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1972–1997, TWENTY-FIVE YEARS OF ENERGY AND ENVIRONMENTAL HISTORY: LESSONS LEARNED*

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by

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"Those who cannot remember the past are condemned to repeat it."

George Santayana
"The Life of Reason"

1 1972 - A PIVOTAL YEAR

Much of the environmental and energy history of the United States has been written in the past 25 years. Until the late sixties, little attention was given to either environmental or energy matters. Americans were enjoying the fruits of the economic boom following the Second World War. During the sixties, their attention turned to the Vietnam War and civil rights.

In this respect, 1972 can be considered a "cusp" year, a point of transition from one historical period to the next. It was in 1972 that Richard Nixon was elected president by a landslide. In that same year, five burglars were arrested in the Democratic headquarters at the Watergate Hotel in Washington, which eventually led to the president's downfall. *Life* magazine ceased publication after 37 years, while the first issue of *Ms* magazine came off the press with a new point of view. It was also in 1972 that the last manned landing on the moon took place with Apollo 17, thus ending the initial phase of manned exploration of space. The changing emphasis was reflected by the launching of the LANDSAT 1 satellite in this same year.

Other events in 1972 contributing to this transitional period included:

- The initiation of security inspections of U.S. airline passengers and their luggage as a result of a wave of airline hijacking and the beginning of terrorist threats;
- The withdrawal of the last full combat units from Vietnam;
- The introduction of the CAT scan in England;
- The breakthrough of the Dow Jones Industrial Average to the 1000 level for the first time; and

- The entrance of social issues in film and television in, for example, the box office hit the *Godfather* and the sitcom *All in the Family.*

On the energy front, gasoline was $.36 a gallon. Crude oil was $3.58 per barrel. The retail price for electricity was $.019 cents per kilowatt-hour. Energy supplies were abundant and prices were relatively low and stable. Under these conditions, neither the political or public arena paid much attention to energy issues; in fact, energy up until that time was a "nonissue." This, of course, would change drastically within a year.

On the environmental front, the situation was a little different. The environmental movement was in its infancy, but rapidly encroaching into the mainstream of public life. The U.S. Environmental Protection Agency and the National Oceanographic and Atmospheric Administration (both signed into law in 1970) were barely two-years old. A number of landmark environmental regulations had already been passed, including the Clean Air Act and the National Environmental Policy Act. The United Nations Conference on Human Environment was held in Stockholm in 1972 and was a harbinger, perhaps better than any other event, of the hold that environmental concerns were going to have in the future. Also in 1972, the Federal Water Pollution Control Act was passed. This act essentially provided for the elimination of the discharge of all pollutants into U.S. waters and established a system of national effluent standards. This act is considered, along with the Clean Air Act, one of the most comprehensive and ambitious pieces of environmental legislation ever passed by Congress. In 1972, it was obvious that the environment was becoming a "rising star."

2 THE ROLLER-COASTER RIDE OF ENERGY AND ENVIRONMENT

In the 25 years since 1972, many events have taken place in the energy and environmental arenas that have forever changed the ways in which we view these resources. Figure 1 illustrates the pivotal events from then until now that have shaped and changed the energy and environmental configuration, often in unpredictable ways.

While some hard lessons and crises occurred during this period, it is not clear that the opportunities to learn or profit from these events were taken full advantage of.

2.1 ENERGY

2.1.1 Petroleum

The oil sector has experienced the most turbulence and disruption during the past 25 years. Crude oil prices have varied dramatically over this period; the price of a barrel of crude oil ranged from $3.58 in 1972 to $9.07 in 1974, to over $35.00 in 1982, and then down to $15.60 in 1994, to $20.65 today. Figure 2 shows the range of crude oil prices over the past 25 years in both nominal and constant 1992 dollars.

Gasoline prices have mirrored the dramatic changes in crude oil prices. From a price of $.36 per gallon in 1972, the cost of a gallon of gasoline rose to $.53 in 1974, to $1.35 in 1981, and then decreased to under a dollar in 1986. Today, a gallon of gasoline costs approximately $1.40. Figure 3 illustrates this trend in gasoline prices over the past 25 years in both nominal and 1992 dollars. Measured in constant currency, gasoline is less than 10% more expensive now than it was 25 years ago.

Such changes in crude oil and gasoline prices have obviously had enormous effects on the U.S. economy and energy consumption patterns. Reaction to this volatility, however, has varied across different sectors.

In the industrial sector, oil constituted 29% of total consumption in 1972 and totaled 8.5 quads. This consumption peaked at 10.6 quads in 1979, and then dropped to less than 7.4 quads in the following years. Industrial use of oil has increased slowly since 1984 and has varied between 8.0 and 9.0 quads (9.11 in 1996), representing 26% of total industrial consumption.

In the residential and commercial sectors, oil consumption patterns have changed more dramatically over the past 25 years, likely a reaction to the large volatility in oil prices and the availability of suitable substitutes. Oil consumption in these sectors peaked in 1972 at 4.4 quads, but has declined steadily over the past 25 years to about 2.2 quads.

In the transportation sector, the volatility in oil prices has had a smaller impact. Gasoline consumption declined briefly in 1974 and 1979 to 1982 in reaction to shortages and steep increases in prices. The increase in price and the continuing threat of gasoline shortages led automobile manufacturers to begin producing more fuel-efficient vehicles. However, these brief periods of decline in gasoline consumption turned out to be merely aberrations in the steady increase in gasoline consumption over the past 25 years. Consumption of gasoline today is almost 50% higher than it was in 1972.

A number of conclusions can be drawn from these differing reactions to volatility in oil prices over the past two and a half decades. Industrial operators have energy options that have allowed them to adjust to oil price swings. The large quantities of energy used by this sector make energy costs a critical factor in the viability of industrial enterprises. Thus, this sector is ready and willing to adjust to swings in the price of oil by moving to other fuel sources and by improving energy efficiency.

The residential and commercial sectors have been the most adaptable in terms of shifting away from oil when oil prices have undergone steep increases. This shift was motivated initially by increases in oil prices but was probably sustained by factors other than price, particularly the convenience of gas and electricity.

The transportation sector, unlike the others, has had little choice but to endure and accept increases in the price of gasoline as it is hopelessly wed to oil as a fuel source. There is no doubt that Americans (and increasingly, the rest of the world) have an insatiable love for the automobile. And the choice of car that Americans "love" has not changed much in size or gas consumption over the past 25 years. In 1972, the "Car of Choice" was a 4,000-pound Chevy with a 440-cubic inch, 380-horsepower engine that got 8 miles to the gallon. In 1989, the Geo Metro made its debut as an energy-efficient car with a 1-liter, three-cylinder engine that could get over 50 miles to the gallon. The initial enthusiasm soon waned, however, as the performance limitations associated with the small engine became apparent. A recent column in the *Chicago Tribune* called the Metro "the industry's mileage champ, but it is also the sales chump." The "Car of Choice" in 1997 is a 5,000-pound sport-utility vehicle (SUV) that gets 12 to 14 miles to the gallon. The newest craze in SUVs is the civilian version of the military Humvee, which is being used in California to deliver pizzas.

The instability in the price and supplies of oil has resulted in a roller-coaster ride in terms of major oil suppliers used by the United States. In 1972, OPEC (Organization of Petroleum Exporting Countries) nations provided 43.5% of petroleum to the United States. In 1977, this percentage peaked at 70.3%. In 1985, in the aftermath of oil price increases levied by OPEC nations in 1979, this reliance on OPEC decreased to 36.1%. However, changing political and economic patterns worldwide since the 1979 oil price increase have led to the United States once more depending more and more heavily on OPEC countries for its oil supplies. In 1996, U.S. dependence on OPEC for oil was 44.6%, more than it was in 1972.

