanisms for handling energy through the bureaucracy are growing faster than the energy supplies. Both sides are frustrated. And the public is more than a little frustrated when they realize that somewhere along the line they are being "had" by both sides.

And other views

George Bush, former United Nations ambassador and the U.S. delegate to the People's Republic of China, told the API that the entire world is waiting to see if the United States has the "will to solve its energy problem." Bush allowed that the energy package in the Congress was worked out too quickly and was "hurriedly conceived." Carter's proposed energy program is "too negative" and "steeped in adding tax to people already overtaxed," Bush said. Katharine Graham, publisher of the Washington Post, said that the Congressional conferences, held to hammer out an energy program, are "beginning to look like the moral equivalent of the Vietnam war." Ms. Graham said that the petroleum industry is so complex that most laymen have trouble understanding it, and that part of the public "blocks out the message." There was no indication that the petroleum industry really has any quarrel with any of those views.

Past policies regulating the price of petroleum and natural gas have had their flaws. The attitude persists that if these policies are tinkered with, the supply situation will change. The current situation certainly needs some tinkering, but that is not what really bothers the petroleum industry. A cohesive blend of policy and investment incentives that will direct to the American people an assured source of supply, reasonable conservation measures, environmental guarantees, and inflationary impact safeguards is desired. The petroleum industry does not feel that "the big cost scare" is sound logic.

This "cost scare" logic would have sky-rocketing costs and no one would be able to pay for needed oil and gas. The big cost scare would even have interstate gas costing what intrastate gas already costs.

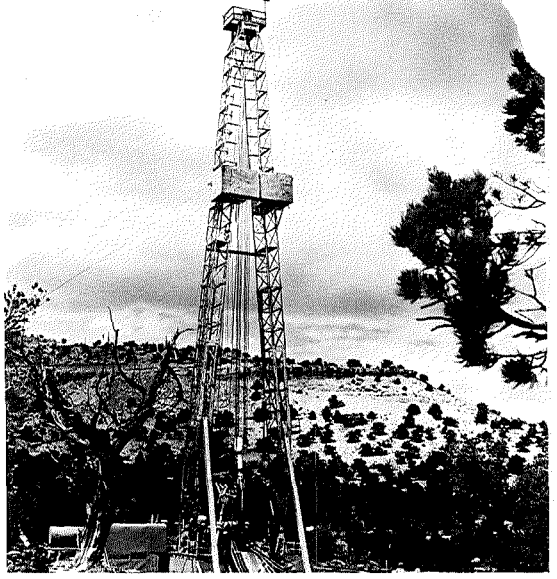
Drilling: tough and not understood

The understanding of the technology of drilling for natural gas and petroleum is often limited in the layman's mind and often in the agencies regulating the industry. Most of the non-land drilling in this country is done by drilling contractors. Contractor performance requires financial strength and stability on the part of the drilling organization. If the drilling contractor is to bid for drilling jobs, he must have the capability to send men and machinery great distances with equipment that will function effectively under unusual conditions. This capability has been achieved through partnerships, mergers, and incorporation. Operating companies have found it profitable to utilize the men, equipment, skills and experi-

New Petroleum Capacity

The American Petroleum Institute reports that capacity of U.S. oil refineries at year's end was 16,944,137 barrels per day (bpd), and increase of 545,765 bpd over a year ago. The survey also indicated that by the end of next September, U.S. refining capacity is expected to grow to 17,146,107 bpd, an increase of 201,970 bpd. Among the major expansions of refinery capacity expected to be completed by the end of next September are the following:

- a 45,100 bpd addition to Texas City Refining at Texas City, Texas;
- a 40,000 bpd addition to Good Hope Refineries at Good Hope, Louisiana;
- a 23,000 bpd addition to the Cities Service Oil Co. refinery at Lake Charles, Louisiana;
- a 25,000 bpd addition to the Atlas Processing (Pennzoil) refinery at Shreveport, Louisiana.



ence of drilling contractors. Drilling contractors must be competitive in prices and services to stay in the business.

The drilling contractor bids for the job of making a hole for the operating company. The contract is on the basis of the best bid, which is based on past performances and proven capacity and capability. There are many other contracts that the operating company awards directly to service and supply companies. All of these related operations may run into a hundred additional employees at one time or another at one well site. That would be for "easy" onshore oil. To drill offshore and in greater and greater water depths, under more and more adverse conditions makes for greater expenses and even more difficult manpower arrangements.

Most oil does not just flow out of the well; at least not in the U.S. In the early years of this century, the oil companies roamed the world in search of their booty and found the mysterious fluid often with little trouble. At times the world rocked under the economics of a crude oil glut. In Saudi Arabia, the oil flows from the ground with little assistance and there are only two pressurized wells in the kingdom. Most of our domestic crude is encouraged from the ground with artificial lift. Acidizing operations pump from fifty to several thousands of gallons of acid under pressure into wells to create greater porosity in carbonate rocks. The acid travels down the tubing and enters the perforation points. If the production zone is not cased, then it migrates out into the pay zone directly. Often sandstone formations contain oil and gas in commercial quantities, but the permeability is too low to permit good recovery. "Fracturing" may be used to increase the permeability to a practical level. This consists of forcing a sand/fluid suspension into the formation and literally cracking it open. Done properly the formation is opened, the grains of sand remain, propping open the cracks while the suspending agent flows back out. This leaves the formation with greater permeability and enables the gas and oil to flow into the hole. This is still under the category of "easy" oil, without encountering any real production problems. Crude oil *per se* is of little value and must be transported to a refinery to be transformed into gasoline or petrochemicals. Misconceptions abound that tend to equate "energy supply" with gasoline and ignore the costs and expensive technology that go to locating, drilling, and producing a barrel of crude oil and/or associated gas.

Major oil reserves are known on nearly every continent, including the continental shelves, gulfs, bays and marshlands. Each discovery brings new drilling problems, and thus far, the development of new solutions. New locations bring problems of getting in the drilling equipment and supplies, and how to deal with ice floes, tidal currents, waves and storms, and changes in governmental policy. Not every attempt at a new technology is successful. Last year, underground caverns formed by nuclear explosions were sealed and abandoned to mark the end of attempts to recover through nuclear explosion the large natural gas resources of western Colorado. The gas simply cannot be commercially produced by conventional or other means. The large explosions did increase the flow of natural gas, but the production was not enough to justify the expense of the technique. Other finds of natural gas in Oklahoma are 15,000 feet straight down. To get this natural gas, one must drill three miles into the Deep Anadarko Basin which covers 12,000 square miles in western Oklahoma and the Texas Panhandle. There could be over 100 trillion cubic feet of natural gas in the basin. A deep well is any hole below 15,000 feet and requires from one to two years to drill.

Some of these super-depth wells have become super producers. The cost is also super. A study of the Anadarko Basin indicates 1,150 wells have the capacity of producing the energy equivalent of one million barrels of crude oil in a lifetime. State regulations limit the daily production of each well, based on a percentage of the potential maximum daily production of the well. In Texas, the daily ceiling is 25% of the potential maximum and in Oklahoma it is 50%. The average rig and cost for one day of drilling in the basin is $8,000 at the lesser levels.

Temperatures in the deep basin normally are 250°F with pressures of over 20,000 psi. Only one or two per cent of the drilling cost is in salaries. The gas producers feel that to take extraordinary risks, they have to have a chance of making some profit, even extraordinary profits. Most of the money for the drilling is borrowed at 12 to 15% interest. Every producing well must make enough to offset a portion of the cost of drilling a dry hole. The drillers in the Anadarko Basin feel they must have deregulation of new gas. The independent drillers feel that deregulation of new gas is so obviously in the best interest of the country that it will come about.

No one is too sure what "new gas" really means. The Administration's original definition of onshore new gas was "that found 1,000 feet deeper than the deepest completion location and 2.5 miles or more from any old well." This eliminates a substantial percentage of geologically new gas. The new definition merely adds a third category that includes newly discovered reserves which must be certified as such by state and federal agencies. □

Energy Outlook: Coal as a Fuel

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Adapted from a paper presented at
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We should produce 1.0-1.3 billion tons of coal by 1985, if we are to prevent this country from becoming overwhelmingly dependent upon insecure, high-priced supplies of foreign crude oil and refined products. Our increasing dependence upon the Middle East as the source of this crude oil should be of immediate and serious concern to all Americans. Meeting the one billion ton goal is going to be very difficult. But we do not see any signs that those in charge of our energy program understand the magnitude of the task facing us in order to reach that coal production goal. Even worse, other Government agencies, such as FTC, EPA and MESA, have been acting and are continuing to act in a way which prevents the coal industry from achieving the 1985 goal.

