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Energy and Environmental Issues for the Midwest Economy

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This paper reviews energy issues in the Midwest region of the U.S., which encompasses Illinois, Indiana, Iowa, Michigan, and Wisconsin. The region's percentage share of the U.S. resident population has decreased since 1970 and its land area is only 7.3% of the U.S. But the region's diverse economy includes the industrial heartland of the country, as well as a thriving service component and a large agriculture component. The region possesses almost 20% of U.S. coal reserves. The Ohio and Mississippi Rivers provide the region with access to the Gulf of Mexico, while the bordering Great Lakes provide access to the Atlantic Ocean through the St. Lawrence Seaway. So the region's energy issues are important to the economies of both the region and the nation.

This paper will first review and compare energy consumption and gross product for both the region and the nation for the period 1970 to 1993. The region and the nation will be compared on the basis of per capita energy consumption and energy consumption per dollar of real output. Because of the wide interest in electricity generation, the paper will also cover national and regional per capita energy input to produce electricity.

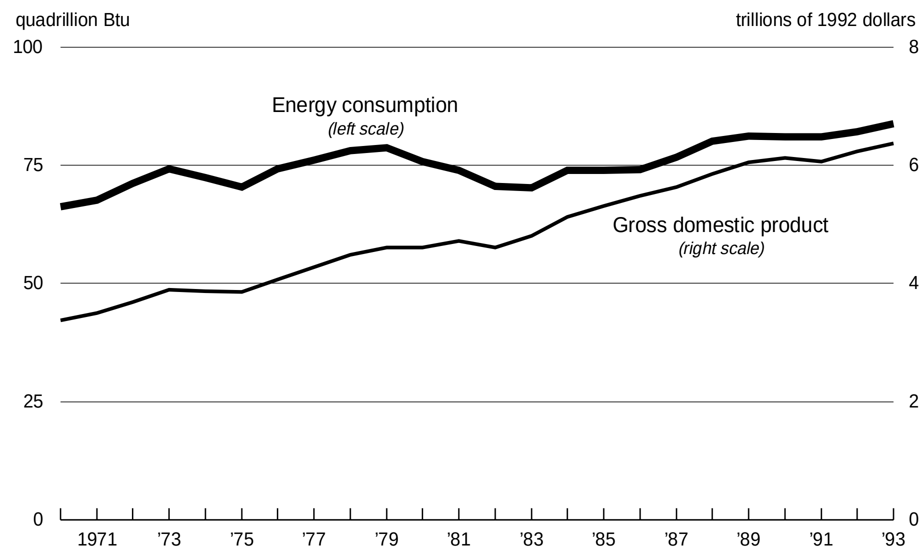
The paper will then analyze patterns of energy use and economic activity in each state of the region, and compare these with the region as a whole and the entire United States, for the years 1970, 1980, 1990, and 1993. It will give special attention to the pattern of energy use among the end-use sectors and to relative changes in fuel use patterns. It will briefly outline the region's energy resource base and analyze shifts in energy production within the region. And it will review some policy issues that may have an important impact on the future of the region.

National Energy Use and Economic Activity

The resident population of the country grew 26.9%, from 203.3 million to 257.9 million, in the period between 1970 to 1993 [9]. In contrast with the steadiness in population growth, national energy consumption and the gross domestic product (in 1992 dollars) have undergone rather dramatic ups and downs over the same 23-year period, as shown in figure 1 [9, 19]. The nation's energy consumption grew from 66.3 quadrillion British thermal units (Btu) in 1970 to 84 quads in 1993, a 26.6% increase. In the same period, the nation's gross domestic product (GDP) grew from $3.39 trillion to $6.38 trillion (in 1992 dollars), an 88.4% increase. From 1970 to 1973 the nation's energy consumption grew 12%, an average annual rate of 3.8%. This was accompanied by a parallel 15% increase in GDP, a 4.8% annual growth rate.

In October 1973 the Arab oil embargo occurred, followed by a large jump in OPEC oil prices, which in turn caused substantial price increases for end-users. This is reflected in Figure 2 [11, 18, 20], which gives the ratio of real prices (deflated in 1992 dollars using the consumer price index) relative to the 1970 price (thus removing the influence of inflation and price differences among alternate fuel types; a value greater than 1.00 means that the inflation-adjusted price increased during the period under review). The graph shows that the price of distillate fuel rose steeply, by 56% from 1973 to 1974, and remained relatively stable until 1978. Motor gasoline prices were less affected, rising only by 28% compared with 1973. Real motor gasoline prices declined in 1975 through 1978.

Figure 1 Total U.S. Energy Consumption and Gross Domestic Product



Coal prices rose by 98% in 1974 and then declined by a rate of 6.9% annually until 1976. Following smaller price increases in 1977 and 1978, coal prices eased during the following few years. Coal prices exhibit a continuing downward trend in the 1980s.

Electricity prices increased by almost 16% in 1974, and continued with small but steady increases until 1978. Prices increased in these years at an average annual rate of 5.3% compared with 1973. Electricity prices peaked in 1982, then declined slowly.

Natural gas prices increased in 1974 compared with 1973 and prices continued to rise at an annual rate of about 8% until 1983. Natural gas prices then declined until 1992.

The increase in OPEC oil prices negatively influenced the balance of trade. The annual out-flow of U.S. dollars increased from approximately $7.6 billion in 1973 to $24.3 billion in 1974 to pay for the imported petroleum and petroleum products. Crude and partly refined petroleum cost rose from $4.6 billion in 1973 to $16.5 billion in 1974 [9].

The higher fuel prices and the increased outward flow of U.S. dollars resulted in a downturn in energy consumption, at an annual rate of 2.5%, while real GDP declined at an annual rate of 0.75% during the 1974-1975 period. The economy recovered in the 1976-1978 period, while the real prices of petroleum products remained relatively constant, although there was some increase in the real price of natural gas.[1] In this period both energy consumption and gross national product increased, and the country appeared to be on the road to recovery.

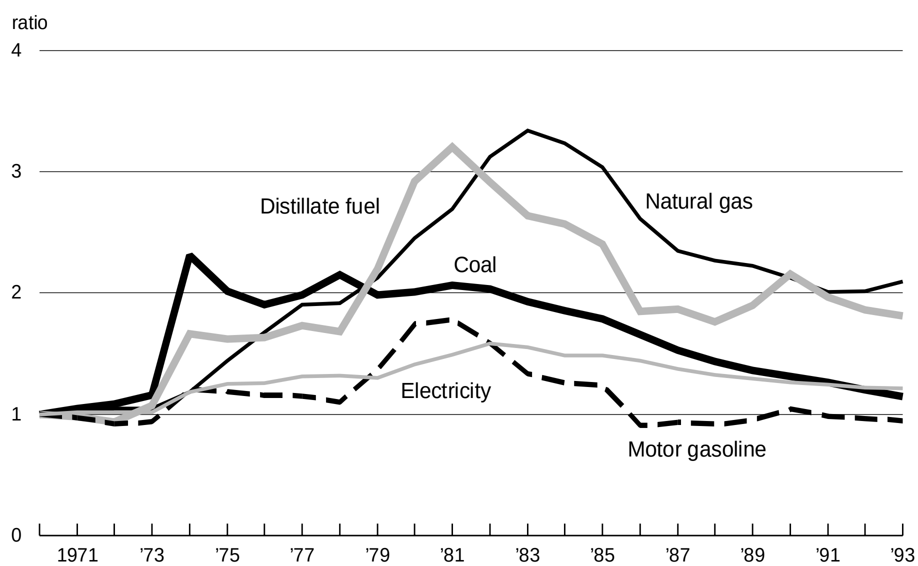
The economic recovery period was interrupted by the Iranian revolution in early 1979, which caused a rapid increase in distillate fuel prices that continued until 1981 (figure 2). Distillate fuel prices increased at an annual rate of about 15% in the 1979-1982 period as compared with 1978. Natural gas prices also increased significantly, at an annual rate of 13% as compared with 1978. Actual electricity prices declined in 1979 but rose during the 1980-1982 period, declining afterward. Motor gasoline prices increased in 1979-1981 at an annual rate of 17% and declined afterward. Coal prices were not significantly affected by the oil supply interruption because of the limited opportunity for substituting coal for crude oil in electrical generation and the large coal reserves of the country.