U.S. dependence on imported petroleum continues to be a major energy issue. In 1972, imports made up 27.6% of total oil consumption in this country. In spite of the experience of the oil embargo of 1973, imports continued to increase, peaking at 46.5% of total oil consumption in 1977. Imported oil supplies bottomed out at 27.3% of the total oil consumed in 1985, in reaction to the second oil price shock of 1978-79 and a resulting slowdown of economic growth. In spite of all the concerns and negative experiences in relying on imported oil, imports have increased since 1985. In 1996, 46.2% of U.S. oil supplies were imported, almost double the 1972 level and near the historical peak of 1977.

2.1.2 Coal

Consumption of other energy sources has also changed over the past 25 years. Coal consumption has exhibited a steady increase over this period, rising from approximately 524 million short tons in 1972 to over one billion short tons today, as shown in Figure 4. This increase has been accompanied by a steady decline in coal prices since 1984. In 1972, the price of coal was approximately $8.44 per short ton. This peaked at over $35 per short ton in 1984. Today, the price of coal is approximately $26 per short ton. The changes in the price of coal, both in nominal and constant 1992 dollars, are shown in Figure 5.

The most dramatic change in coal consumption has been the rapid rise in the use of Western low-sulfur coal. The use of Eastern coal has remained steady at between 500 and 600 million short tons during the past 25 years. This is in contrast to the eight-fold increase in the use of Western low-sulfur coal, from about 64 million short tons in 1972 to over 500 million short tons today, as shown in Figure 6. This dramatic change can be attributed to the demands of the air pollutant emission limits placed on utility and industrial boilers.

Because of significant environmental issues associated with the coal industry, this industry has been more heavily affected by environmental concerns than any other energy source. Despite the rise in demand, the lack of a substantial rise in coal prices is related to the major increase in productivity (almost 230% as measured by tons of coal produced per miner hour). However, in spite of increases in the price of oil and the relative low price of coal, promises of the widespread development and use of advanced coal technologies such as coal gasification and coal liquifaction have not materialized. Falling oil prices and deregulation of natural gas prices have squeezed these advanced technologies out of the current market.

2.1.3 Natural Gas

The natural gas industry has also had its share of ups and downs over the past quarter century. Consumption of natural gas has not changed as significantly as other fuels and has remained between 15 and 22 trillion cubic feet during this period. The lowest consumption of natural gas occurred in 1986 (16 trillion cubic feet); current levels nearly equal those of 1972 (22 trillion cubic feet). Figure 7 depicts these changes in consumption.

Consumption of natural gas has varied in different sectors of the economy during this period. Residential gas consumption has remained virtually constant, while commercial gas use has grown modestly (by about 0.96% annually). In the industrial sector, gas consumption declined from 1972 through 1986 but then started a substantial growth trend, increasing 4.4% per year, through the present.

The price of natural gas has fluctuated more widely than consumption levels over the past 25 years. In 1972, the wellhead price of natural gas was $.19 per thousand cubic feet. This increased to $2.66 per thousand cubic feet in 1984, coinciding with (and likely accounting for) the lowest level of gas consumption experienced during the period. Currently, the price of natural gas is approximately $2.25 per thousand cubic feet. Figure 8 provides a graphical depiction of the changes in the wellhead price of natural gas in both nominal and 1992 dollars.

A number of reasons account for the changes in natural gas production and consumption levels during the past 25 years. Gas deregulation was effected in 1993. The development of new drilling techniques, particularly horizontal drilling technology, has made it feasible and more economical to tap new gas fields. The improvement of aeroderivative gas turbines has led to more efficient generation of electricity from this fuel source. This combination of regulatory changes, resource technology improvements and gas-fired electricity generation technology has created a "natural gas bubble" of ample supply, a situation that did not exist previously.

2.1.4 Electricity

The electricity sector has seen steady growth during the past quarter century. In 1972, total electricity generation was 1,750 gigawatt-hours. This increased to 3,078 gigawatt-hours in 1996. Figure 9 depicts the almost continuous increase in electricity generation during this period.

This steady increase reflects the relatively modest changes in the price of electricity during this period. As shown in Figure 10, the price of a kilowatt-hour of electricity for residential consumers, in constant 1992 dollars, rose from $.072 in 1972 to a high of $.098 in 1982 and receded to $.077 in 1996, an increase of only 7% over 25 years. The pattern for commercial customers is even flatter; 1996 prices equaled their inflation-adjusted 1972 levels. For industrial users, the price of electricity peaked in 1982 at almost twice 1972 levels before declining to a current level that is only about 17% higher than it was in 1972.

One of the most dramatic changes in the electricity sector over the past 25 years has been the change in the fuel mix used to generate electricity. In 1972, 44% of the electricity generated in the United States was produced from coal. In 1996, this percentage increased to over 56%. The use of oil for electricity generation has declined substantially over this period. Oil accounted for 15% of electricity generation in 1972, but declined to less than 2% of total electricity generation in 1996. The percentage of electricity generated from nuclear fuel has increased significantly over this period and accounted for 3% of total electricity generation in 1972 and 22% in 1996. Figure 11 illustrates the change in fuel mix for electricity generation for 1972 and 1996.

Although capacity expansion in the electricity sector increased during the 1970s, it has come almost to a standstill during the past 10 years, as shown in Figure 12. Much of this trend can be attributed to an overexpansion of the electric system that was carried out when utility load forecasts predicted continued, substantial increases in demand. The increase in energy prices and

improvements in energy efficiency, coupled with economic slowdowns in the mid-1980s, resulted in lower than anticipated load growth. Only recently has the load begun to catch up to available capacity.

2.1.5 Nuclear Power

The nuclear power industry grew rapidly during the 1970s and early 1980s. However, it has been significantly curtailed during the past 10 years. In 1972, there were 29 operating nuclear power plants. This peaked at 111 units in 1990 to 1991. In 1996, 110 units were operational.

Although nuclear power plants in operation today produce 22% of the nation's electricity, there will not be any increase in the number of units in the near future. The last reactor order was placed in 1977. In 1989, the Shoreham, New York, nuclear plant was sold by the utility to the state for $1 and was to be decommissioned. In 1997, Commonwealth Edison in Illinois announced that it would close the Zion nuclear plant before the end of the term of its operating license because it would not be economically advantageous to perform its next scheduled steam generator rehabilitation. During the next year, industry experts expect 5 to 10 additional announcements of premature nuclear plant retirements.

This decline in the nuclear power industry is reflected in the drop in uranium prices from $34 per pound in 1981 to under $14 per pound in 1996.

2.1.6 Renewable Resources

In spite of their great promise and potential, renewable resources have had limited success in penetrating the energy market over the past 25 years. Wind, solar, geothermal, and biofuels have increased only slightly during the 1990s (even slower than the rise during the 1970s and 1980s). In 1990, renewable energy consumption was approximately 3.1 quads, representing 3.6% of total U.S. energy consumption. In 1996, this increased to 3.5 quads, representing 3.7% of total energy consumption. Figure 13 depicts the changes in the consumption of various renewables from 1990 through 1996. Conventional hydroelectric power generation is not included in this figure; it would add another 3 to 4 quads to the totals.

2.2 ENVIRONMENT

Unlike the situation for the energy sector, the environment was already a significant issue in 1972 and the emphasis on environmental concerns has continued over the past 25 years. Although the threat of environmental problems still exists today, there have been some notable environmental successes during the past two and a half decades. The most extraordinary success has been the

case of lead. From 1970 (when the Clean Air Act was passed and target ambient levels for some air pollutants were implemented) through 1994, total annual emissions of lead in the United States decreased from 200,000 tonnes to 4,500 tonnes, a decline of 98%. Much of this decrease was due to the replacement of leaded gasoline with unleaded fuels. Figure 14 depicts this dramatic decline in lead emissions.