Coal, which represents 90% of our total fuel resources, must be allowed to play its very important role in supplying fuel for electric power generation, as well as the other essential uses. We not only have to remove all the obstacles which now prevent the coal industry and all other fuel energy industries from producing at their maximum capabilities, but we must also prevent the Congress from breaking up these industries.

How to reach our goals

In order to increase the U.S. coal production to the 1 billion ton per year level by 1985, we must not only determine what is needed directly in the form of capital, manpower, equipment and similar requirements but we also need to determine what other actions need to be taken directly and indirectly and what restraints there are from an environmental, legislative, political and social standpoint. Having determined what these are, we then must study how these obstacles and restraints can be removed, how long it will take to remove them and what alternative approaches there are to solving the problems we perceive.

Sulfur dioxide limitations

The sulfur dioxide limitations imposed by EPA have already resulted in a reduced rate of coal production in the Eastern and Mid-Western states because of the high-sulfur content of the coal in these states. Further reductions have been forecast in the study for the USBM by ADR Services. This study shows the following declines for the states shown for utility coal, comparing 1978 with 1973.

District	
02 Western Pennsylvania	— Down by 21.2%
06 Panhandle West Virginia	— Down by 55.5%
11 Indiana	— Down by 3.3%
12 Iowa	— Down by 15.7%
16 N. Colorado	— Down by 79.7%
24 Anthracite-Pa.	— Down by 12.1%

In order to offset this loss of eastern coal production, and at the same time nearly double coal production by 1985, the game plan is to mine western coal and ship it East by rail and pipeline if these can be built. But it is foolhardy to write off, even in part, the eastern and midwestern coal mine capacity and capability and production especially when the coal consumption is in these same areas and its production in these areas will minimize coal transportation. Yet the forecasts by ADR show that eastern and mid-western coal production destined for electric utilities is expected to decline by 32 million tons per year by 1983 compared with 1973 (Table 1).

The sulfur dioxide problem can be solved in a number of ways. The easiest and cheapest way is by the use of intermittent control systems. However, EPA and Congress refuse to approve of this method. As a result, the requirements for low sulfur coal are increased by ten times over what they would be if intermittent control systems were allowed.

The confusion which has resulted from Federal and State air quality laws has prevented electric utilities from making future commitments for coal. As a result, coal companies are not making the commitments to new coal mines either. Many of the new mines which are listed as planned in current forecasts have already been delayed due to environmental suits and other restraints.

There are many similar problems which will prevent coal production from reaching 1 billion tons by 1985. These include the following:

1. Clean Air Act of 1970
2. Federal Mine Safety Act of 1969
3. Federal Leasing Regulations
4. Transportation Facilities
5. Technical Manpower
6. Mine Labor
7. Equipment Availability

The development of a network of activities (showing the relationship of each activity to all other activities) would prove that EPA regulations with regard to sulfur dioxide will prevent new eastern coal mines with high sulfur coal from ever being developed and in time will shut down all mines currently in production with high sulfur coal. Likewise, environmental suits and leasing delays will prevent new western coal mines from ever

Source: National Coal Association

Table 1

Partial List of Sources: Eastern and Mid-Western States Utility Coal (Million Tons Per Year)

State	1973 Use	1978 Forecast	1983 Forecast
E. PA	33.5	45.4	40.3
W. PA	9.8	7.7	7.8
N.W. PA	21.0	23.4	16.3
Ohio	38.7	38.5	31.8
Panhandle, W.Va.	8.8	3.9	3.8
W.Va., VA	1.1	1.4	0.9
W.Va., VA, KY, Tenn.	75.2	82.4	65.1
W.KY	48.1	51.1	46.4
Illinois	53.5	58.0	51.3
Indiana	24.6	23.8	18.4
Total	314.3	335.6	282.1

Decline Under 1973: 32.217

being developed.

We also need to determine how many additional tons have to be mined due to the lower heating value of the western coals. Coal with a heating value of 8,000 Btu per pound will require 50% more tons to give the same heating value as eastern coal with a heating value of 12,000 Btu per pound. This means that we really will need 1.25 billion tons of coal by 1985 instead of 1.0 billion tons if half the coal is to come from the western states.

As a result of the overkill provisions in the Clean Air Act, over 50% of the coal being burned by electric utility power plants is non-complying coal due to its high sulfur content. It is obvious that the Clean Air Act has to be amended to allow the burning of high-sulfur coal.

The SNG industry?

Faced with the above obstacles to mining enough coal for conventional uses, it is difficult to see how we can develop a synthetic fuel industry based on coal unless we make it more attractive from an economic standpoint. The consumption of coal and the capital investments required are very large, as shown in Table 2.

Consumption of coal will amount to approximately eight million tons per year, per plant, each with a capacity of 250 million CF/day.

The February 1976 FEA forecast for coal-based SNG plants shows a total of 16 million tons per year of coal requirements by 1985, implying that two SNG coal based plants will be in operation and producing 0.16×10^{15} Btu per year. The AGA October 11, 1976 report in "Prospects to the Year 2000", shows the following forecast of the production of SNG from coal and petroleum:

	10^{15} Btu/Year	
	1985	2000
SNG-Coal based	0.4	2.5
SNG from Petroleum	0.4	0.5
Total	0.8	3.0

The AGA forecast for coal gasification in terms of numbers of plants and coal consumption is as follows:

SNG-Coal Based	1985	2000
10^{15} Btu/yr	0.4	2.5
Number Plants	5	31
Million Tons Coal/yr	40	248

(Note: This assumes that each plant produces 0.08 TCF/yr. and requires 8.0 million tons of coal per year).

We will not be able to develop a synthetic fuel industry based on coal until the price of natural gas reaches its true market value. An interstate price ceiling of $0.52 per Mcf which the FPC imposed a year or so ago or the new ceiling price currently at $1.45 per Mcf, prevents natural gas from reaching its real market value of between $2.00 and $3.00 per Mcf. Gas from coal cannot compete at these artificially low prices for natural gas. Therefore, the first priority is to remove the wellhead ceiling price from natural gas. After that is done and the real market price for natural gas is determined, the question of whether synfuel is real or an illusion can be answered.

Low and medium Btu plants

We should remember that low and medium Btu gas from coal should be considered as lower cost alternatives to pipeline quality high-Btu gas. For one thing, the capital investment for low Btu gas plants is lower than the high-Btu gas plants.

As the natural gas shortage worsens it is inevitable that many industrial plants will install their own coal gasification plants to produce a low or medium Btu gas for process use and boiler fuel. Since their plants are capable of burning gaseous fuels, the installation of coal-based gasification plants will make them self-sufficient and will give them a domestic source of fuel to rely on.

The estimated cost of gas from the low-Btu gasification plant using coal with the following prices is shown below:

Cost of Coal ($/ton)	Gas Cost ($/Btu $\times 10^6$)
$20.00	$2.37
30.00	2.92
40.00	3.48

(Data from Holley, Kenney, Schott, Inc.)

U.S. industry is heavily dependent upon natural gas for energy. In 1975, gas provided over 40% of the energy used by industry compared to 26% for oil and 20% for coal. If more natural gas had been available, much more could have been sold; some forecast as much as eight trillion cubic feet this year, or an increase of 40% over current levels.

The fuel shift

As a result of this shortage of premium fuel, industry is shifting fuels at an accelerating rate. In the short term during the next two to five years, the shift is predominantly to oil. However, for the longer term, five to ten years, the shift is to coal and electricity. The type and magnitude of the fuel and energy shifting varies widely from industry to industry.

In a recent survey prepared by Stone & Webster Management Consultants for the Edison Electric Institute, of 142 companies in the 15 most energy intensive industries surveyed, 114 companies indicated they expected a shortfall of certain types of fossil energy. When these respondents were asked what fuels they expected to be in short supply, 126 responses were made: 113 anticipated natural gas shortages, 11 expected oil supply problems, and two questioned the long-term availability of electric power. Clearly, the natural gas industry has a problem of trying to hold on to their existing industrial customers who have been curtailed at ever increasing amounts during the past five years. All signs point to a continua-

Table 2

Capital Costs of Coal-Based SNG Plants[1]

Process	Plant Installed Cost ($ Million)	Plant Installed Cost ($/Mil. Btu-Day)	First Year Gas Cost ($/Million Btu)	20 Year Average Gas Cost
Hygas Steam-Oxygen	870	3,867	3.55	2.71
CO_2 Acceptor	890	3,956	4.25	3.38
BI-Gas	1,020	4,533	4.44	3.45
Lurgi	1,060	4,711	4.25	3.22
Hygas Steam-Iron	1,280	5,689	4.97	3.83
Synthane Slurry Feed	1,150	5,111	4.81	3.70

[1] C. F. Braun & Co., Alhambra, CA assessment as reported in AGA *Gas Supply Review*, Sept. 15, 1976.

tion of these curtailments under the present regulatory climate.