Again, as in 1973, the 1979 energy price increases contributed to a decrease in national energy consumption and a slowdown in the gross domestic product. However, the decrease in national energy consumption from 1979 to 1983, in part caused by the economic slowdown, also reflects some improvement in energy efficiency, as shown by an increasing GDP in 1981 and 1983. This point will be discussed later. Events such as the 1973 oil embargo and the 1979 oil supply interruption bring out the continuing vulnerability of the U.S. economy to events beyond its borders and beyond the direct control of the U.S. or the Midwest region.

Regional Energy Use and Economic Activity

The region's land area, at 258,461 square miles, is only 7.3% of the United States [9]. In 1970, the region's population was about 16% of the U.S. resident population. By 1993, although the region's population grew in absolute terms, its percentage of U.S. resident population had dropped to 13.5%. The resident population of the Midwest region grew from 32.4 million in 1970 to 34.7 million in 1993 [9], an increase

Figure 2 Ratio of Real Fuel Prices Relative to 1970 Fuel Prices—U.S.



of approximately 7.1%, equivalent to an annual growth rate of 0.3%. In contrast, the U.S. population increased by 26.9%, a 1.04% annual growth rate, more than three times the Midwest population rate. All the states in the region have population growth rates well below the national growth rate. Wisconsin had the highest population growth during the 1970-1993 period, with 14%. Indiana, with 10%; Michigan, with 6.7%; and Illinois, with 5.3%, had smaller population growth. Iowa, the least populous state in the region, showed a small decline (–0.4%). These figures reflect a population shift to the Sun Belt states.

Economic activity in the Midwest region, as measured by gross state product (in 1992 dollars), is given in figure 3 [10, 19]. The Midwest region shows the same general trends as the nation (figure 1), but the region exhibits smaller growth and greater decline rates than the nation. Since 1970 the region's gross state product (GSP) has increased from $0.551 trillion in 1970 to $0.803 trillion in 1993, a 45.7% increase equivalent to an average rate of 1.6% per year in real growth. During the same period the United States gross domestic product (GDP) increased by 87%, or an average rate of about 2.8% per year, from $3.278 trillion in 1970 to $6.128 trillion in 1993. Thus, the region's real economic output grew at an average rate that was 43% of the growth rate of the national gross domestic product. Overall, the Midwest gross state product share to the U.S. GDP declined from 16.8% in 1970 to 13.1% in 1993.

The region's annual energy consumption trend, also shown in figure 3 [10, 19], generally reveals the same peaks and valleys shown in figure 1 for the nation. While U.S. energy consumption shows a rising trend, however, energy consumption in the Midwest region was almost flat over the 1970-1993 period. While the nation shows an increase of about 26.6%, from 66.3 quad to 84 quad, the region shows a 7.2% increase in energy consumption, from 10.7 quad in 1970 to 11.4 quad in 1993.

Midwest fuel prices in figure 4 [11, 18, 20] exhibit shifts similar to U.S. fuel prices (shown in figure 2). However, compared with the nation, Midwest distillate fuel shows larger price increases, while natural gas shows smaller increases, during the 1980s. Coal prices in the Midwest were higher than in the nation as a whole except for 1974, 1978, and the period 1990-1993. Natural gas prices in the Midwest have been consistently higher, often by as high as 20%. Distillate fuel prices were lower in the Midwest prior to the OPEC oil shock. By 1978 the gap between Midwest and the national distillate fuel prices had been eliminated. Motor gasoline prices in the Midwest closely followed the national prices. Electricity prices in the Midwest were about 12% to 16% higher in 1970-1973. After the oil embargo, Midwest electricity followed closely the national prices and since 1988 has been lower than the national prices.

A more meaningful comparison of the regional and national economies is shown in figure 5 [9, 10, 19], which gives the regional and national economic output per-capita (in 1992 dollars) in the U.S. and Midwest and the corresponding energy consumption per-capita. In 1993, the region's GSP per-capita was about 3% less than the nation's per-capita GDP. In 1970 the per-capita regional product was about 5% higher than the nation's per-capita product. It remained higher during the 1970-1979 period, although the per-capita output difference was decreasing. However, in 1980, following the Iranian revolution, the nation's economic output per-capita slightly exceeded the

Figure 3 Midwest Energy Consumption and Gross State Product

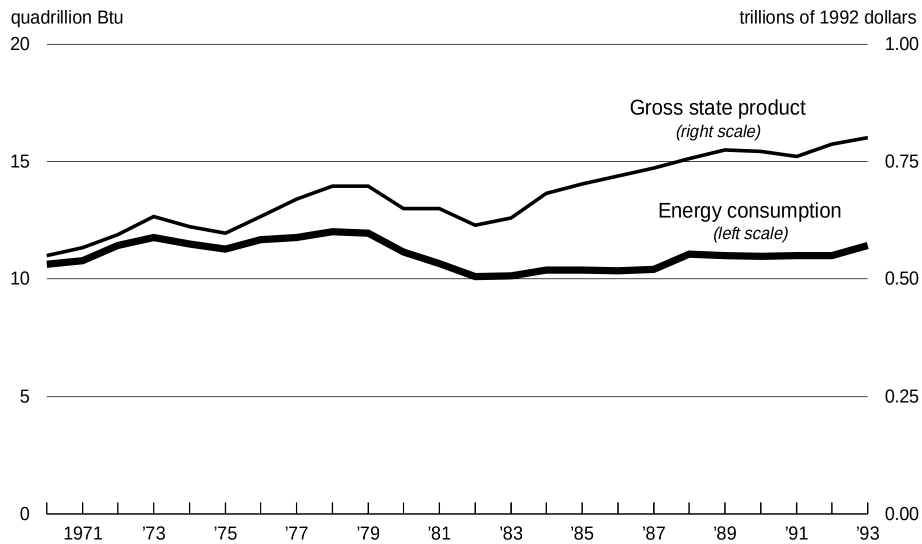
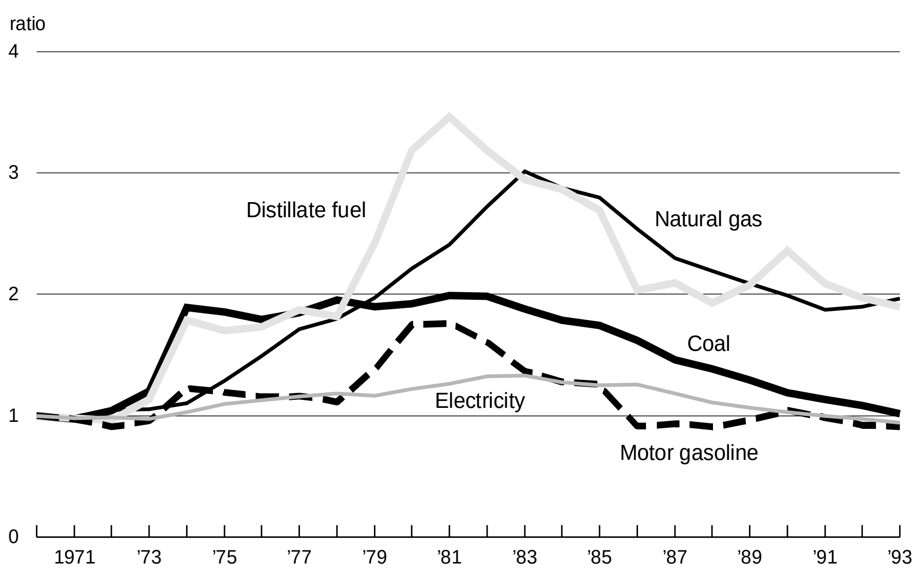