Another success story is that of sulfur dioxide (SO_2) emissions and ambient levels of this pollutant. Until 1970, emissions of SO_2 had been rising rapidly. With restrictions imposed on such emissions by the 1970 Clean Air Act, total annual SO_2 emissions declined by 32% from 1970 through 1994 (from 28.3 million tonnes to 19.2 million tonnes). The majority of SO_2 emissions were (and still are) the result of electricity generation, particularly from coal-fired power plants. Emissions of this pollutant from electricity generation alone have declined further since 1992, from 16 million tons in 1992 to 13 million tons in 1995, as shown in Figure 15. Much of this reduction can be attributed to the use of low-sulfur Western coal and the deployment of flue gas desulfurization equipment. These approaches have reduced emissions even as generation from coal-fired equipment has increased.

Emissions of particulate matter have also declined during the past 25 years; a 71% decrease occurred between 1970 and 1994. In addition, hydrocarbon (HC) and carbon monoxide (CO) emissions dropped rapidly between 1970 and 1987, declining by 28% and 38%, respectively, due in large part, to the enactment of the Clean Air Act in 1970.

These declines in air pollutant emissions are all the more remarkable given the strong economic and population growth that have occurred in the United States over the past 25 years. For example, the number of motor vehicles has almost doubled from 1972 to 1996, and each of these vehicles is being driven many more miles today.

In spite of these successes, many environmental problems remain. Millions of Americans still breathe unhealthy air, particularly due to high ozone and toxic air pollutant levels. The health and viability of many natural ecosystems, especially wetlands and estuaries, are in critical condition. Concentrations of carbon dioxide (CO_2) in the atmosphere have increased at an average rate of 1.4% a year, giving rise to concerns about global warming. U.S. CO_2 emissions in 1980 were about 1.3 billion metric tons of carbon. This amount declined to under 1.2 billion metric tons in 1982 to 1983 (due primarily to an economic recession) but has been steadily rising since then. In 1995, CO_2 emissions reached over 1.4 billion metric tons, as shown in Figure 16.

3 LESSONS LEARNED

Given the events of the past 25 years concerning energy and environmental issues and our reaction to them, what lessons can we learn?

First, the individual American consumer wants and expects energy to be a stable commodity with low prices and easy availability. As evidenced by the heated debate over increasing the federal gasoline tax by $.05 per gallon (which would still leave Americans paying only one-third of what Europeans pay for gasoline), increases in energy prices elicit very strong public and political opposition. As further evidence, it has been argued that the general public support of the Gulf War was due, in part, to a recognition of the need to maintain a stable source of cheap oil from the region. The American public wants to maintain the benefits of cheap and abundant energy and expects its political leaders to make it happen.

A second lesson is that if constraints on the energy supply do occur (e.g., the OPEC-imposed oil embargo) and/or environmental impacts from energy use do appear to be significant (e.g., SO_2 and CO_2 emissions), the preference is for a technology fix rather than a behavioral change. This is evidenced by our reliance on moving low-sulfur coal more than 1,000 miles from Wyoming to burn in Illinois power plants rather than reducing the demand for electricity with energy-efficient measures in residential, commercial, and industrial activities. National research programs to produce an automobile that gets 80+ miles per gallon take higher priority over working to get people to use mass transit to reduce their driving mileage. Americans expect that advanced technology can be relied upon to come up with solutions to energy and environmental problems without having to change their lifestyles. The experience with natural gas, in which a regulatory change (deregulation) was combined with technology developments (horizontal drilling and improved gas turbines for electricity generation) to increase available supply and hold prices down, has added to the confidence in the efficacy of technology fixes to solve energy and environmental problems.

Third, it is difficult for government to tamper with energy markets and achieve the desired results. Witness some of the attempts:

- The implementation of gasoline rationing during the oil crises did not effectively deal with the problem. Rather, it created a large "rolling storage system" as consumers hoarded gasoline by continually topping off their tanks, even when they were only slightly empty.

- The federally funded synthetic fuels program was designed to produce oil products and natural gas from domestic coal resources. The program fell victim to the drop in oil prices in the mid-1980s and did not reach any significant commercial level of production.

- Project Independence was a federal analysis conducted in 1973-74 and was designed to develop a national energy strategy that would make the U.S. independent of foreign energy sources. It was never implemented.

- Government investments in the development of nuclear power that was to be "too cheap to meter" have not realized their targets. Likewise, federal investments in renewable resource technologies (solar, wind, and biomass) that were to provide energy from a sustainable resource base have not yet seen an adequate return. Some question the continuation of research into fusion power, for which similar promises of unlimited, cheap energy have been made.

The energy system has shown itself to be a complex adaptive system that adjusts to even the most strenuous burdens in ways that are not easy to predict. Governmental attempts to predict and then prescribe the development of the future energy system are bound to meet with limited, if any, success. Rather, the more appropriate goal seems to be development of a robust and flexible energy system that can evolve and adjust to changing conditions.

Given the experiences of the past and the lessons learned from these experiences, what might the future bring? Some predictions can be made with considerable confidence. It is highly likely that the trend of deregulating the energy sector will continue, with electricity deregulation a virtual certainty. It is also highly probable that the demand and consumption of energy from developing countries will soon surpass those of the United States, Europe, and Japan, thus making them serious competitors for limited fossil fuel resources. In the environmental arena, some form of emission control of greenhouse gases from the energy sector will be agreed upon soon by the international community. More stringent regulations in the United States for the emissions of some air and water pollutants are also likely. Preservation of biological diversity will also likely continue to be an issue of increasing importance.

It is safe to state that the future, as evidenced by the past, will bring many unexpected and unpredictable changes to the energy and environmental sectors. Will we be able to cope with these uncontrollable changes? The answer to this question is yes; but if, and only if, we maintain a technologically diverse, economically robust, and adaptable energy system that can make the necessary changes to meet the changing environment.