The natural gas industry may soon, if not already, find itself in a situation in which its industrial customers are running away from it faster than the available supply of natural gas is declining. Under these circumstances, there will be an excess supply of natural gas—not a shortage. Therefore, closer ties between the natural gas industry and its industrial customers must be set up and maintained. The biggest single action which will help the entire supply-demand relationship in natural gas is to decontrol the wellhead price of all new gas. Until this is done, we can expect to see irrational actions.

Nuclear power, which now accounts for about 3% of our total energy consumption, (about 12% of the total electric generation) has to be allowed to grow rapidly in order for it to provide its share of energy which will of course be based on domestic uranium reserves. Do not be misled by politicians who announce that nuclear power should be used only as a last resort. The fact is that without nuclear power neither the United States nor any of the industrial nations of the world can long exist as industrial nations. The sooner our leaders recognize this fact, the faster we can start solving our energy problems.

Table 3

Coal Gasification Investment Requirements

Daily Output (Btu × 10^9)	Vessels (No.)	Total Capital Invest. ($ Million)	Invest./ Mil. Btu/Day ($)
A. Low-Btu Gas Plants (175-200 Btu/cf)[1]			
2	1	6.0	3,333
4	2	9.5	2,639
8	4	15.0	2,083
12	6	20.0	1,852
16	8	25.0	1,736
20	10	29.0	1,611
24	12	34.0	1,574
B. Medium-Btu Gas Plants (350 Btu/cf)[1]			
8	4	20.0	2,778
C. High-Btu Pipeline Gas Plants (Lurgi)			
250		1,060.0	4,771

[1] Data from Holley, Kenney, Schott, Inc. of Pittsburgh, PA, based on use of Woodall-Duckham coal gasification process.

Details on coal availability

The United States is fortunate in having one of the world's largest reserves of coal. Total measured and indicated reserves of coal in beds over 28 inches thick and under less than 1,000 feet of overburden totaled 434 billion tons as of January 1, 1974. Of these reserves, 297 billion tons were considered underground reserves and 137 billion tons capable of being mined by surface mining.

Geographically, 47% of these reserves occur east of the Mississippi River with the remaining 53% in the Western States and Alaska. Three-fourths of the strippable coal and one-half of the coal which can be mined by underground methods are west of the Mississippi River. Since the recoverable reserve figure is the most important number, the above reserve tonnages have to be divided by two based on 50% recovery in order to show recoverable reserves. After taking into account the deductions from reserves due to losses in mining, the total amount of recoverable reserves amounts to 148.5 billion tons of underground coal and 68.5 billion tons of surface coal reserves for a total of 217 billion tons.

To further amplify on just one of the above obstacles to increasing the U.S. coal production, the average underground productivity of U.S. coal mines increased from 10.64 tons per manday in 1960 to a high of 15.61 tons in 1969 and has been dropping steadily ever since to a level of 9.50 tons per manday in 1975 and down to 8.5 tons per manday in 1976. It should be noted that the Federal Coal Mine Health and Safety Act was enacted in 1969 and it is no coincidence that coal productivity has been declining ever since. As a result of the impact of the Mine Safety Act and labor unrest on underground mining productivity, the coal industry has, in effect, lost 40% of its deep mine capacity during the period 1970-1976. This has had the effect of eliminating over 200 million tons per year of productive capacity. We, therefore, have to develop 200 new coal mines each with a capacity of one million tons per year at a cost of $30 million to $50 million per mine to bring capacity back to what it was before the Mine Safety Act was enacted.

Major obstacles to increasing coal production

It really does not make any difference whether we have 300 years of reserves of coal or 3,000 years of reserves. Congress has made it impossible to mine coal, and has made it illegal to burn half of what is being mined. The reasons for our inability to expand coal production are very simple and should be understood by everyone.

First, the only new coal mines which are going to be developed will have to be financed on the basis of take-or-pay contracts with prices sufficiently high to attract the capital needed for the investment. Profits as high as $10 per ton are required to finance new deep coal mines today. Secondly, the take-or-pay contracts which are required to finance these mines have to be for long enough periods to amortize the investment in the mine, so 20-year or longer contracts have to be entered into. Thirdly, these new mines are going to take six to eight years to develop in the case of underground mines and three to five years in the case of surface mines.

In recent years, Congress has entertained the idea of passing laws prohibiting or severely limiting the surface mining of coal. If a total prohibition were to be put into law, it would eliminate 32% of all the coal reserves in the U.S.

The Clean Air Act has had the effect of prohibiting the burning and thus eventually the mining of much of the underground coal which has over certain sulfur levels. Only 11% of the eastern coal reserves contain 0.7% or less sulfur. Most of this coal is low-volatile metallurgical coal, unsuitable for burning in electric power plants and, in any event, more valuable for the production of coke required for steel-making.

If as much as 5% of the eastern coal reserves are available for use as low sulfur fuel for utilities, and if this is all that can be counted on for power generation due to western coal leasing problems and low heating value to sulfur content ratios, this could mean that only 5% of 102 billion tons (5 billion tons) or enough to last eight years could be available for mining.

It will be impossible to expand the U.S. coal industry to a level of 1.0 to 1.2 billion tons by 1985. This fact is slowly being recognized by our leaders in Washington and you will soon start to see lower estimates of coal production being forecast for 1985. For example, figures of 1,000 million tons including 100 million tons for export by 1985 are now being circulated. But unless an authority begins to understand what even this lower level of production means in terms of the job to be done, even this lower forecast will not be attained.

For example, if the present coal production capacity of 635 million tons is to be increased to 1,000 million tons by 1985, we have to increase the mine capacity by 365 million tons plus the mine capacity which will be depleted at the rate of about 3% for eastern coal capacity a year or 15 million tons per year which is 150 million tons of capacity in 10 years. The total additional new capacity is therefore 515 million tons. If we assume that 300 million tons will be western coal, this will require 60 new 5 million-tons-per-year mines in the Western States. The balance of 215 million tons per year could be obtained by developing 80 new 2 million-tons-per-year underground mines and 28 new 2 million-tons-per-year surface mines in the East. This schedule, which calls for constructing 168 new large mines by 1985, needs to be compared with the number of new large coal mines which have started producing coal since 1965.

According to 1976 data, there are only 22 U.S. coal mines with a capacity of two million tons per year or more which started producing coal since 1965. Of these, only two mines produce more than five million tons per year. When the list of large coal mines in operation in 1975 is examined without regard to when the mine first started production, we find that there are only 45 coal mines which produced two million tons per year or more and only four of these mines exceeded five million tons.

Table 4

Annual Production of Coal in the U.S.

(million tons)

Year	3%/yr. Increase	2%/yr. Increase	Actual
1975	635	635	648
1976	654	648	679
1977	674	661	673
1978	694	674	—
1979	715	687	—
1980	736	701	—
1981	758	715	—
1982	781	729	—
1983	804	744	—
1984	829	759	—
1985	853	774	—

If we exerted a superhuman effort and if we removed all the roadblocks and obstacles to developing all the new coal mines which we need, we would probably still fall short of this revised and lower forecast of 1,000 million tons per year by 1985. Since I see no hope that anyone in Washington either understands the problem or in fact seems to care, I believe it will be impossible to attain a level of coal production of 1,000 million tons by 1985. The 1975 production level of 635 million tons was only 1% higher than the 1974 production, when the loss in production due to the 1974 strike is taken into account.

Table 5

NCA Forecast on U.S. Coal

(million short tons)

	Actual 1976	Forecast 1977	Forecast 1978
Electric	446	447	508
Coking Coal	84	80	84
General	61	70	75
Retail	7	7	7
Total Domestic	598	634	674
Canada	16	16	17
Overseas	43	38	39
Total Exports	59	54	56
Grand Total	657	688	730
Production	679	673	730

Note: The National Coal Association Economics Committee issued the above forecasts on December 21, 1977 for U.S. coal consumption and production for 1977 and 1978.

If we were able to achieve a 2-3% net increase per year from 1976 through 1985, we would reach a production of 774 to 853 million tons by 1985. It is interesting to note that the average increase in coal production during the period 1960-1975 was 2.6% per year. The actual increase for 1976 was 2.6% over the 1975 production. The 2% annual increase, resulting in a production level of 774 million tons by 1985, would still require the development of new mine capacity totaling 289 million tons per year, based on 139 million tons for new net increase and 150 million tons per year due to depletion.

Since this coal industry expansion will require huge sums of capital, as much as $25 billion at the extreme, the coal industry must have the high profits and cash flow required, plus an assured long-term market for their coal before any new coal mine expansion can begin.

As we can see from the recoverable reserve figures, we have many years' supply of coal if we are allowed to mine it. But unless a commitment is made to coal by our Government which will remove the restrictions already in place and prevent other restrictions from being placed on the industry, this coal will not be mined regardless of how many years there are of reserves.