Figure 4 Ratio of Real Fuel Prices Relative to 1970 Fuel Prices—Midwest



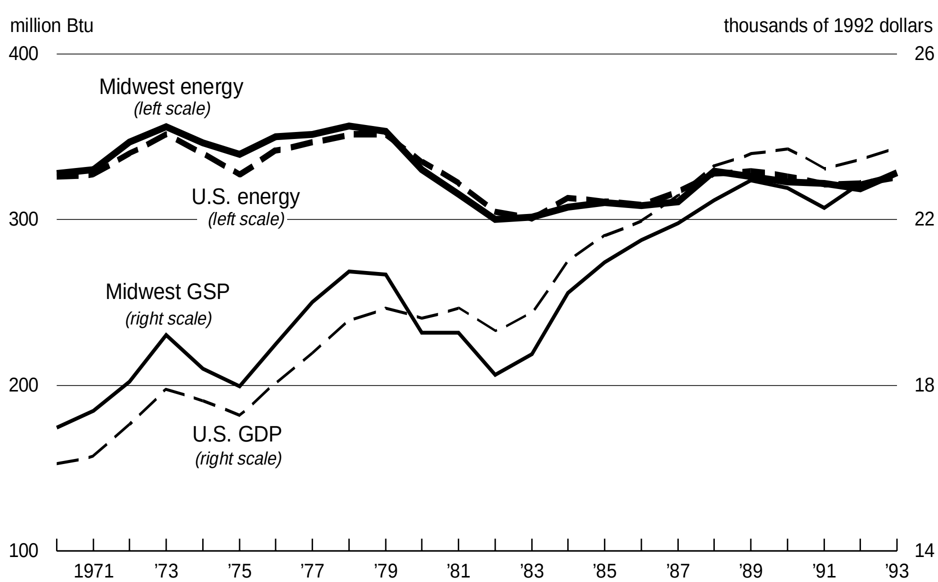
regional per-capita economic output. This trend has continued since. The economic output per-capita reveals clearly the effect of the oil shocks to the economy. Both the regional and the national output per-capita declined following the 1973 and 1979 oil supply interruptions. During 1974 and 1975, the economy declined (in output per-capita) by an average annual rate of 3.2% for the region and 1.7% for the nation. Following the 1979 Iranian revolution, the region's economy declined until 1982 by an average annual rate of 2.9% while the nation's economy declined slightly in 1980 and 1982 only by about 1.1% and 2.7% respectively.

The regional economy, on a per-capita basis, grew at an average annual rate of less than 1.4% and the national economy grew at a rate of 1.7% during the period 1982-1993. This is indicative of the greater sensitivity to energy disruptions of the regional economy compared with the national economy. For the entire period under review, the regional economy, in output per capita, grew 36% while the national economy grew by 47.4%.

Figure 5 shows that the Midwest region, in 1980 and thereafter, consumed approximately the same amount of energy per capita as the nation, even though the region is home to heavy industries, which are considered inefficient energy consumers. Energy use per capita peaked in 1978 and then declined until 1986. Both the region and the nation exhibit a small increase in energy use in the following years.

Another meaningful measure of energy performance is energy use per real dollar of economic output, which is shown in figure 6 [10, 19] for the United States and the Midwest. The national figure decreased from 20.2 thousand Btu per dollar of real output (1992 dollars) in 1970 to 13.7 thousand Btu per dollar of real output in 1993, a

Figure 5 Gross State Product Per Capita and Energy Use Per Capita



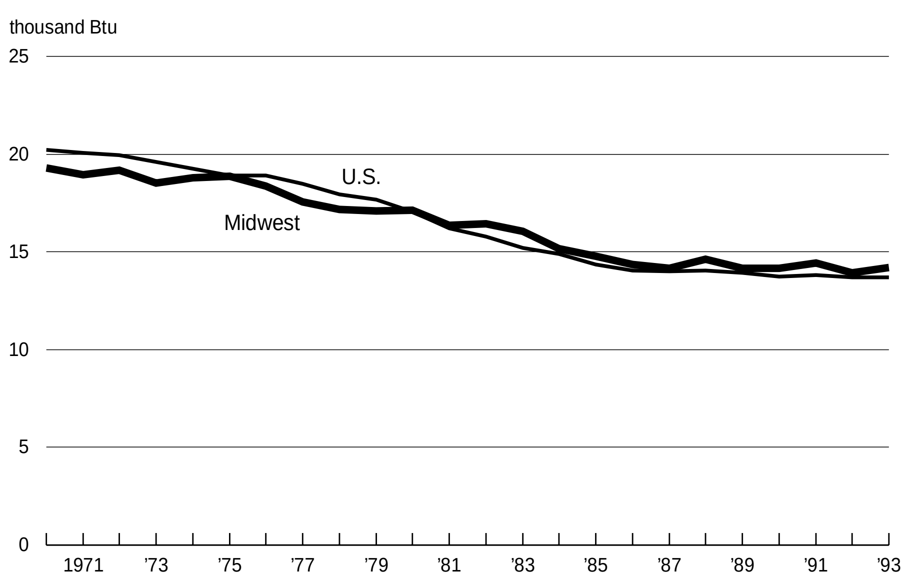
decrease of 32.3%, reflecting a decrease in energy use. The regional energy use per dollar of real output dropped from 19.3 thousand Btu in 1970 to 14.2 thousand Btu per dollar of real output in 1993, a 26.4% decrease. The downward trend of the energy use per dollar of output leveled off during the 1986-1993 period.

The nation and the region have the potential for additional improvements in the efficient use of energy (i.e., to a continuing decrease in the energy use per real dollar of output). However, the relatively inexpensive methods of improving energy efficiency through modified operating procedures and minor capital improvements are running out. Continued efficiency increases in the use of energy will depend on much larger capital investments.

Figure 7 [19] is a more detailed look at the regional energy consumption flows. The dominant role of petroleum (32% of total input) is evident, with coal (30.3%) and natural gas (26.2%) in second and third places. Nuclear fuel and renewable resources (including hydroelectric power) provide approximately 11.5% of the total regional energy; more than 95% of this is nuclear.

In the end-use sectors, the transportation sector uses 23.1% of the total energy consumed in the region, fueled predominantly by petroleum (98%). This emphasizes the need to improve energy efficiency in the transportation sector (or to find alternative fuel for transportation) if there is to be a substantial decrease in the use of petroleum. The industrial sector, with 26.1% of the region's total energy consumption, is the largest consumer of energy, with natural gas (37.1%), petroleum (27.5%), coal (19.4%), and electricity (16%) supplying its basic fuel needs. The residential and commercial sectors

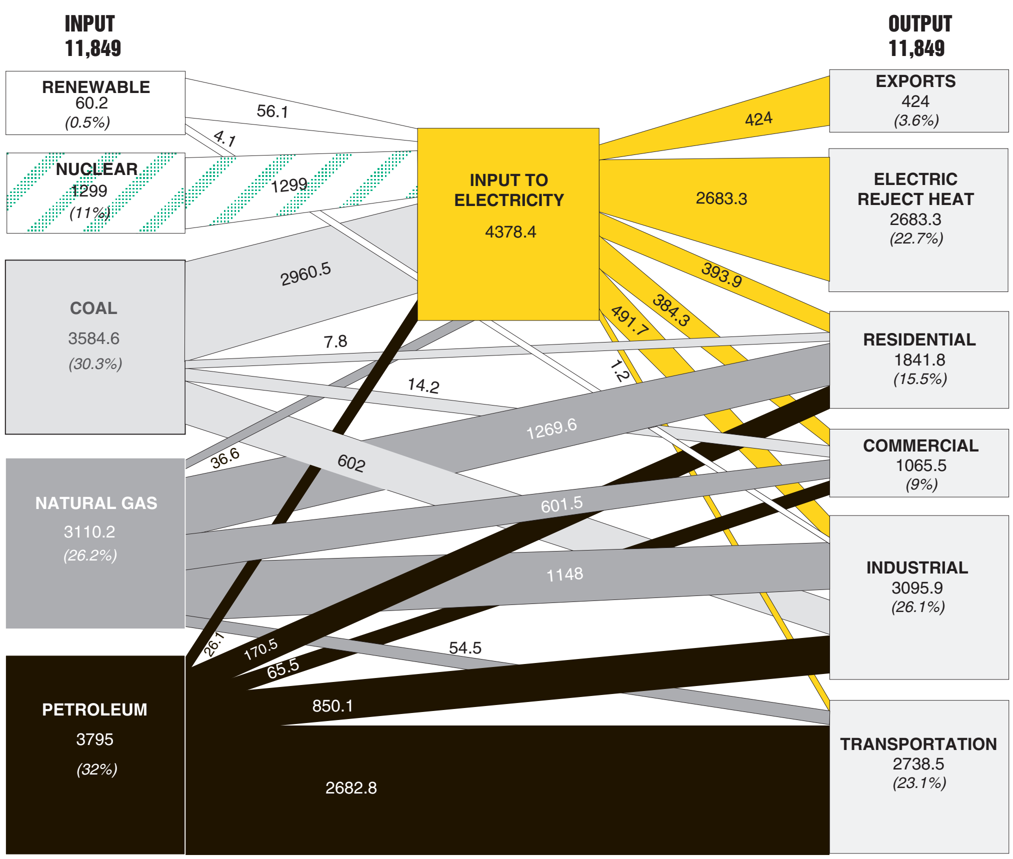
Figure 6 Energy Use Per 1992 Dollars of Real Output