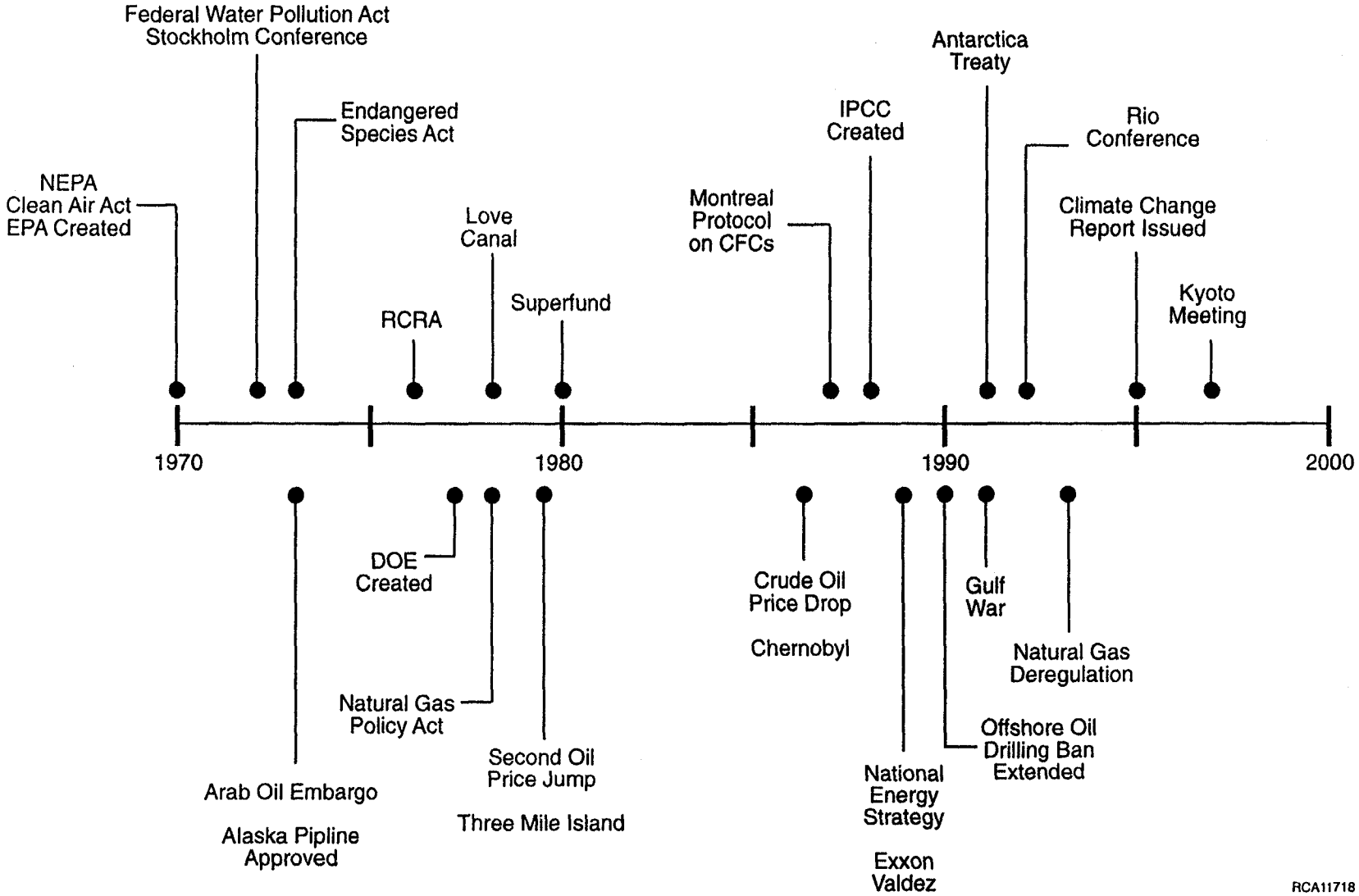

FIGURE 1 Major Energy and Environmental Events

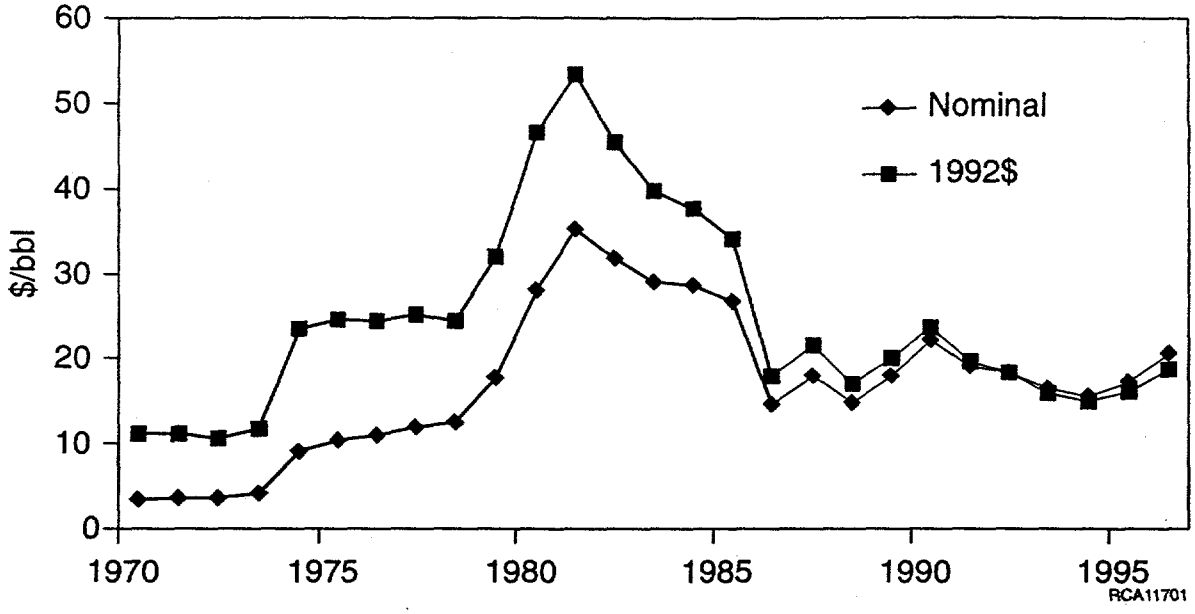

FIGURE 2 Crude Oil Refiner Costs

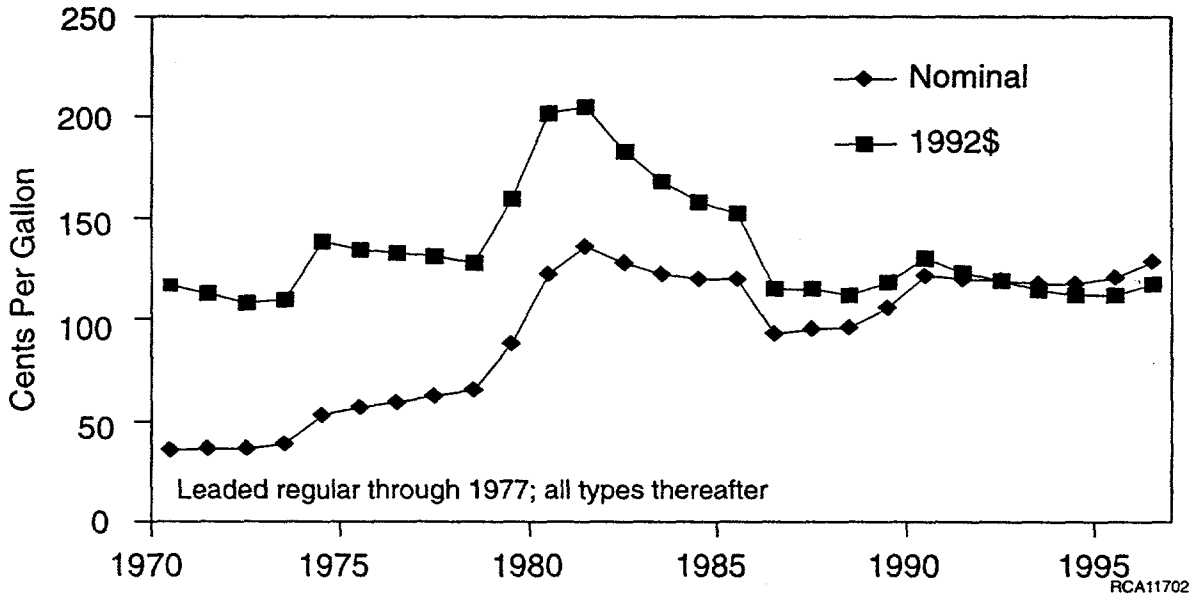