In order to fully comprehend the serious nature of our energy situation, we must look at where we get our fuels and energy now, and how we expect to get them 10 and 25 years from now. The United States consumed a total of 78 quadrillion Btu's in 1975 or 30% of the total world's energy consumption. The sources of energy in the United States in 1977 in absolute quantities were as follows:

Fuel	Quantity
Bituminous Coal & Lignite	670 Mil. Sh. Tons
Anthracite	5 Mil. Sh. Tons
Petroleum Products	
From Crude Oil	5.4 Bil. Bbls.
From Other Sources	.7 Bil Bbls.
Natural Gas, Dry	19.8 TCF
Natural Gas, Liquids	584 Mil. Bbls.
Electricity, Water Power	250×10^9 KWH
Electricity, Nuclear Power	250×10^9 KWH

□

Nuclear Energy: New President, New Department, New Direction

Douglas C. Bauer,
former Director, Division of Nuclear Research and Applications, U.S. Department of Energy

Based on a speech submitted to Energy magazine

Light water reactors produce about 12 percent of the Nation's electric power today and are perceived to be essential, at least for this century, to help provide a major source of central station electric power. However, success has been uneven. Areas of uncertainty encompass both the front and back ends of the fuel cycle, including extent of uranium resources, reprocessing of fuel, and waste management and disposal. Light water reactor technology also has not met the hoped for levels of reliability and maintainability needed. The time has come to reassess both the direction and underlying assumptions of the nuclear power program.

It became apparent as the nuclear power age progressed that some of the more optimistic projections for nuclear power were not going to be attained: it was not going to be "too cheap to meter;" it was not going to be introduced at such a rate that over a 1000 GWe of nuclear power would be installed by the turn of the century; it was not likely to achieve capacity factors of 80 percent; and there were increasing concerns by small but influential groups concerning the safety, reliability, economics, environmental and safeguard aspects of nuclear power. These different concerns found a focus and a sounding board in the procedural requirements of the National Environmental Policy Act (NEPA) for providing Environmental Impact Statements not only on individual plants but even on entire programs.

Nonproliferation programs

A major element in the redirected nuclear program to limit the spread of sensitive technologies and facilities, which allow access to directly usable weapons material, is the International Nuclear Fuel Cycle Evaluation program (INFCE) and its concomitant United States based program, the Nonproliferation Alternative Systems Assessment Program (NASAP). The NASAP has been set up to develop recommendations for U.S. Department of Energy research and development nuclear priorities, as well as to provide technical support to the INFCE. It is the major DOE effort directed toward evaluating fuel cycle alternatives.

The program is well into its initial phases of selection of candidate systems; development of evaluation criteria and methodologies; and characterization and evaluation of each system. Performance of comparative assessments for particular countries and regions, integration of the evaluation effort, and ranking of alternatives are still to come before the development of recommended programs and priorities is completed about a year from now. To accomplish this effort, the NASAP program, which was launched late in FY 1977, was budgeted for $2 million in FY '77 and $11 million in FY '78.

Reactor program redirection

Breeder reactor program. In line with this new emphasis in the nuclear power area, the President has made some profound decisions in the current nuclear energy program which are embodied in his National Energy Plan. These relate primarily to the Liquid Metal Fast Breeder Reactor program. The President has proposed the cancellation of the Clinch River Breeder Reactor program and deferral of work on the reprocessing of nuclear power reactor fuel. The intent of these actions is to defer a U.S.

commitment to advanced fission technologies that are based on plutonium. While these recommendations are being weighed by Congress, and to the extent permitted by law, the breeder program has been redirected toward the development of alternative breeders, advanced converter reactors and alternative fuel cycles, with an emphasis on nonproliferation and safety concerns. A broad-based R&D program will continue, but a number of breeder program support facilities previously planned will be delayed in the light of the program re-examination and stretchout. However, the Fast Flux Test Facility at Hanford, Washington will be completed and used for fuel studies pointed toward development of proliferation-resistant fuel cycles.

That the reorientation in the breeder reactor program is indeed major is reflected in the Presidential request for budget authority reductions in the breeder reactor program of $203 million dollars (from $686 million in FY 1977 to $483 million in FY 1978). The reduction is even more dramatic when it is compared to the January 1978 Presidential request for the program of $855 million.

Light water reactor program. The President has also determined that the current commercial nuclear power system, the LWR, is needed at least for this century, and installation of about 380 GWe of capacity by the end of the century is desirable.

To this end, he has directed that efforts be made to simplify and shorten the licensing and regulatory procedures and to improve the reliability and availability of light water reactor technology. Programs to accomplish these goals are being formulated and some are already underway. The effort in this area is two-pronged, involving a Light Water Reactor technology improvement program and legislative initiative to reduce the complexity and time involved in the licensing process.

The major deficiencies in LWR reliability and operating experience relate to greater than expected outages caused by equipment failure, maintenance and testing, and refueling. While much of this is expected and unavoidable, the magnitude is greater than it need be and can be significantly reduced. For example, equipment failure is causing 20-30% of all outages, maintenance and testing 18-20%, and refueling 30-40%. Perhaps a more revealing way of looking at these numbers is to note that scheduled outages consumed 15-19% of the available time at nuclear plants in 1975-1976 and forced outages 12-13%. This resulted in availability factors in the 70% range and capacity factors of about 63-66%.

Gas reactor program. While the program in current breeder and LWR technology is being revamped, the utility industry is also indicating renewed interest in gas cooled reactor technology as a possible attractive alternative to meet some of the weapons proliferation concerns. A significant reorientation in the Gas Cooled Reactor program has taken place. There is renewed interest in the High Temperature Gas Reactor (HTGR) operating on a low-enriched uranium fuel cycle, and a planning program has been initiated with $380,000 devoted in FY 1978 toward characterizing the low-enriched uranium fuels which might later be irradiated in the Fort St. Vrain reactor. The Gas Cooled Fast Reactor program is also being redirected toward the U-233/thorium fuel cycle using denatured U-233/U-238 fuel. This program will be conducted in close cooperation with, and under the leadership of, industry.

Fuel Cycle Technology

There are serious deficiencies in the front and back end of the fuel cycle technology. In keeping with the actions taken in the reactor programs, the nuclear fuel cycle program is being redirected toward alternative fuel cycle technologies including increased emphasis on the thorium fuel cycle. The objective of the Department of Energy programs in support of the nuclear fuel cycle is the development of safe, protected processes which will foster the contribution of the nuclear fission power option to the Nation's energy economy through maximum utilization of nuclear fuel resources. There are two major programs to achieve this objective. One is designated Support of the Nuclear Fuel Cycle and the other is termed Commercial Waste Management.

Work will also be performed on the HTGR fuel recyle technology needed to recover and recycle U-233 from spent HTGR fuel, with particular attention to the fuel cycles involving the use of low and medium enriched uranium and denatured uranium fuel to minimize the potential for nuclear weapons proliferation. A program is under way to provide the fuel processing data required to allow effective utilization of the extensive thorium reserves of the United States and abroad within the guidelines of the Administration's nonproliferation policy.

A total of $104 million has been authorized in the FY 1978 budget for Support to the Nuclear Fuel Cycle, an increase of $84 million over the FY 1977 budget of $60 million.

Commercial waste management program. With respect to the Commercial Waste Management program, the strategy is to develop and design processing and long-term isolation or terminal storage concepts for radioactive waste or spent fuel from the commercial nuclear power industry. This program is divided into three subprograms: Terminal Storage; Spent Unreprocessed Fuel (SURF) Facility; and Waste Processing R&D.

The objective of the National Waste Terminal Storage (NWTS) subprogram is to provide the technologies and facilities to meet Federal responsibilities for long-term management of radioactive wastes from the nuclear fuel cycles of commercial nuclear power reactors in use and those that may be introduced in the future. The strategy of the research and development program is to provide an operational facility for the terminal storage of either spent fuel elements or waste from reprocessed fuels by 1985. The NWTS program has been structured to pursue investigations in multiple geological formations and geographic locations. The selection of the specific site for the first geological, waste repository is not scheduled to be completed before the end of FY 1979.

This objective of the SURF Facility program is the interim storage of spent fuel from United States commercial nuclear reactors. The spent fuel will be stored at the SURF Facility until a decision is made on reprocessing or disposal as radioactive waste. It is currently planned that the SURF Facility will be available to receive spent fuel in 1985 and will eventually be sized to receive, package, and store all of the spent fuel discharged from United States commercial nuclear power reactors through 1990. The work performed under this program will identify and develop the necessary technology, demonstrate the storage method, and design and construct the facilities to receive, package and store spent fuel.