together use approximately the same amount of energy as the industrial sector but are more dependent on natural gas, which supplies 68.9% of the residential sector's and 56.5% of the commercial sector's energy requirements. The remaining residential requirements are primarily electricity (21.4%), oil (9.3%), and coal (0.4%). The remaining commercial requirements are primarily electricity (36.1%), oil (6.1%), and coal (1.3%).

Reject heat associated with the generation of electricity constitutes almost one-quarter (22.7%) of the regional energy consumption. This is a large amount of energy, but it is generally low-temperature energy. It is possible to put this energy to productive use, but it is usually expensive to do so. Current design and development projects in district heating and cogeneration are evaluating the economic feasibility of these options. However, the location practices of power-generating plants may restrict the use of reject heat. Figure 7 demonstrates that electrical generation is a conversion process, taking input fuel, which is primarily coal (67.6%) and nuclear (29.7%) and relatively little oil, natural gas,

Figure 7 Energy Flows in the Midwest Region, 1993 (trillion Btu)



and renewable energy sources, and converting it to useful electricity and reject heat. Because the fuel input to electricity constitutes more than one-third (37%) of the total energy consumed in the region, the electrical sector is of special interest.

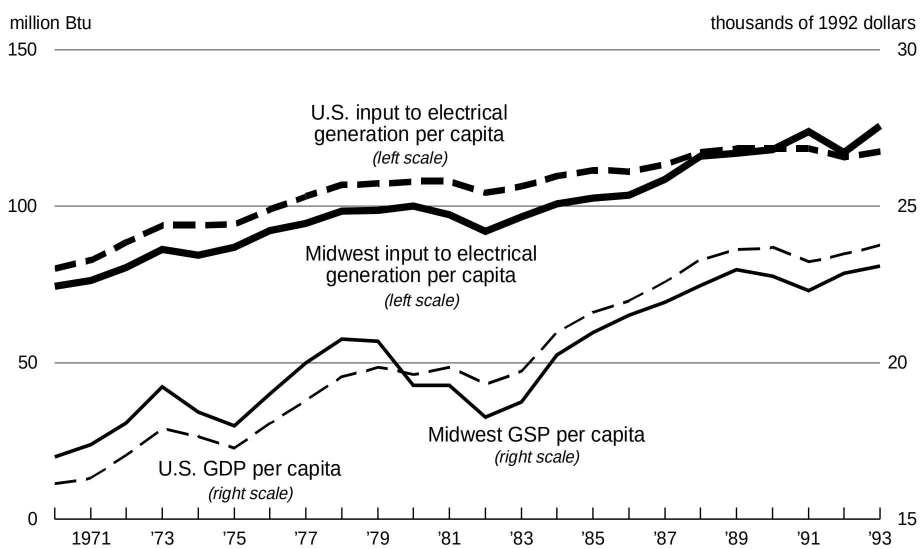
Figure 8 [7, 9, 10, 19] shows the per capita fuel energy input to the electrical sector for the United States and the region for the 1970-1993 period. The average annual growth rate of the per capita fuel input to electrical generation was approximately 2.3% for the region (a total of 68.9%) and 1.7% for the nation (a total of 47.1%) during the 1970-1993 period. Before 1990, the region's per capita fuel input to the electrical sector was lower than the nation's. After 1990, the region had a higher energy input to electrical generation. Starting in 1987, the region became a net exporter of electricity. The electric generation closely follows the pattern of per capita gross product for the region and the nation (also shown in figure 8).

State Energy Use and Economic Activity

State-Level Energy Consumption Per Capita in 1970-1993

The end-use energy consumption per capita statistics for selected years from 1970 to 1993 are shown in figures 9 and 10 [9, 19] for the nation, the region, and each of the states. Figure 9 shows United States and Midwest energy consumption per capita. It shows that the region used about the same amount of energy per capita as the country as a whole.

Figure 8 Per Capita Input to Electrical Generation and Gross State Product Use Per Capita



The region had a higher level of energy use per capita in the residential sector (probably because of a colder winter climate), about equal levels in the commercial and industrial sectors, and less consumption per capita in the transportation sector (probably because of the industrialization of the region and the large concentrations of population in metropolitan areas). Figure 9 shows that the per capita energy consumption for both the United States and the region varied during the 1970-1993 period but was at about the same level in 1993 as in 1970.

Figure 10 shows the variations that occurred from state to state in the per capita energy consumption in each end-use sector and in the overall figure. For example, in 1993 the energy consumption per capita ranged from a low of 291 million Btu for New York to a high of 440 million Btu for Indiana, compared with a regional average of 329 million Btu and a national average of 326 million Btu. The unusually high value for Indiana reflects the high industrial use, perhaps because of the presence of the steel industry in that state. Also, the Indiana transportation sector had a higher per capita energy consumption than any other state. Wisconsin had the lowest consumption of energy, with a value of about 291 million Btu per capita in 1993. This is because of the lower residential and commercial energy use per capita in the region.

A few general observations can be made for each end-use sector from figure 10. In the residential sector, Wisconsin has the lowest energy requirements while Indiana has the highest. The per capita requirements of the commercial sector are lowest in Wisconsin and highest in Illinois. Indiana has the highest per capita energy consumption in the industrial sector while Wisconsin and Michigan have the lowest. In the transportation sector, Illinois and Wisconsin have the lowest energy consumption per person, while Indiana consumes the largest amount of energy per capita.