FIGURE 3 Gasoline Prices

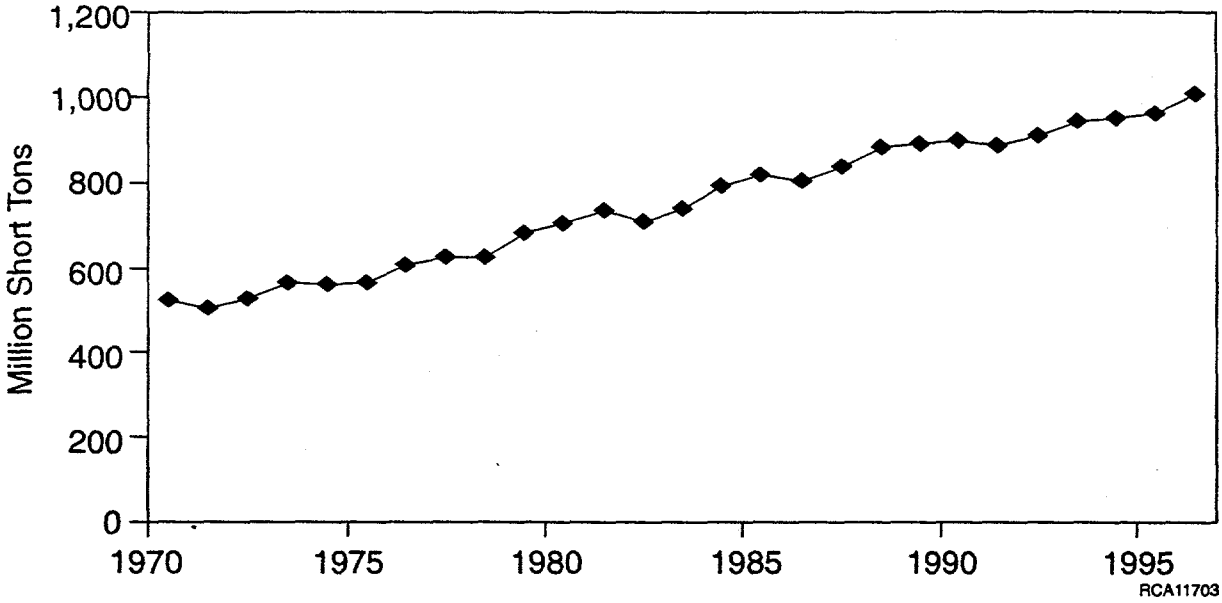

FIGURE 4 Coal Consumption

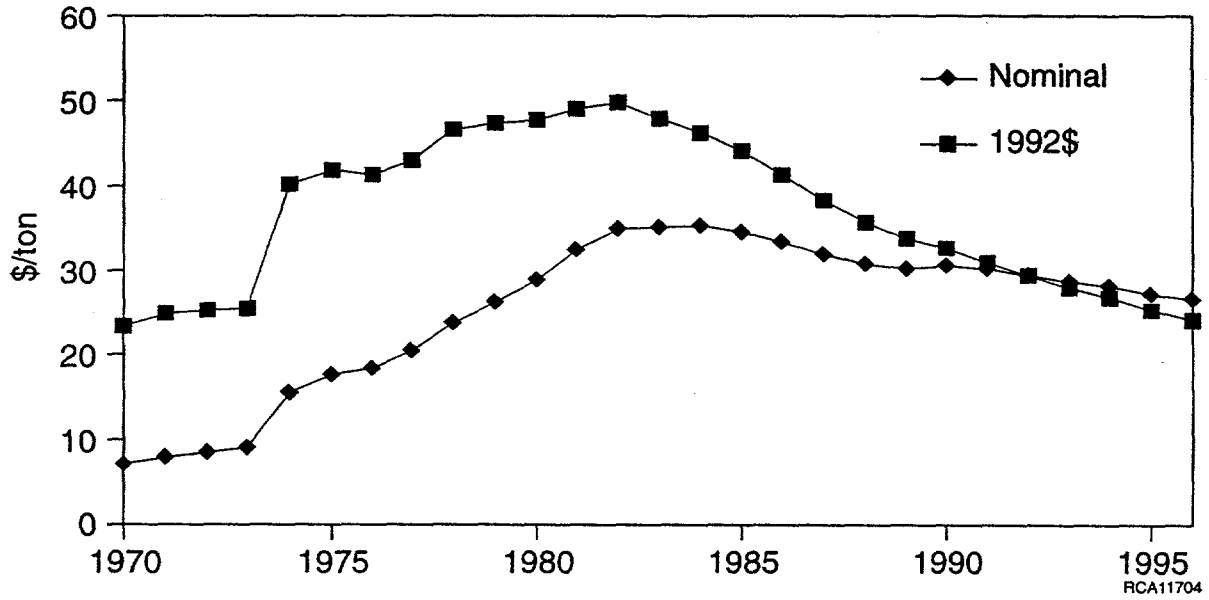

FIGURE 5 Coal Prices

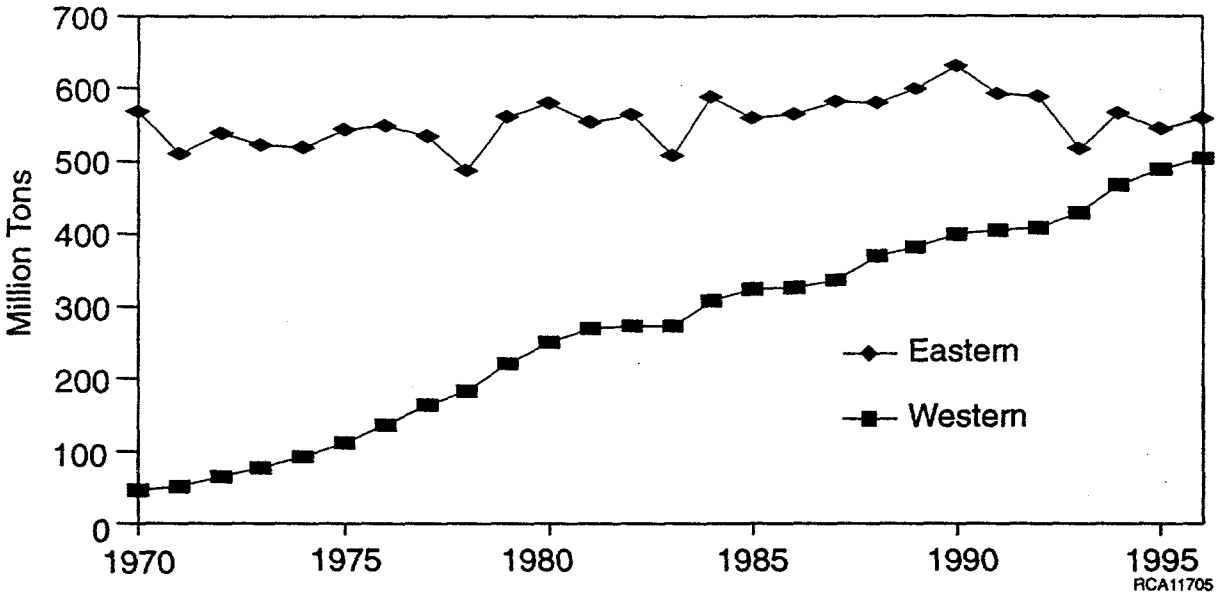

FIGURE 6 Coal Sources.