The third major element of the program, Waste Processing R&D, develops the technology which will be

Six Nuclear Realities

Dr. Leslie G. Cook, Consultant
Adapted from a paper presented at
Energy magazine's First Annual International Conference on Energy
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Governments can plan, but all plans change. What will eventually happen to nuclear? Who knows? Some people are in a position to make better prognostications than others. Here is what one expert thinks. He has been associated with fission as long or longer than anyone who is now active. Here are the realities according to Dr. Cook.

First Reality: There is no way we can see ourselves into our energy supply future without nuclear electricity. Not even through the next ten years. Nuclear power is in for surging growth as soon as the present state of semiparalysis is brought to an end by blackouts and brownouts, teaching us that electricity does not come like manna from heaven, but has to be earned.

Second Reality: Nuclear power stations are good neighbors. They require less land around them than coal stations; have no unsightly and dusty coal and ash piles beside them; have no stacks emitting products of combustion or pollutants; and, in fact, emit less radioactive material than a coal plant does. Those who complain about nuclear plant are always outsiders, it seems, and never those who are enjoying or know they are enjoying the benefits. Nuclear plants will in fact take over electricity generation not only in the U.S. but in the Western World. By eventually I mean within about 40 years, beginning, of course, with base load on which it has already made major inroads.

Third Reality: There is growing concern over the problem of proliferation of nuclear explosives capability. There are over 30 countries with nuclear power stations operating or under construction. Denying ourselves electricity is not going to impede the international development at all. In any case, military plutonium is awkward and expensive to get out of power reactors. There are much simpler and easier reactors preferred for this purpose, and so far, everyone who has set off nuclear explosions has used these simpler reactors. The plutonium from power reactors requires greater technical sophistication to make a useful explosive. Anyone with that sophistication knows enough to build and use the simpler reactors, and will do so. Power reactors must be fueled with expensive fuel element assemblies, and the supplier of these, whoever he is, has a good check on possible diversion of plutonium, if he chooses to control it. The problems of proliferation will be controlled, if they are controlled at all, by political and military measures, and not by prohibiting the use of nuclear electricity generation. This is for the very simple reason that this is the only combination that can be effective.

Fourth Reality: Of the uranium we mine, 99.6% does not burn in our present type of reactor. If we had to remove 99.6% of all the coal and oil which was unburned that we put into our burners, just because we had forbidden ourselves to develop the burner technology to use it, we would think we were mad. Yet that is what we are doing with uranium concerning the breeder. We already have enough uranium stored, already mined, to equal the entire coal reserves of this country. And it sits in Government storage sites while we argue whether or not to develop the type of reactor that would use it: the so-called breeders.

We will be breeding plutonium fuel from all this uranium and be using it before too long, because we have no other choice for getting economic electricity to fuel our technological economy. We will probably have to wait until the blackouts and brownouts begin before we come to our senses. Meanwhile, Britain, France, Russia and Germany are developing the technology anyway; France already has a production model under construction. So if we delay much more, we may have to purchase the technology from them, a possibility of which France is pleasantly aware.

Fifth Reality: Since fuel reprocessing is essential in the breeding operation, it will be done. After all, it has already been done for 35 years successfully both in this country, the United Kingdom, Russia, China, and even in Canada. So there is no intrinsic technical problem.

Sixth Reality: There is no question but the uranium supply will be inadequate and will result in higher prices and trouble within the next 25-30 years, so long as we persist in using reactors that can only use one third of one percent of the uranium we mine. This may be great business for the mining industry, but it can only be described from a national point of view as technically and economically stupid. We will indeed see high prices and shortages of uranium in the next 20-30 years until we wake up and start to use the uranium we have already mined, after which there will be no shortage of uranium for at least many, many centuries.

needed to convert radioactive wastes from the commercial nuclear fuel cycle to stable packaged forms acceptable at the Federal repositories for long-term management. In FY 1978, studies will continue on alternate technologies to evaluate the effects of the alternate fuel cycles being considered for control of nuclear proliferation. This will provide information leading to a decision on implementation of radioactive waste management options.

The commercial waste management program has increased in budget authorization from $88 million in FY 1977 to $181 million in FY 1978.

Other changes?

These are by no means the totality of changes underway. The dramatic decision to shift new enrichment capacity from gaseous diffusion technology to centrifuge technology is a case in point. Standing in the wings awaiting successful development are yet more advanced isotope enrichment technologies: molecular, atomic and plasma processes which can potentially complement both the gaseous diffusion and centrifuge methods. The President is determined to make good on his pledge to make enrichment services available to all who require them.

Another area is the National Uranium Resource Evaluation (NURE) program which is intended to provide a comprehensive assessment of U.S. uranium resources and expand our ability to develop the Nation's uranium supply. □

Natural Gas Projections Related to Price

The name of the game in the natural gas industry is how much gas will be available, when, where and at what price? The gas industry believes that the President's original proposed pricing policy for new domestic gas of $1.75/mcf and increasing at about 7.5%/yr is just not good enough. The American Gas Association analysis, for example, indicates that this pricing policy will eventually result in a slight increase in domestic production relative to continuing FPC Opinion 770A, but significantly less than could be achieved under deregulation. Short-term and long-term, the AGA proposes deregulation as the most effective way of increasing production. Either way, it is price that counts.

Worldwide, natural gas production substantially above current levels can be sustained at least until the year 2020, although in the two most mature production areas, North America and Western Europe, production should peak before 2000 and be down substantially by 2020. Worldwide, about 8% of the world's estimated gas supplies have been used (including gas produced to date, proven reserves and estimated undiscovered reserves). North America has used 27.9% of its reserves; exploitation here has been sufficiently intense that 68.5% of the gas produced in the world to date has been produced and used in North America, primarily, of course, in the United States. These conclusions are based on numbers put together by the American Gas Association (AGA) in a report prepared for the World Energy Conference.

Although estimates of remaining recoverable world gas resources vary from 5,145 trillion cubic feet (tcf) to 11,950 tcf, AGA use the 1977 estimate of the Institute of Gas Technology, about 9,650 tcf or (in the terms used by AGA and used in the accompanying tables and charts) 10,500 exajoules (1.0885 tcf equals 1 exajoule). In the U.S., AGA estimates that there are 700-1200 tcf of recoverable gas.

In making its production capacity projections, AGA made no attempt to estimate demand but rather showed production potential, based on additions to proven reserves and the rate at which exploration and development can occur within a region, varying with terrain and offshore depth.

Gas production

In many areas of the world, such as the Middle East, where gas has been traditionally flared, rapid production increases could easily be achieved if demand developed. But the gas could not be used unless domestic demand increased considerably in these parts of the world or it could be exported in the form of LNG.

The Workshop on Alternative Energy Strategies sees a need by North America, Western Europe and Japan to import 7 tcf of natural gas in 1985 and 17.8 tcf in 2000. Worldwide intercontinental trade in natural gas in 1975 came to only 0.64 tcf.

Where available, gas consumption has risen rapidly. In 1950, natural gas consumption in North America was 6.78 tcf, 9% of total North American energy consumption, 91% of world natural gas consumption. By 1975, gas consumption in North America had risen to 24 tcf, one third of North American primary energy and about 68% of the gas consumed outside of Communist countries. Discoveries of gas in the Netherlands in the early 1960's and in the North Sea in the middle 1960's increased natural gas consumption in Western Europe by 30% a year between 1969 and 1972, rising in the U.S. from 2% of total energy in 1960 to 15% in 1975.

In the U.S., the reserve to production ratio (R/P ratio) for natural gas declined from about 17 to 1 in 1966 to about 11 to 1 in 1974, as demand increases exceeded new discoveries. The 11 to 1 ratio is expected to continue. By 1985, according to projections by Workshop on Alternative Energy Strategies, U.S. gas production should be at either 19 tcf or 16 tcf, depending on whether the gas price remains at low regulated levels or not. Either way, it should begin to decline after 1985, falling to 11.4-15.3 tcf by 2000. It projects demand at 18.2-21.2 tcf in 1985, dropping to 16.5-18.7 tcf in 2000. Maximum imports would be 2.54 tcf in 1985 and 5.3 tcf in 2000.