Figure 9 Energy Consumption Per Capita, U.S. vs. Midwest

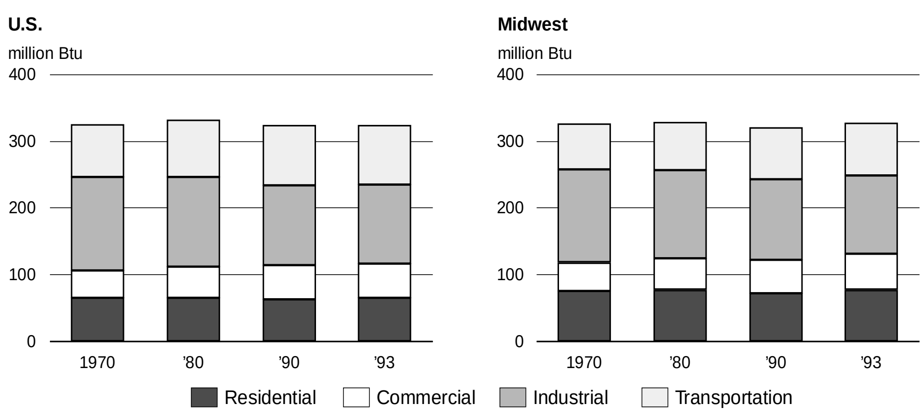
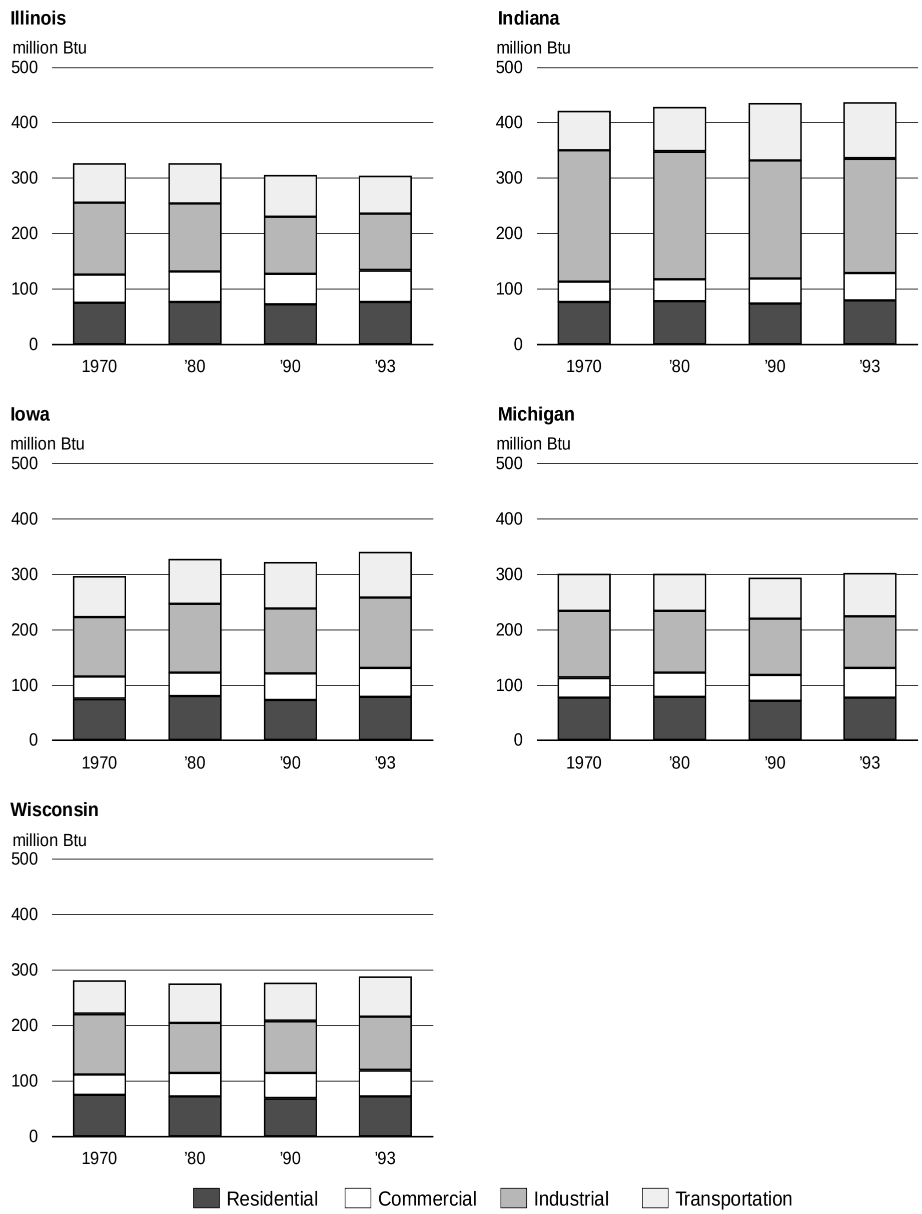


Figure 10 Midwest Energy Consumption Per Capita, by State



Energy Consumption Per Dollar of Gross State Product between 1970 and 1993

Figures 11 and 12 [10, 19] show the energy consumption per real dollar output of goods and services for the nation, the region, and each state in the region. Figure 11 presents, in bar chart form, the same basic information as figure 6, but gives more detail for each end-use sector. Both the region and the nation reduced energy consumption per dollar of gross output by about 32% and 26% respectively. Overall, in 1993 the energy consumption per dollar of output for the Midwest region was about 5% higher than for the nation. In 1970, the energy consumption per dollar of output for the Midwest region was about 4% below the nation's. Except for transportation, all other sectors of the regional economy showed higher energy consumption per real dollar of output than the national economy.

Figure 12 presents the state-by-state performance. The national and regional trend of decreasing energy required to produce a real dollar of output is also displayed by every state of the region, with improvements ranging from a low of about 18% in Iowa to a high of 32% in Illinois during the 1970-1993 period.

The actual magnitude of the energy consumption per dollar of gross state product within the individual states in 1993 ranged from a low of 11.7 thousand Btu for Illinois to a high of 19.3 thousand Btu for Indiana (again probably reflecting the steel industry). Indiana and Iowa were above the national average in energy consumed per real dollar of gross state product. The energy consumption per real output in Illinois and Wisconsin were below the energy consumption per real dollar output for both the nation and Midwest region in 1993.

A few general observations can be made for energy consumption per gross state product for each end-use sector in 1993. In the residential sector, Illinois has the lowest energy requirement while Iowa and Indiana have the highest. The energy requirements of the commercial sector are lowest in Illinois and Wisconsin and the highest in Iowa. Indiana has the highest energy consumption per output in the industrial and transportation sectors while Illinois has the lowest.

State Fuel Use Patterns between 1970 and 1993

The energy problems the country experienced in 1973 and 1979 clearly resulted from our dependency on imported oil. Accordingly, it is instructive to review the fuel use patterns in the region and nation to determine whether there have been significant