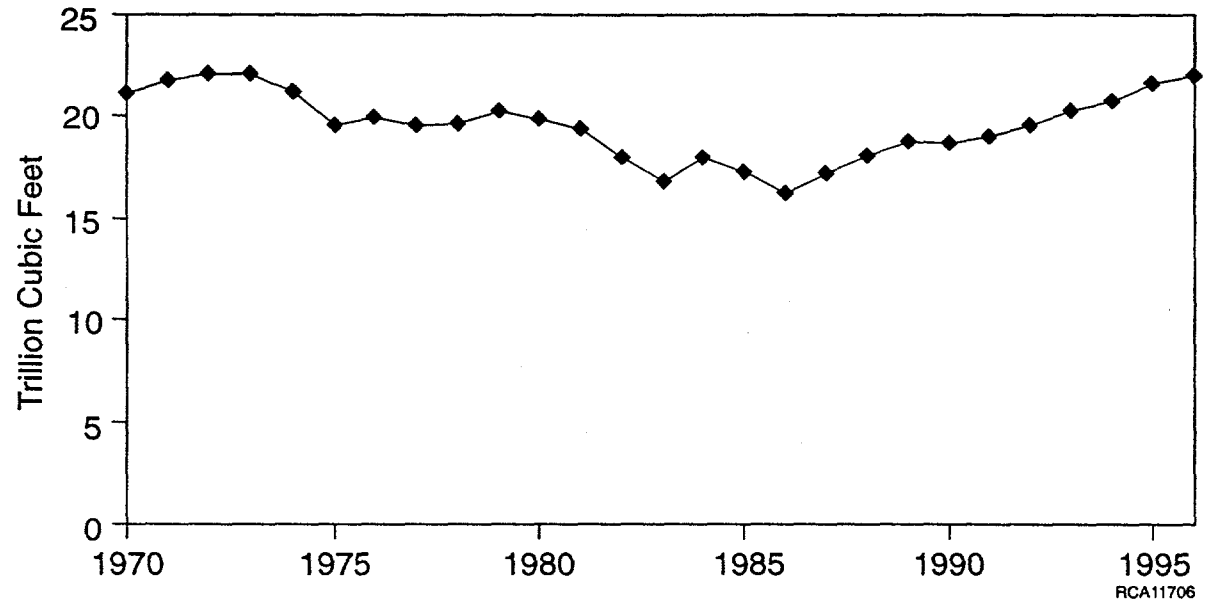

FIGURE 7 Natural Gas Consumption

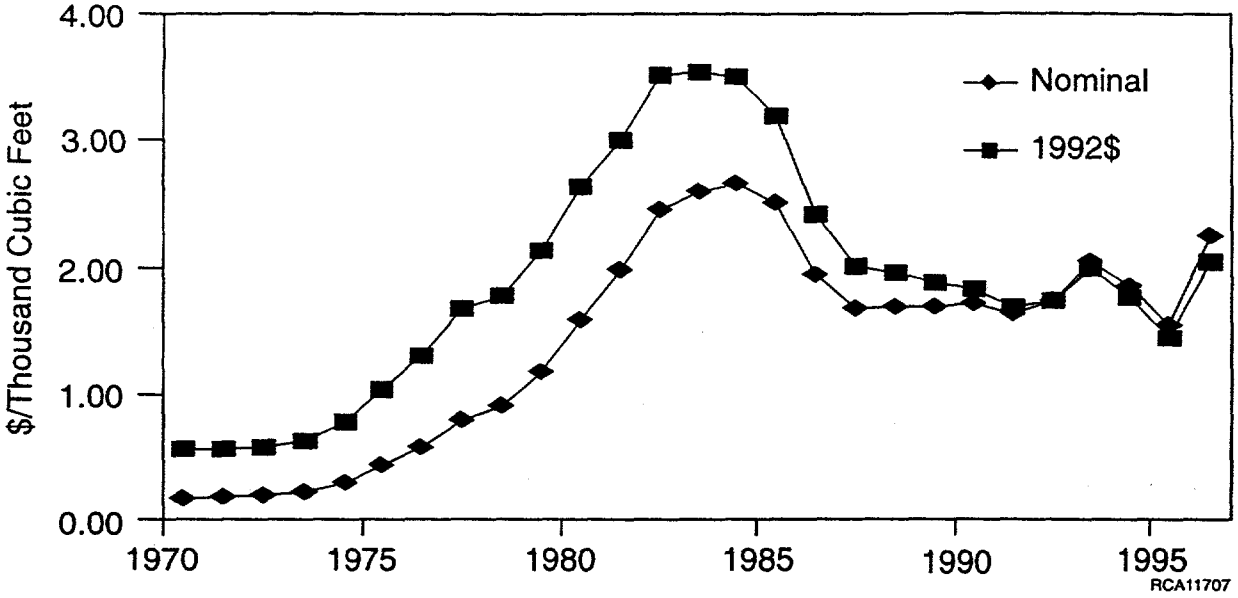

FIGURE 8 Natural Gas Wellhead Price

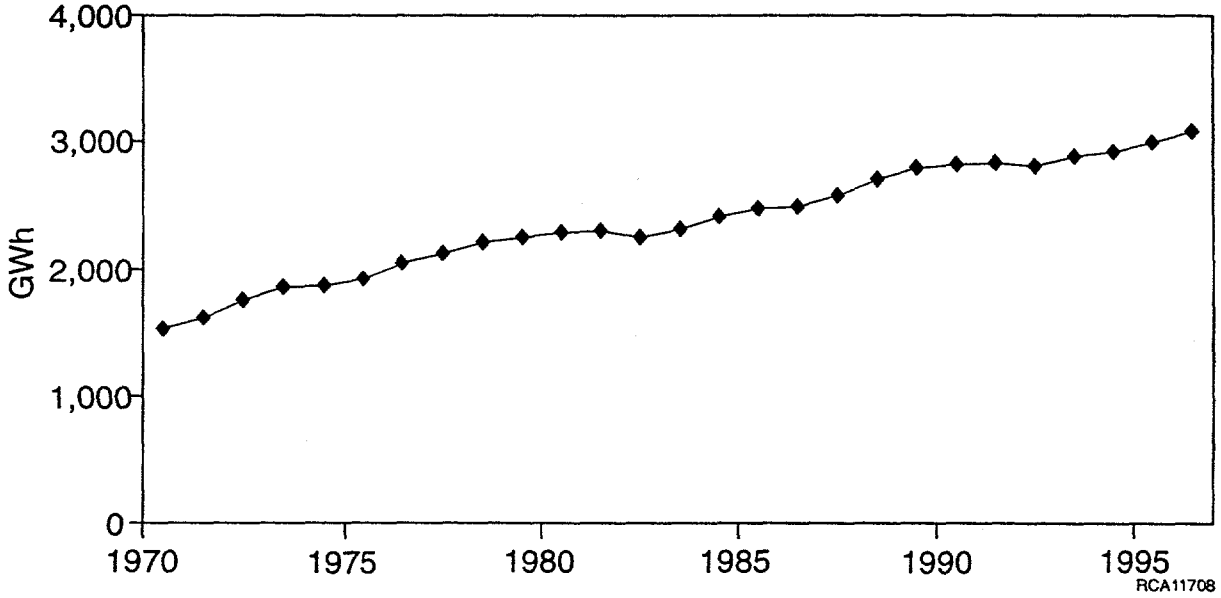

FIGURE 9 Electricity Generation

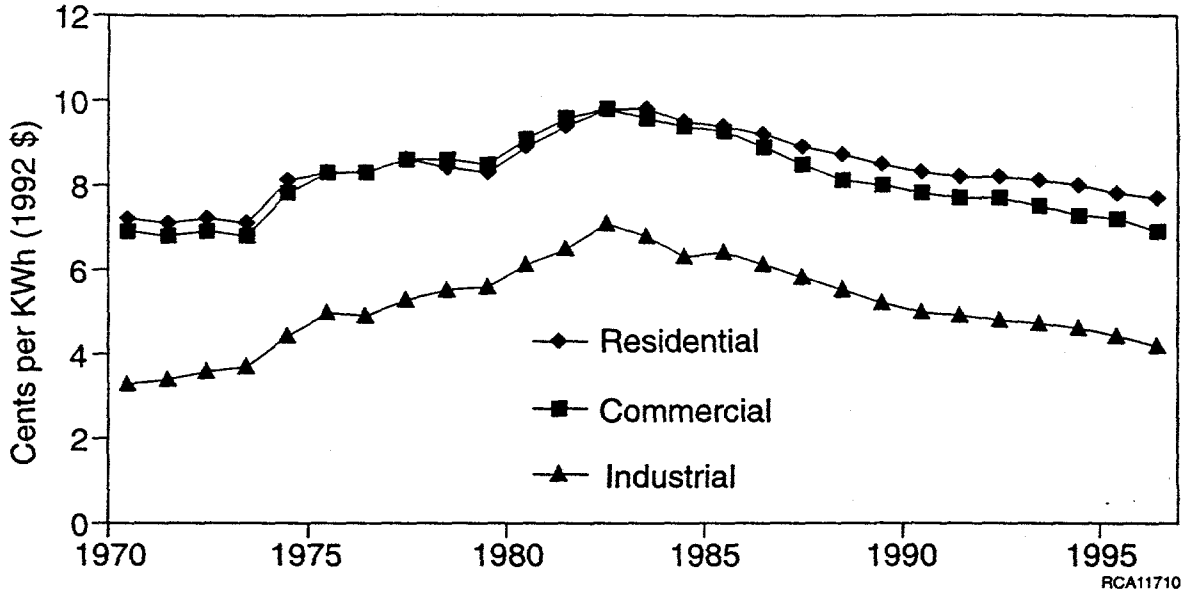