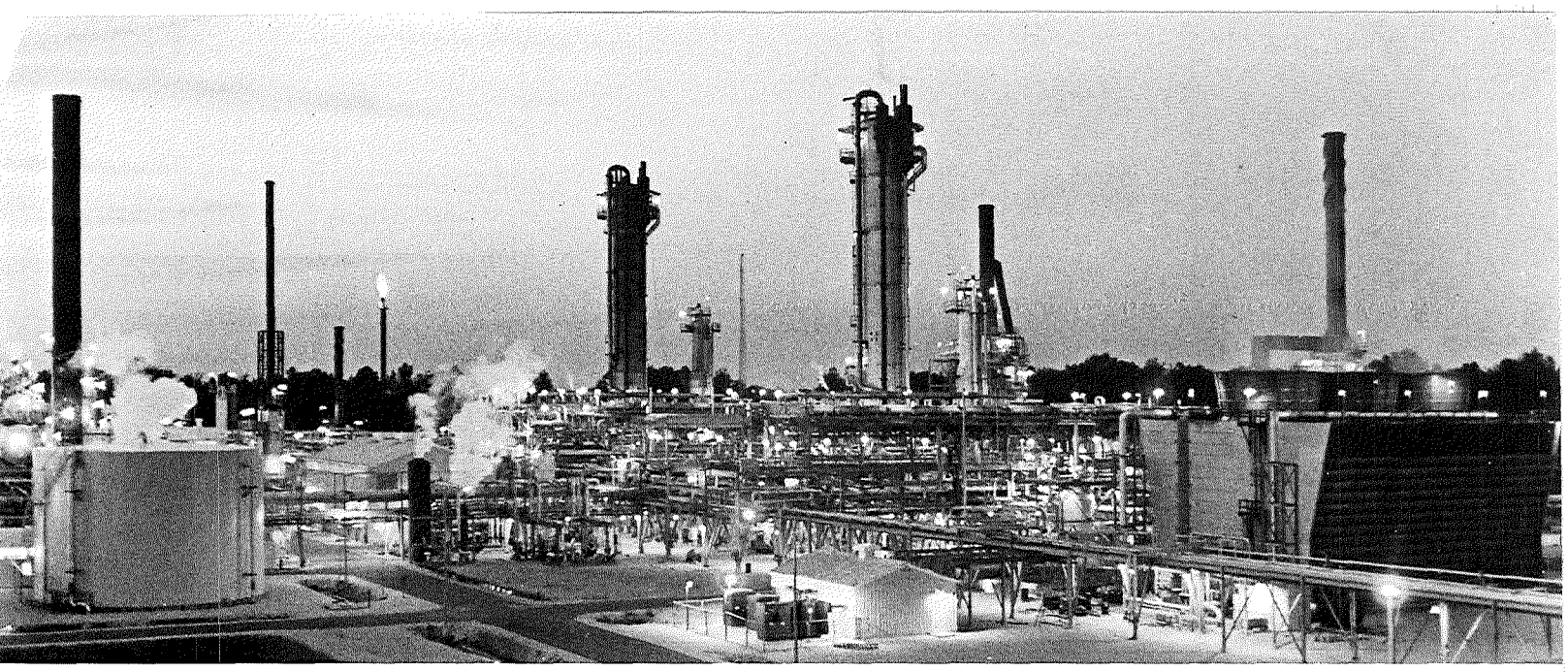
To meet worldwide needs for natural gas in 2000, OPEC countries would have to produce in excess of 31.8 tcf of gas (assuming average losses between the wellhead and consumer through LPG conversion and transport of 25%, thus requiring 21.2 tcf of gas to supply the needed imports of 18.6 tcf, and assuming OPEC internal consumption of 10.6 tcf). The AGA sees a capability of about 51 tcf

Table 1

First Quarter 1978 "New" Gas Price (Based on 4th Quarter 1977 —Average Refiner Acquisition Cost)[1]

Category[2]	*MMB/D*	*Price/ Barrel*
Lower Tier	3.7	$ 5.52
Upper Tier	2.9	12.38
Stripper	1.1	14.84
"New" Oil	0.2	14.84
Average All Wellhead	7.9	$ 9.56
Transportation		0.60
Total Cost		$10.16
Natural Gas Conversion Price/Barrel / Mcf/Barrel	$10.16 / 5.8	= $1.75

[1] FEA projections of controlled crude prices based on initial relaxation of current domestic crude price freeze in July 1977.
[2] Under the President's plan these categories will be redefined: Lower Tier becomes Tier I, Upper Tier becomes Tier II and "New" Oil becomes Tier III.



in 2000, so this should be no problem if the LNG transport functions.

Obstacles to LNG

There are a number of obstacles to the expansion of LNG international trade. Although LNG, like natural gas, could probably command a superior consumer price because of its clean easy handling qualities, producers may be expected to get less than they would for the petroleum liquids they are producing. The difference will be the expensive liquefication and transportation necessary. There is some speculation that OPEC countries will not see enough money in selling LNG to justify exporting a commodity which will compete with their more profitable petroleum. They might prefer to use gas more to replace oil for domestic use or reinject it into oil wells to improve recovery. Also:

- Investment to deliver 16 tcf of LNG, the lowest level that Workshop on Alternative Energy Strategies foresees for the year 2000, would be $70 billion (1975 dollars). Without long-term contracts and assurance of stability of supply and price at the wellhead, neither side would be willing to make that kind of investment.
- Another worry is safety. Explosion of an LNG tanker in a busy harbor would be a catastrophe such as people have been fearing from nuclear power. (This is possibly more likely.) With one such accident, or even without one, the building up of an opposition force similar to that which now plagues nuclear power could bring LNG development to a halt and render investments useless. AGA maintains that LNG can be transported and stored safely.

Table 2

Supply Impact of President's Proposed Ceiling Price On Lower 48 State Natural Gas Production

	Estimated Annual Production (Tcf)			
	1978	*1980*	*1985*	*1990*
Offshore				
FPC 770A	4.1	4.4	5.0	5.2
President's Proposal	4.1	4.4	5.4	5.8
New Gas Deregulation	4.1	4.6	5.7	6.0
Onshore				
FPC 770A	14.7	13.7	11.1	9.4
President's Proposal	14.6	13.4	10.9	9.4
New Gas Deregulation	15.3	15.0	14.3	14.1
Total U.S. Supply				
FPC 770A	18.8	18.1	16.1	14.6
President's Proposal	18.7	17.8	16.3	15.2
New Gas Deregulation	19.4	19.6	20.0	20.1

Table 3

Estimates of Potential Supply of Natural Gas (TCF)

	PGC[1]	Mobil	Exxon	USGS[2]
Growth of Known Fields	266	52	56-321	202
High Degree of Attainment	266	372	203-423	524
Most Likely Degree of Attainment	650	537	398-693	686
Speculative Nature	1,146	752	863-1,143	857

[1] Potential Gas Committee
[2] U.S. Geological Survey

Source: American Gas Association

Other alternatives
Alternatives to a continuing natural gas supply are to convert natural gas into liquid methanol, either to blend into gasoline manufacture or to use for other liquid fuel purposes (a solution for natural gas suppliers); or gasification of coal (a solution for gas users). The AGA believes that the economics favor gasification relative to a new coal-burning generative plant, complete with pollution control equipment. The latter solution is really only an option for North America: Western Europe and Japan would have to import either the coal or the gas.

Deregulation: A major issue
The AGA believes that deregulation of new gas is the only pricing approach which can accommodate increased production costs. It notes that the Administration's new gas ceiling price of $1.75 discriminates against natural gas in that it provides less of an incentive than proposed for new domestic oil, which would escalate over three years to the price of foreign oil. The AGA also makes the following points:

- Production of old interstate gas (pre-1973) under leases which expire after April 20 is not expected to significantly increase above currently expected levels in response to the present maximum $1.45 ceiling.
- Beyond 1985, the effect of the President's new gas pricing proposal compared with continued regulation is expected to be a 0.2 tcf increase in total U.S. gas production in 1985, rising to 0.6 tcf annually in 1990.
- Onshore production would return to currently projected levels under the FPC's Opinion 770A, as prices once more approach those which would have prevailed in the intrastate market.
- As prices are allowed to rise above levels anticipated under present FPC regulation, offshore production would climb above the levels presently expected under 770A.
- FPC reports show that, for the first quarter of 1977, 64% of new contracts and 63% of renegotiated contracts in the intrastate market exceeded the Administration's proposed $1.75/mcf (thousand cubic feet) ceiling price.
- Even more significantly, compared with higher annual gas production expected under deregulation of new gas prices, the Carter plan is expected to result in 0.4 tcf less production in 1978, 1.6 tcf less in 1980, 3.7 tcf less in 1985, and 4.8 tcf less in 1990. □

AGA Makes Some Interesting Points

Importance of Natural Gas to the U.S. Gas currently provides a major contribution to U.S. energy supplies accounting for 27% of all energy consumed in the U.S. and 35% of all energy produced in the U.S. Gas supplies over half of all residences and commercial establishments in the U.S., serving over 44 million customers. Industry also depends very heavily on gas, which accounts for over 40% of all energy consumed. Moreover, the Nation has a very large financial commitment to natural gas with a total utility industry and consumer equipment investment of over $100 billion. Half of this investment is represented by over one million miles of underground gas pipeline and main throughout the U.S. The gas utility industry alone has an annual payroll of more than $3 billion and a total employment in excess of 200,000 people.