Figure 11 Energy Consumption Per 1992 Dollar of Gross Product, U.S. vs. Midwest

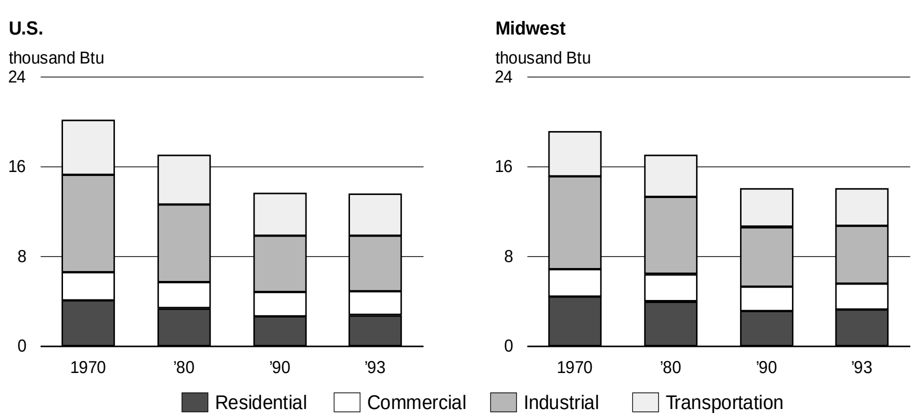
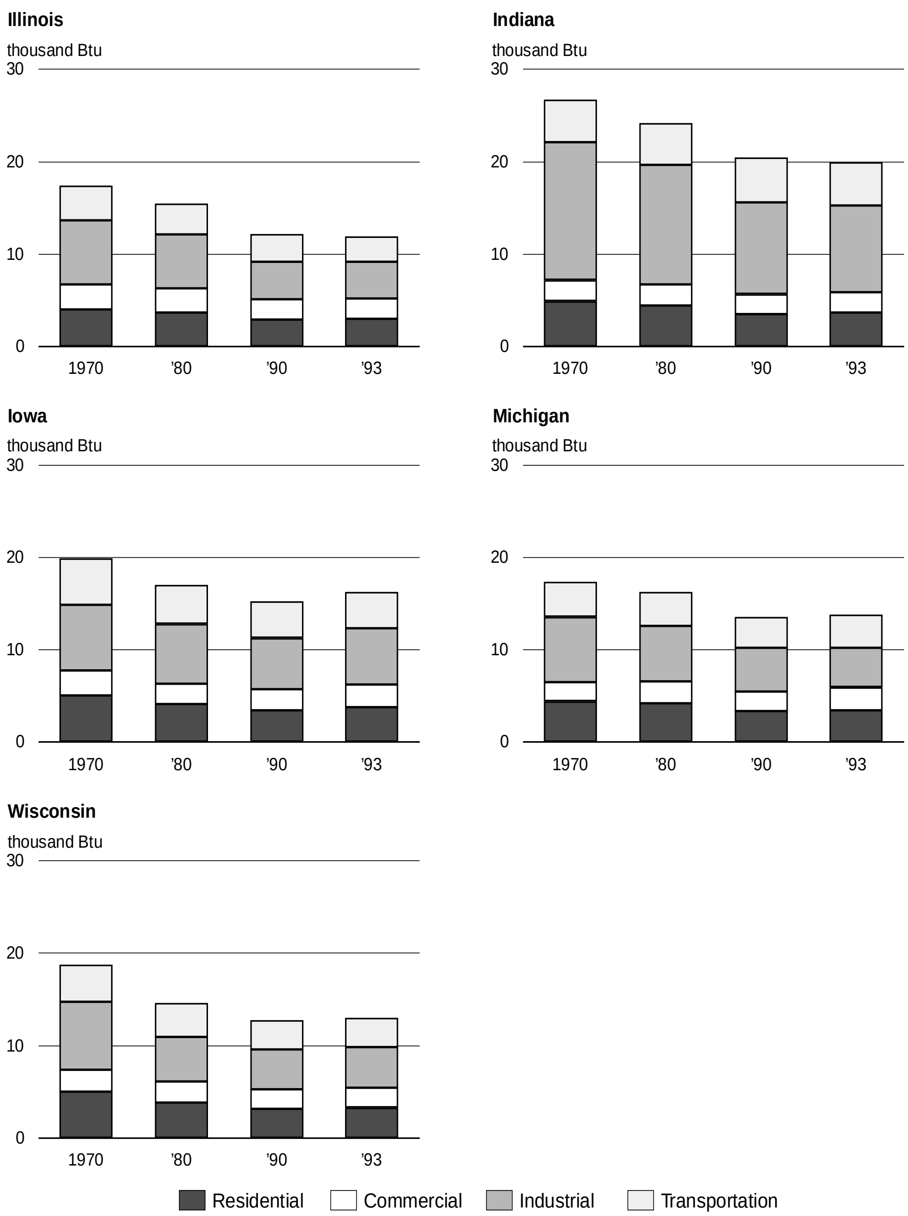
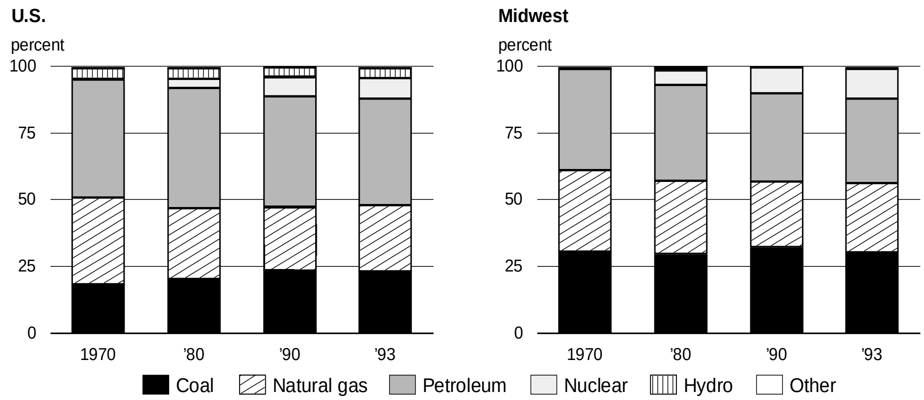


Figure 12 Midwest Energy Consumption Per 1992 Dollar of Gross Product, by State



shifts away from oil toward increasing use of other energy resources. Figure 13 [19][2] shows that both the nation and the region reduced their reliance on oil during the period, but the nation was somewhat more dependent on oil than the region. The nation's petroleum share decreased from approximately 44.5% in 1970 to 40.3% in 1993. The region also experienced the same trends in the use of petroleum over this same period, with a decrease in oil dependency from 38.1% in 1970 to 32% in 1993.

Figure 13 Relative Energy Shares by Fuel Types, U.S. vs. Midwest



This reduction does not indicate that the country reduced its oil consumption; however, it shows that a new source, nuclear power, increased its role over the same period.

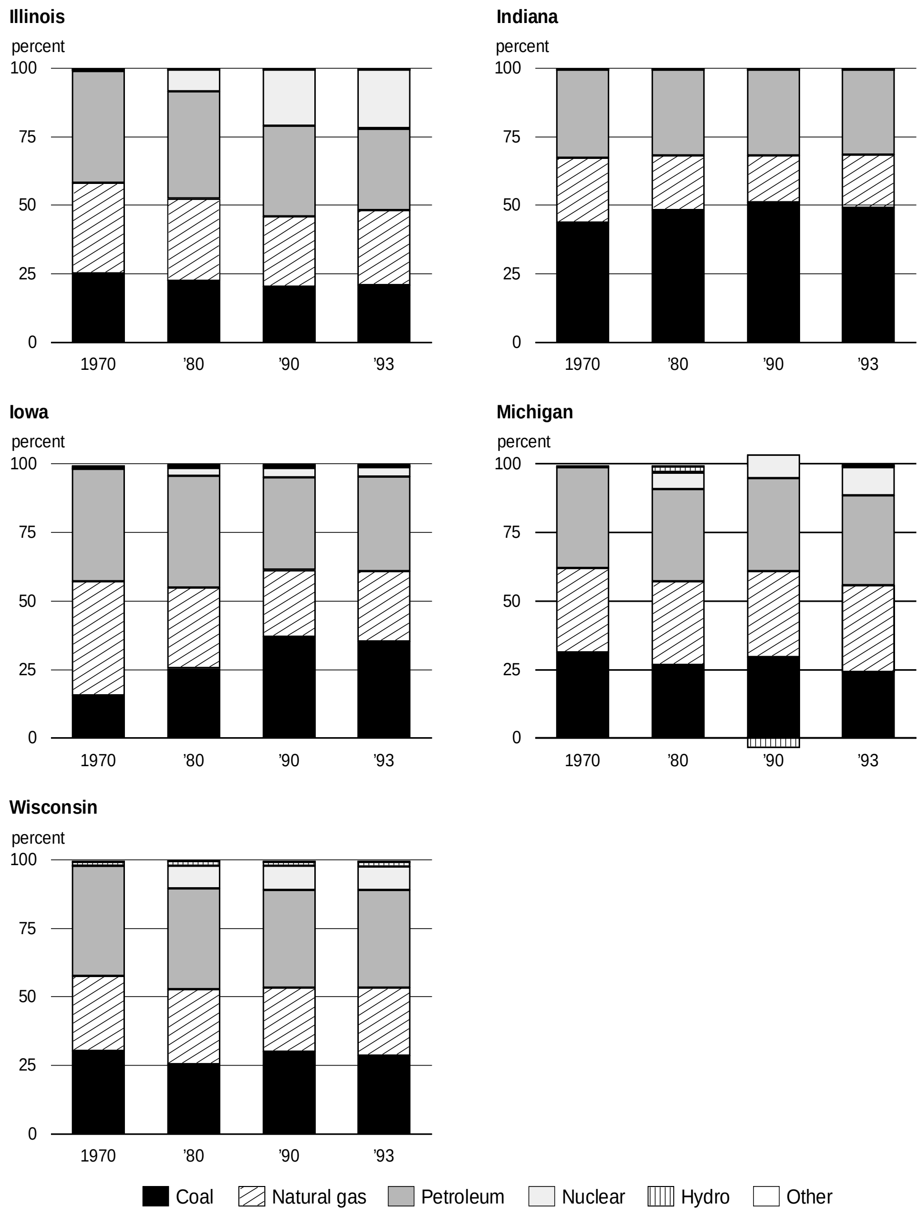
The region is generally more dependent on coal than the nation, although coal's share has remained relatively constant at 30.6% in 1970 and 30.3% in 1993. Nationally, coal carried approximately 18.5% of the country's energy requirements in 1970 and increased to 23.2% in 1993.