FIGURE 10 Electricity Prices

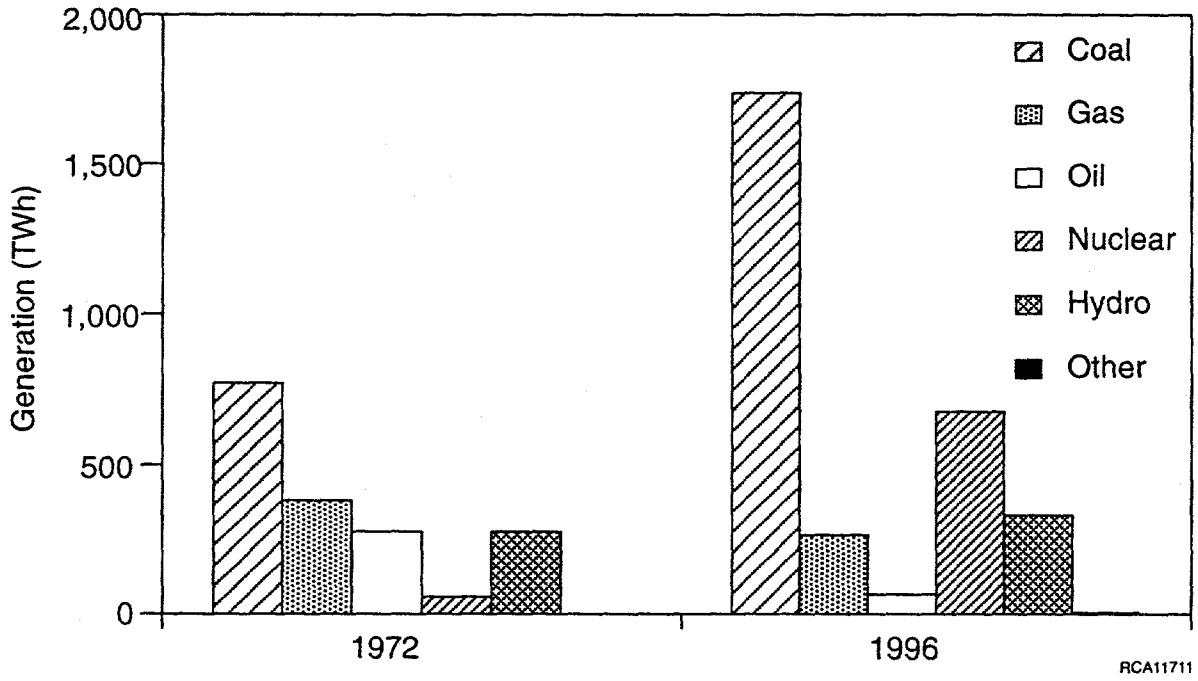

FIGURE 11 Generation Mix

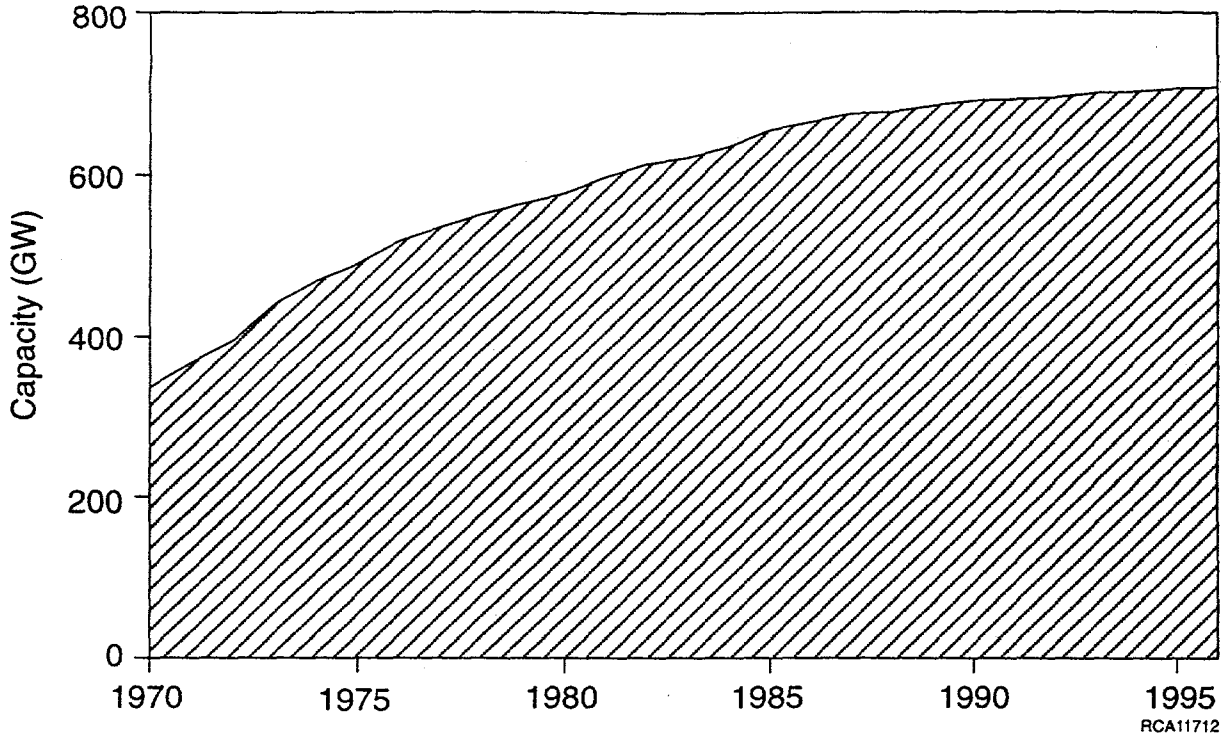

FIGURE 12 Capacity Expansion

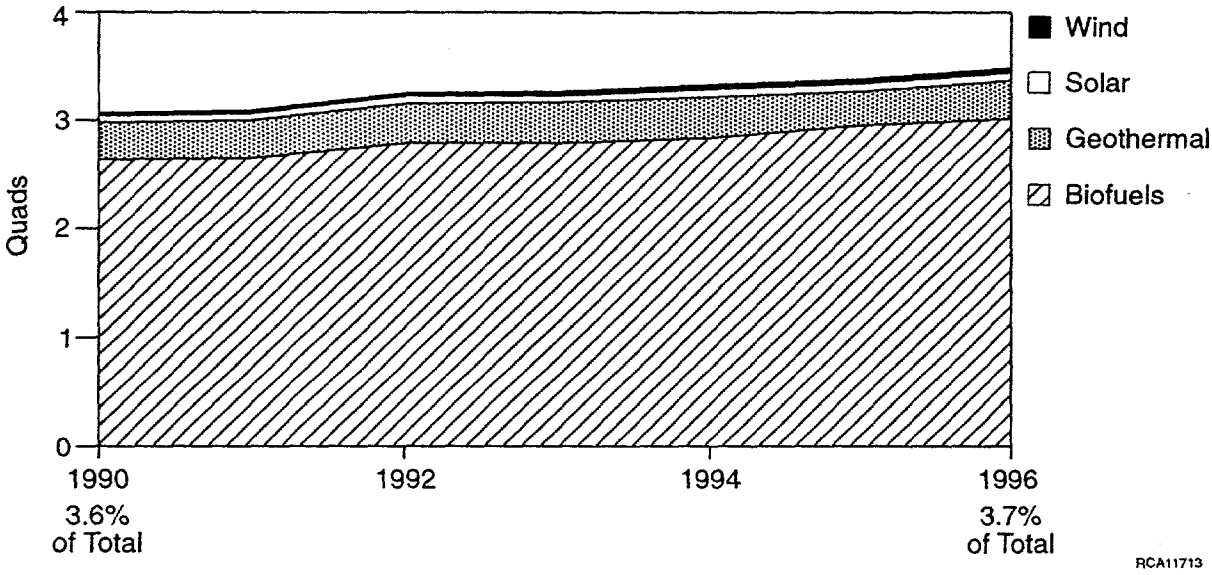

FIGURE 13 Renewable Energy Consumption

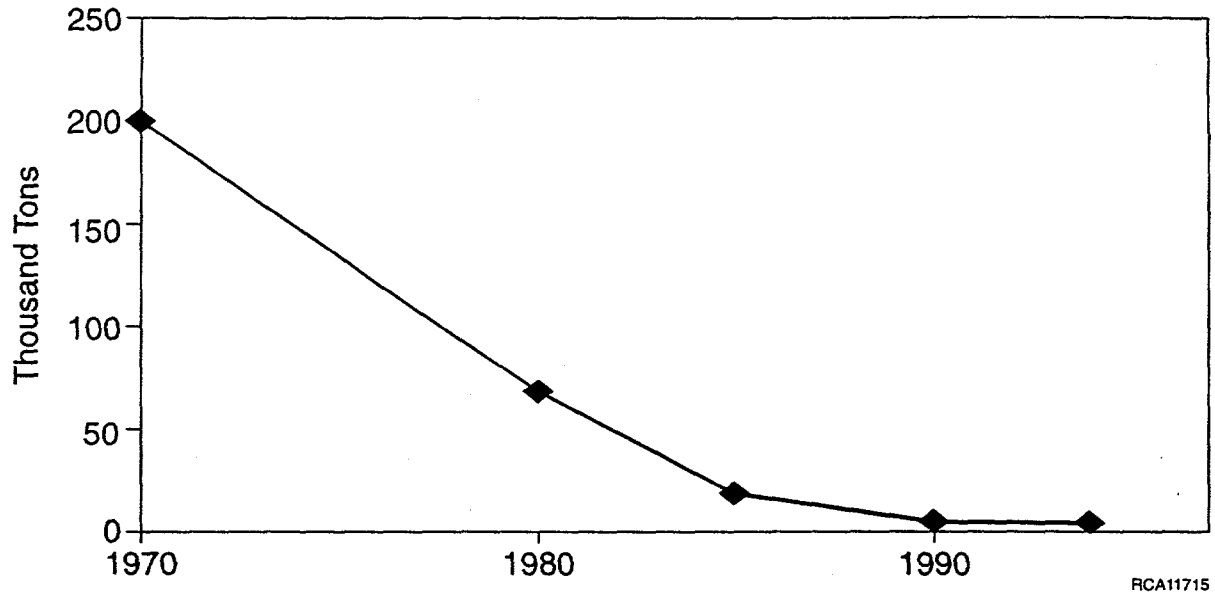