Gas Well Completions While total gas well completions in the U.S. in 1976 were at an all-time high, over 85% of the gas wells completed were developmental, as opposed to 16% for exploratory. Exploratory well drilling has shown a consistent downward trend since the late 1950's (after Federal wellhead price regulation was authorized) and has only in the past four years begun to show signs of some increase, although presently it is still at only 60% of the peak level reached in 1956. New gas discoveries have continued to decline largely because the predominance of drilling and well completions is in older, less risky, and less costly areas. These areas are generally onshore and at shallow-to-moderate welldepths.

In 1976, about 95% of all gas wells completed were onshore and at depths of less than 15,000 feet. Drilling cost associated with these wells averaged only about $37/ft. By contrast, only 10% of gas well completions were generally in offshore or deep onshore areas (deeper than 15,000 feet), where drilling costs averaged over $135/ft. Estimated 1977 costs were higher.

Predominant drilling activity and well completions have not been in areas containing new potential, which are generally deep onshore, offshore and Alaska. (U.S. potential gas resources are estimated to be in the 600-900 tcf range, in addition to proven reserves of 216 tcf.) For example, about 90% of all gas wells now completed are in areas and at depths where only 30% of the estimated potential gas resource exists. Even in the case of exploratory gas well activity, less than 4% of the gas well completions were in areas with over 50% of the estimated potential resource.

Supplemental Sources of Gas Increases in production from supplementals could be substantial enough by the 1990's to more than offset declining lower 48 state production of conventional natural gas. By the year 2000, supplemental gas sources, mainly from baseload LNG, coal gasification and Alaskan gas, might provide almost 15 tcf of gas: nearly half of all gas expected to be consumed in the U.S. (Editor's note: This is unlikely.)

High-Btu Gasification On a Btu basis, the end-use costs of energy from coal gasification are still over 40% less than coal electricity, even assuming the most advanced electric heat pump technologies. From the standpoint of overall efficiency of coal utilization, coal gasification is considerably more efficient than electrification, i.e., by 20% to 30%. Also:

- On the basis of capital requirements, a coal gasification plant requires about one-half the investment of a coal electric plant with all the necessary anti-pollution equipment installed. For 250 billion Btu's per day, the capital cost is $1.3 billion for a coal gasification plant compared with about $2.7 billion for a coal electric plant with the same energy output.
- On an environmental basis, in the key categories of environmental residuals (i.e., particulates, SO_2, and NO_x), the generation of gas from coal is expected to be five to ten times cleaner than coal electrification.
- From the perspective of water requirements, a coal gasification plant would use about one-eighth of the amount of water as a coal electric plant on an equivalent energy basis.

DOE Major Contractors and —Special Intervenor List—

List recently obtained from DOE shows who's doing what in operational, process development and R&D contracts. Some of the big sums are for nuclear-type contracts.

A RANKING OF CONTRACTORS BY TOTAL COST Fiscal Year 1977

Contractor	Total Cost
Union Carbide Corp.	1,069,420,539
Westinghouse Electric	326,130,402
Sandia Corp.	324,153,861
Goodyear Atomic Corp.	293,554,797
California, Univ. of, LLL	264,811,043
California, Univ. of, LASL	250,686,349
DuPont, E. I. de Nemours	244,252,901
Westinghouse Hanford Co.	197,742,843
Chicago, Univ. of, ANL	178,962,182
HQ & Nonintegrated	152,548,563
Rockwell Int'l Corp.	113,984,701
General Electric Co.-KAPL	112,393,657
Bendix Corp.	108,309,137
E G & G Inc.	95,899,463
Associated Universities	94,442,410
Reynolds Elect. & Engrg.	88,399,170
Rockwell Hanford Oper.	84,589,464
General Electric Co.	74,381,826
Univ. Research Assn. Inc.	66,015,407
California, Univ. of, LBL	65,864,591
Battelle Northwest Labs	61,467,253
NASA	60,899,062
Princeton Univ.	57,599,650
Monsanto Research Corp.	50,760,204
AL & Nonintegrated	46,451,128
Stanford University-SLAC	46,344,902
Gulf Energy Senvi Systems	43,698,847
United Nuclear Ind. Inc.	43,101,642
Oak Ridge Nonintegrated	33,427,850
Mason & Hanger—Silas Mason	32,632,420
Massachusetts Inst. Tech.	27,608,493
Allied Chemical Corp.	27,410,241
Fluor Engrs. & Cons. Inc.	26,734,515
Combustion Engineering	26,345,316
Burns & Roe Inc.	25,416,998
Garrett Corp.	24,007,386
SR & Nonintegrated	18,867,671
Bendix Field Eng. Corp.	18,549,707
Swinerton & Walberg	18,013,858
Rust Engineering Corp.	17,612,892
National Lead Co. Ohio	17,306,757
United Technologies Corp.	16,405,861
RL & Nonintegrated	16,170,435
Hydrocarbon Research Inc.	16,098,634
Pittsburgh & Midway Coal	14,813,442
California, Univ. of	14,659,545
Ashland Synthetic Fuels	14,404,001
Inst. Gas Technology	14,065,214
Pittsburgh En. Res. Ctr.	14,000,828
CH & Nonintegrated	13,436,132
TRW Inc.	13,421,896
Continental Oil Co.	12,672,817
Foster Wheeler	11,973,782
Duquesne Light Company	11,405,529
Iowa State Univ.—Ames Lab	11,339,810
SAN & Nonintegrated	10,769,066
Wallace-Brown-Olds-Howar	10,738,326
Housing & Urban Dev. Dept.	10,499,853
Aerojet Nuclear Co.	10,398,229
Oak Ridge Assoc. Univ.	9,751,415
Exxon Res. & Engng. Co.	9,590,718
Curtiss Wright Corp.	9,462,259
NV & Nonintegrated	9,391,458
Jones, J. A. Construction	9,385,160
Laramie En. Res. Ctr.	8,934,994
National Academy Science	8,766,495
ID & Nonintegrated	8,750,607
BCS-Richland Inc.	8,491,758
Rochester, University of	8,333,449
Morgantown En. Res. Ctr.	8,257,537
Bituminous Coal Research	7,878,888
Battelle Memorial Inst.	7,706,650
Mitre Corp.	7,091,669
KMS Fusion Inc.	7,080,000
National Bureau standards	6,795,501
Army, Dept. of	6,521,424
Commonwealth Res. Corp.	6,275,625
Clinch River Office	6,162,230
Jones Boecon	6,109,250
AVCO Everett Res. Lab	5,939,761
Parsons, Ralph M. Company	5,891,575
Stone & Webster Eng. Corp.	5,796,915
Navy, Dept. of	5,795,635
Lovelace Fdn. Med. Research	5,721,672
Tennessee, Univ. of	5,659,564
Illinois, Univ. of	5,600,995
Environmental Prot. Agcy.	5,551,215
Holmes and Narver Inc.	5,407,090
Aerospace Corp.	5,354,070
Wisconsin, Univ. of	5,301,510
Bartlesville En. Res. Ctr.	5,183,020
Wackenhut Services Inc.	5,136,641
Agriculture, Dept. of	5,084,949
Pope, Evans & Robbins	5,004,806
Gilbert Associates	4,939,401
Utah, Univ. of	4,918,102
Dow Chemical Co.	4,609,836
Texas, Univ. of	4,438,859
California Inst. of Tech.	4,429,973
Braun, C. F. & Co.	4,393,648
Catalytic Inc.	4,330,499
Auerbach Oper. Svcs. Corp.	4,283,237
Honeywell Inc.	4,225,859
Marathon Oil Co.	4,212,879
Southern Co. Services	4,171,659
Martin Marietta Corp.	4,141,054
McKee, Robert E. Inc.	4,126,702
Yale Univ.	4,076,826
Washington, Univ. of	4,051,190
New York Univ.	3,908,790
Commerce, Dept. of	3,888,191
UCLA School of Medicine	3,886,867
Maryland, Univ. of	3,840,928
Coalcon	3,780,095
Interior, Dept. of	3,768,019
Purdue Research Found.	3,603,205
Occidental Oil Shale Co.	3,500,000
Columbia Univ.	3,409,081
Gippels Associates Inc.	3,301,554
Carnegie Mellon Univ.	3,298,522
Chicago, Univ. of—FMMRI	3,298,509
Morrison Knudsen Co. Inc.	3,251,999
Stanford Res. Inst.	3,215,537
Chrysler Corporation	3,199,875
Titan Southern States	3,150,000
McDonnell Douglas Corp.	3,140,484
GJ & Nonintegrated	3,139,304
Pennsylvania State Univ.	3,137,377
Montana Energy	3,137,209
Stanford Leland Jr. UNVR	3,112,023
Cleveland Consolidated	3,071,093
Michigan, Univ. of	2,931,585
Osborne-Hodges-Roberts-W	2,930,014
Defense, Dept. of	2,762,182
Columbia Gas System Serv.	2,728,971
Mechanics Research Inc.	2,711,798
Mobil Research Develop.	2,705,434
Booz Allen & Hamilton	2,638,225
Kaiser Industries Corp.	2,604,900
Puerto Rico, Univ. of	2,595,193
Computer Science Corp.	2,573,322
Sundstrand Energy System	2,496,700
Bechtel Corp.	2,452,113
Ford Motor Co.	2,451,443
Northrop Corp.	2,410,580
PNR & Nonintegrated	2,376,182
Occidental Res. Corp.	2,371,085
Cornell Univ.	2,332,219
Hunt Building Marts, Inc.	2,269,808
Georgia, Univ. of	2,262,115
Pennsylvania, Univ. of	2,256,180
Harvard Univ.	2,247,200
Geological Survey	2,291,912
Ramco Supply Inc.	2,185,164
Goodyear Aerospace Corp.	2,170,804
Science Applications	2,147,480
Teledyne Isotopes Inc.	2,109,712
Mechanilad Technology	2,096,705
Resource Planning Assoc.	2,095,990
Black & Veatch Engrs.	2,034,491
Colorado State Univ.	2,001,535
Mississippi County Comm. Col.	2,000,000
Grand Forks En. Res. Ctr.	1,991,455
Notre Dame, Univ. of	1,986,168
Stearns-Roger Fab. Inc.	1,969,232
Air Force, Dept. of	1,967,321
Minnesota, Univ. of	1,930,631
C-E Lummus Co.	1,905,000
Commonwealth Assocs. Inc.	1,871,981
Battelle Columbus Lab.	1,860,080
Babcock & Wilcox Co.	1,855,523
Michigan State Univ.	1,832,113
Thermo Electron Corp.	1,815,229
Los Alamos, County of	1,800,000
SNR & Nonintegrated	1,790,726
STD Research Corp.	1,775,415
Fluidyne Engineering Co.	1,771,118
Tiptun & Reynolds	1,770,000
Oregon State Univ.	1,759,582
Virginia, Univ. of	1,743,584
Johns Hopkins Univ.	1,699,847
Georgetown Univ.	1,668,696
Long Beach, City of	1,651,054
Little, Arthur D. Inc.	1,572,127
National Coal Board	1,569,774
Chicago, Univ. of	1,564,547
Colorado, Univ. of	1,559,677
Cities Service Oil Co.	1,549,210
Illinois Coal Gas Grp.	1,530,000
Midwest Research	1,514,151
Reynolds, Smith & Hills	1,509,896
North Dakota, Univ. of	1,506,069
RMI Company	1,481,691
Case Western Reserve U.	1,457,868
Ashland Oil	1,438,791
American Technological U.	1,424,725
Waste Management Inc.	1,375,147
International Bus. Mach.	1,364,791
Southern Cal., Univ. of	1,362,553
Fenix & Scisson Inc.	1,345,755
Georgia Inst. of Technology	1,344,178
Taylor-McDonnell Const.	1,326,517
Sundstrand Corp.	1,322,000
Lockheed Missiles & Space	1,307,285
Rand Corp.	1,298,655
Terra Tek Inc.	1,295,538
Forest Builders Inc.	1,291,436
Penn. Grade Crude Oil Assn.	1,280,713
CER Geonuclear Corp.	1,267,587
Hittman Associates Inc.	1,264,186
Mathematical Sciences NW	1,261,178
Daniel Mann Jhnsn. Mench	1,252,445
Virginia Polytechnic Inst.	1,242,641
USS Engineers & Consult.	1,222,835
Stewart Mechanical	1,219,460
Trinity Univ.	1,215,138
Hunter Saucerman	1,212,427
Gulf Res. and Dev. Co.	1,204,899
Energy & Envir. Analysis	1,201,104
Kinney, A. M. Inc.	1,199,701
Metal Properties Council	1,192,749
Minnesota Mining & Mfg.	1,185,980
Badger Plants	1,175,434
Bradbury & Stamm Const.	1,160,533
Woods Hole Ocnogrph. Inst.	1,157,947
Cities Svcs. R&D Dev. Co.	1,148,242
Oklahoma State Univ.	1,129,573
Acurex Corp.	1,122,986
Systems Science Software	1,097,229
Brown Univ.	1,089,593
Texas Tech. Univ.	1,088,588
West Virginia Univ.	1,059,521
Colorado, State of	1,056,064
Northwestern Univ.	1,050,092
Rentenbach Engineering	1,045,698
Consumers Power Co. of MI	1,037,762
Delaware, Univ. of	1,023,298
Facilities Sys. Engr. Corp.	1,017,843
General Services Admin.	1,016,491
San Diego Gas & Elec. Co.	1,011,746
MATSCO	1,006,566
New York St. Univ. Res. Fdn.	1,005,637
Fairchild Industries Inc.	999,192
Hicks, Wiley, Jr., Gen. Contr.	992,269
Titan Electric Service	991,478
Hawaii, Univ. of	987,682
Texas A & M Univ.	981,782
Systems Consultants Inc.	972,317
Peterson and Nielson	961,194
Colorado School of Mines	951,798
Teleco Inc.	950,215
Lavis, John, Gen. Contr. Inc.	948,994
Guyan Oil Company Inc.	945,000
Rensselaer Polytechnic	928,628
Arizona, Univ. of	922,707
Duke Univ.	916,447
City Public Service Bd.	888,088
Wyoming, Univ. of	885,397
Combustion Power Co. Inc.	865,509
Gulf Univ. Res. Con.	864,700
Rice William Marsh Univ.	863,947
Lehigh Univ.	855,773
Florida, Univ. of	842,408
Pittsburgh, Univ. of	831,751
Ramex Construction Co.	827,980