The regional share of energy consumption carried by natural gas declined slightly, from 30.6% in 1970 to 26.2% in 1993, while the national share of gas use declined from 32.7% in 1970 to 24.9% in 1993. The reduced role of natural gas may reflect greater use of less expensive western coal and the increased role of nuclear power. Deregulation, which was supposed to improve gas availability, has not increased the share of gas use at the national or regional level yet.

Nuclear power carried a greater share of the energy burden at the regional and national level in 1993 as compared with 1970. At the national level, nuclear power accounted for 7.8% of the energy requirements of the country in 1993 compared with less than 0.4% in 1970. The region's share of nuclear power was 11% in 1993 compared with 0.3% in 1970. The national and regional share of renewable resources, which includes hydroelectric power, did not show any significant change over the period.

Within the region, the states most dependent on petroleum in 1993 were Wisconsin (35.8% of its energy consumption) and Iowa (34.3%) (figure 14 [19]). Illinois and Indiana (29.9% and 31.2% in 1993 respectively) were least dependent on petroleum. Indiana, at 49.1% of its energy consumption, was the largest user of coal on a percentage basis. Illinois, with the highest coal reserves and production in the region, was the least dependent on coal at 21.1% of its energy consumption. Michigan, with a natural gas share of 31.8%, was the most dependent on that fuel. Indiana, with 19.5%, was the least dependent on natural gas among the region's states. Illinois has the largest

Figure 14 Midwest Relative Energy Shares by Fuel Type, by State



nuclear program, serving 21.7% of its energy needs in 1993. The state's nuclear program has contributed to the reduction of the share of petroleum, natural gas, and coal. Indiana does not have any nuclear power generating capacity. Wisconsin has the most renewable resources; they provided 2% of its energy needs in 1993.

State Level Electrical Use between 1970 and 1993

Figures 15 and 16 [9, 19] present the per capita energy input to the electrical sector on a national, regional, and state-by-state basis. The figures are corrected for exports and imports of electricity and reflect the net energy input used for electricity consumed within the region and states. Of interest is the increasing pattern of electricity use per person over the period; national and regional energy use per capita both remained stable over the period, but electricity use shows a steady increase. The nation's electricity use per capita increased by 47.1% from 80 million Btu per person in 1970 to 117.7 million Btu per person in 1993. The region's electricity use per capita increased by 54.9% between 1970 and 1993 from 73.5 to 113.8 million Btu per person. Coal represents over 50% of the input to electricity generation with 65.3 million Btu per person for the nation and 85.2 million Btu per person for the region, respectively. Nuclear power follows with 25.3 million Btu per person for the nation and 37.4 million Btu per person for the region. The use of natural gas and petroleum has been significantly reduced.

On the state level, electricity use per capita increased over the 1970-1993 period from a 34.9% rate in Michigan to an 89.3% rate in Iowa. In 1993, electrical consumption per person ranged from a high of 152.2 million Btu for Indiana, to a low of 98.1 million Btu for Michigan. The region is an exporter of electricity, with net exports of 423.6 trillion Btu in 1993, or 12.2 million Btu per capita. Exports accounted for about 10% of electricity generation. Illinois exported 274.6 trillion Btu, Indiana exported 172.3 trillion Btu, and Michigan exported 33.2 trillion Btu during the same year. Wisconsin and Iowa were net importers of electricity.

Figure 15 Net Electrical Energy Use Per Person, Input to Electricity, U.S. vs. Midwest

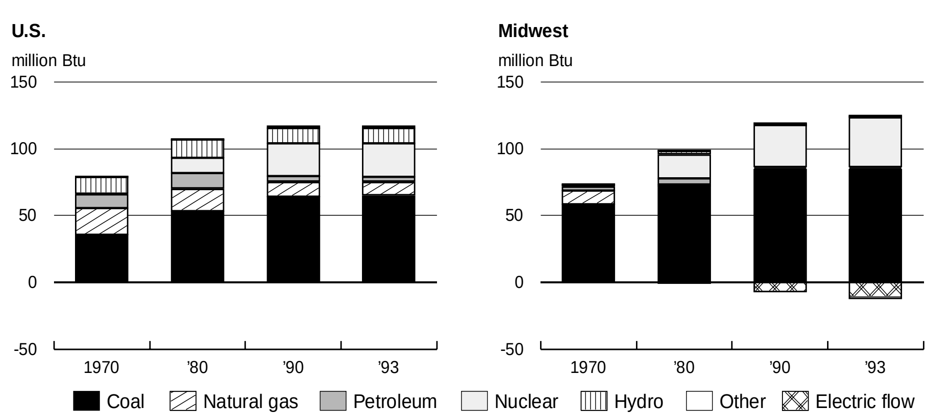
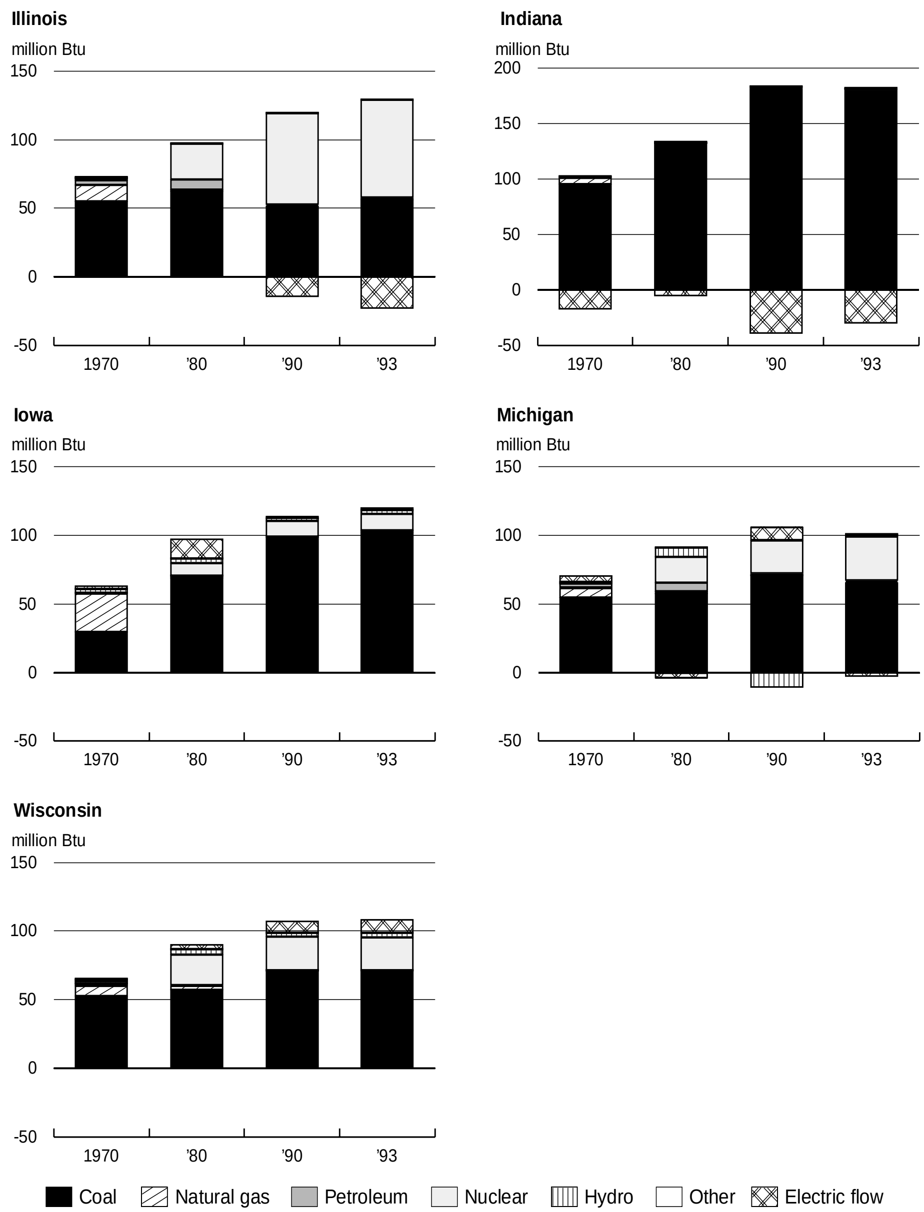


Figure 16 Net Electrical Use Per Person, Input to Electricity, by State



Indiana used coal to generate 98.8% of electricity. Even states such as Michigan and Wisconsin, with no coal production, used a significant amount of coal (65.8 million and 71.8 million Btu per person) for power generation. Although all states have increased coal consumption over the 1970-1993 period, the share of coal for power generation has decreased, replaced by nuclear power. Illinois, especially, has shifted from a majority coal user for electric generation to a majority nuclear power user.