FIGURE 14 Lead Emissions from Mobile and Stationary Sources

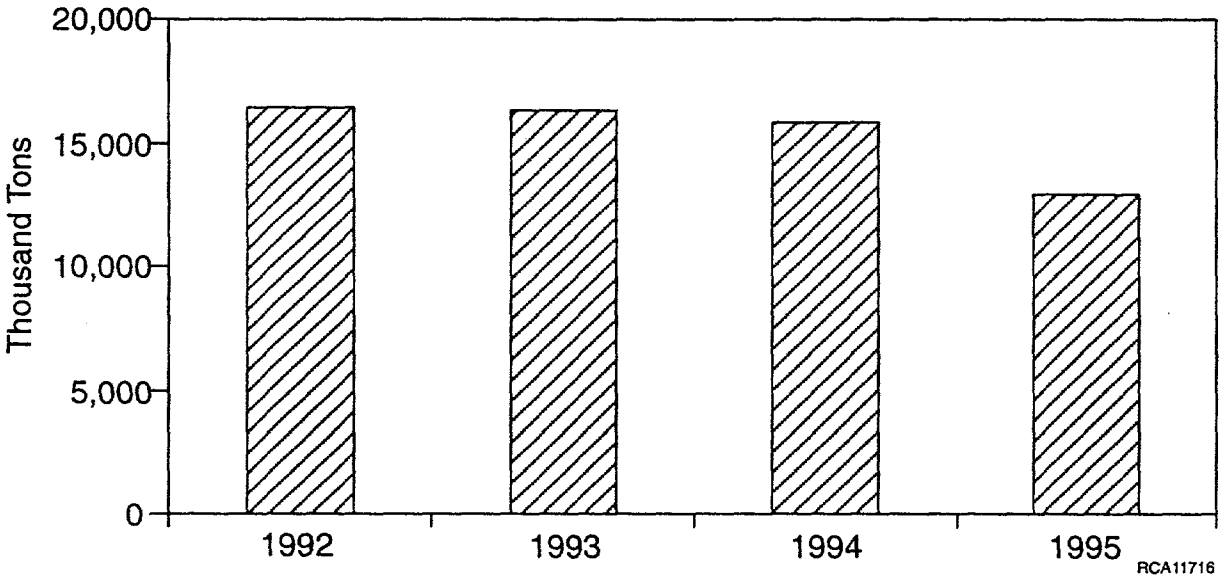

FIGURE 15 SO_2 Emissions from Electricity Generation

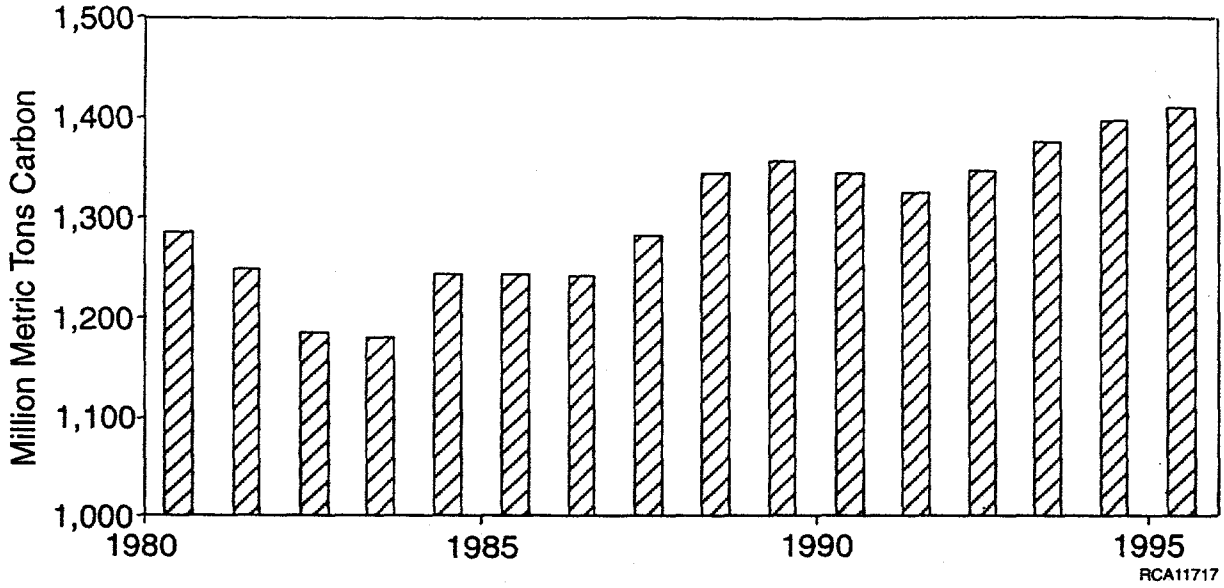

FIGURE 16 CO_2 Emissions

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