Special Intervenor List

American Enterprise Institute for Public Policy Research, 1150 17th St., N.W., Washington, DC 20036

Appalachian Mountain Club, 5 Joy St., Boston, MA 02108

Bass Anglers for Clean Waters, P.O. Box 3044, Montgomery, AL 36109

Center for International Environment Information, 345 E. 46th St., New York, NY 10017

Center for Science in the Public Interest, 1757 S St., N.W., Washington, DC 20009

Center of Concern, 3700 13th St., N.E., Washington, DC 20017

Common Cause, 2030 M St., N.W., Washington, DC 20036

Concern, Inc., 2233 Wisconsin Ave., N.W., Washington, DC 20007

Conservation and Environmental Studies Center, R.D. 2, P.O. Box 2230, Brown Mills, NJ 08015

Conservation Foundation, 1717 Massachusetts Ave., N.W., Washington, DC 20036

Consumer Federation of America, 1012 14th St., N.W., Washington, DC 20005

Consumers Union of the U.S., Inc., 256 Washington St., Mt. Vernon, NY 10550

Desert Protective Council, P.O. Box 4294, Palm Springs, CA 92262

Environmental Action Foundation, 1346 Connecticut Ave., N.W., Washington, DC 20036

Environmental Action, Inc., 1346 Connecticut Ave., N.W., Washington, DC 20036

Environmental Coalition on Nuclear Power, A-400 Benson East, Jenkintown, PA 19046

Environmental Defense Fund, 162 Old Town Rd., East Setauket, NY 11733

Environmental Law Institute, 1346 Connecticut Ave., N.W., Washington, DC 20036

Environmental Policy Center, 317 Pennsylvania Ave., S.E., Washington, DC 20003

Environmental Research Institute, P.O. Box 156, Moose, WY 83012

Friends Committee on National Legislation, 245 Second St., N.E., Washington, DC 20002

Friends of the Earth, 529 Commercial St., San Francisco, CA 94111

Ground Water Council, 221 North La Salle St., Chicago, IL 60601

Indian Rights Association, 1505 Race St., Philadelphia, PA 19102

National Environmental Health Association, 1600 Penn, Denver, CO 80203

National Wildlife Federation, 1412 16th St., N.W., Washington, DC 20036

Natural Resources Defense Council, Inc., 15 W. 44th St., New York, NY 10036

Resources for the Future, Inc., 1755 Massachusetts Ave., N.W., Washington, DC 20036

SANE—A Citizen's Organization for a Sane World, 318 Massachusetts Ave., N.E., Washington, DC 20002

Sierra Club, 530 Bush St., San Francisco, CA 94108

The Heritage Foundation, 513 C St., N.E., Washington, DC 20002

The Rockefeller Foundation, 1133 Avenue of the Americas, New York, NY 10036

The Twentieth Century Fund, 41 E. 70th St., New York, NY 10021

Water Resources Congress, 955 L'Enfant Plaza, S.W., Washington, DC 20024

Wilderness Society, 1901 Pennsylvania Ave., N.W., Washington, DC 20006

World Future Society, P.O. Box 30369-Bethesda, Washington, DC 20014

Zero Population Growth, 1346 Connecticut Ave., N.W., Washington, DC 20036

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