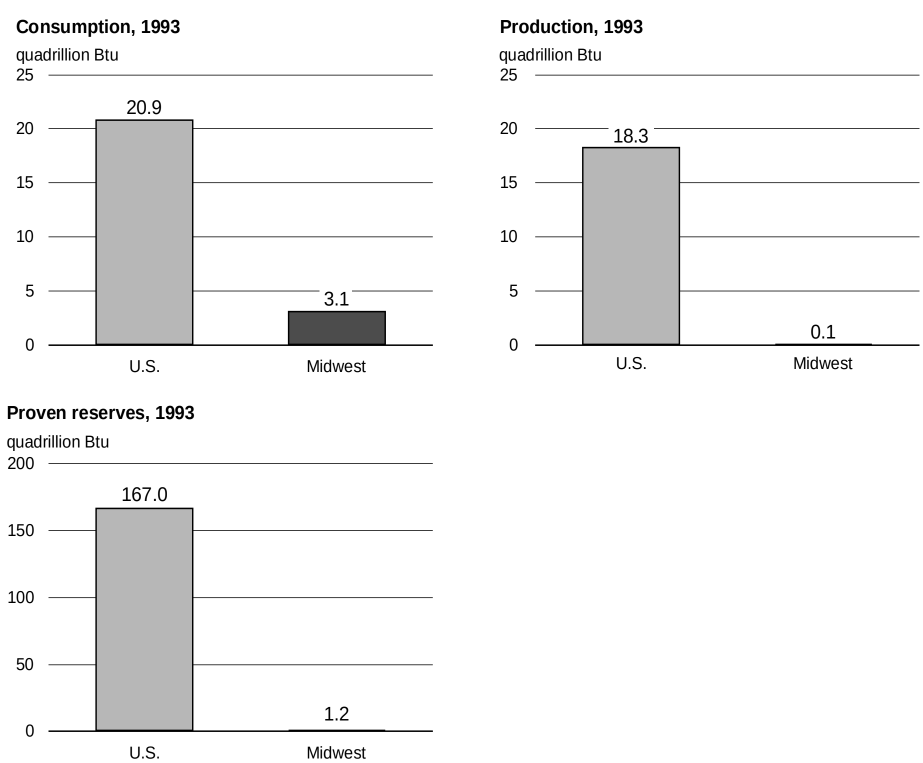
Illinois was the largest nuclear user in the region (71.6 million Btu per person in 1993), followed by Michigan (32.1 million Btu per person). Wisconsin and Iowa had smaller nuclear power generating capacity (23.8% and 10.3% of their electricity generation capacity respectively). Indiana does not have any nuclear power generating capacity.

Regional Energy Resources and Production

Regional reserves, production, and consumption of natural gas for 1993 are presented in figure 17 [12, 19, 22]. The region possesses less than 1% of U.S. gas reserves and produces only 0.8% of the nation's natural gas. In 1993, total reserves for the region amounted to 1,160 billion cubic feet of gas, located in Michigan. The region consumed 3.11 quadrillion Btu, 14.9% of the nation's natural gas consumption. The 1993 regional production of natural gas was approximately 4.5% of the regional consumption of this fuel. It can be concluded that although the production of natural gas may be of importance to Michigan, the region will continue to be a heavy importer of natural gas. The region's demonstrated natural gas reserves are sufficient to meet the consumption needs of the region for less than five months.

The region's petroleum and natural gas liquid reserves, production, and consumption for 1993 are presented in figure 18 [12, 19, 22]. The regional petroleum picture is not markedly different from that of natural gas. In 1993, petroleum reserves amounted to 221 million barrels, equivalent to about 1% of the nation's reserves. Most

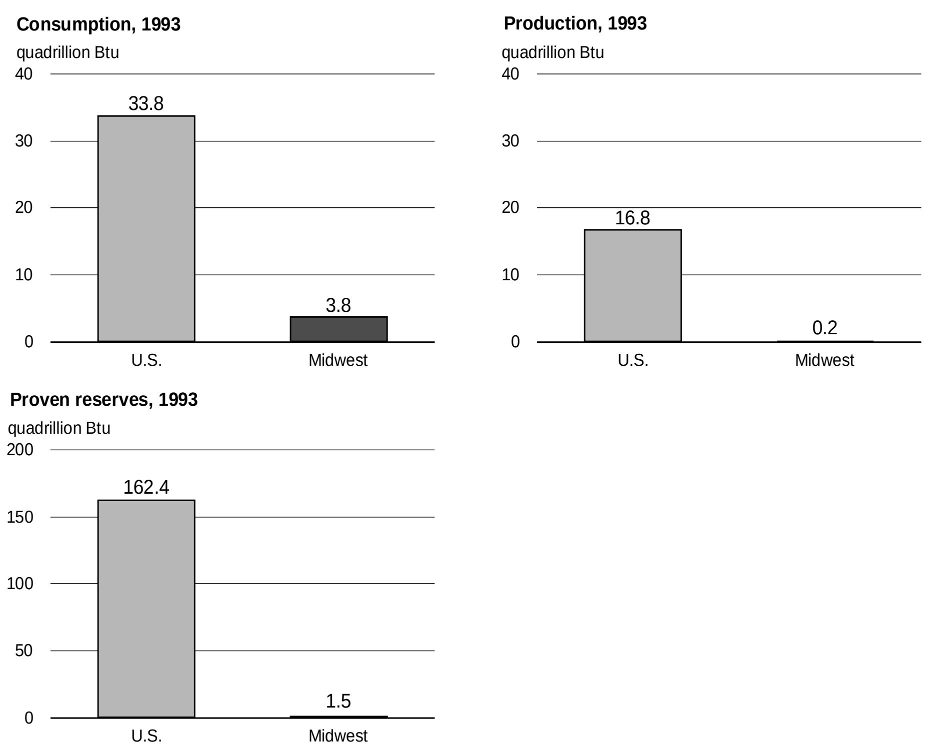
Figure 17 Supply and Demand: Natural Gas



of the petroleum reserves are located in Illinois (52%), Michigan (41%), and Indiana (7%). Natural gas liquid reserves for the region amounted to 57 million barrels, all of them located in Michigan. The region produced approximately 29 million barrels of oil and 6 million barrels of gas liquids in 1993, approximately 1% of the nation's oil and gas liquids production. Illinois accounted for 52% of the region's petroleum production, Michigan for 41%, and Indiana for 7%. Illinois is the only gas liquids producer. The 1993 regional petroleum and gas liquids production was approximately 5% of the region's 3.80 quadrillion Btu consumption of these fuels. The region's demonstrated petroleum and gas liquids reserves are sufficient to meet the consumption needs of the region for less than five months.

Figure 19 [12, 13, 14, 16, 19] displays the reserves, production, and consumption of coal in the region and nation. In 1993, demonstrated coal reserves amounted to 90.4 billion short tons, 19.1% of the national coal tonnage reserves. The region's reserves lie in the interior coal region. Illinois, with 78 billion short tons, has the largest demonstrated reserves, followed by Indiana with 10.1 billion short tons, Iowa with 2.2 billion short tons, and Michigan with only 0.13 billion short tons. In 1993, the region produced 70 million short tons, equivalent to 7.4% of the national production. Coal consumption was 170.8 million short tons, 18.4% of the national coal consumption. The coal consumption was higher than the regional production by about 100 million short tons because of increasing imports of low-sulfur coal (mostly western coal) to the region.

Figure 18 Supply and Demand: Petroleum and Natural Gas Liquids



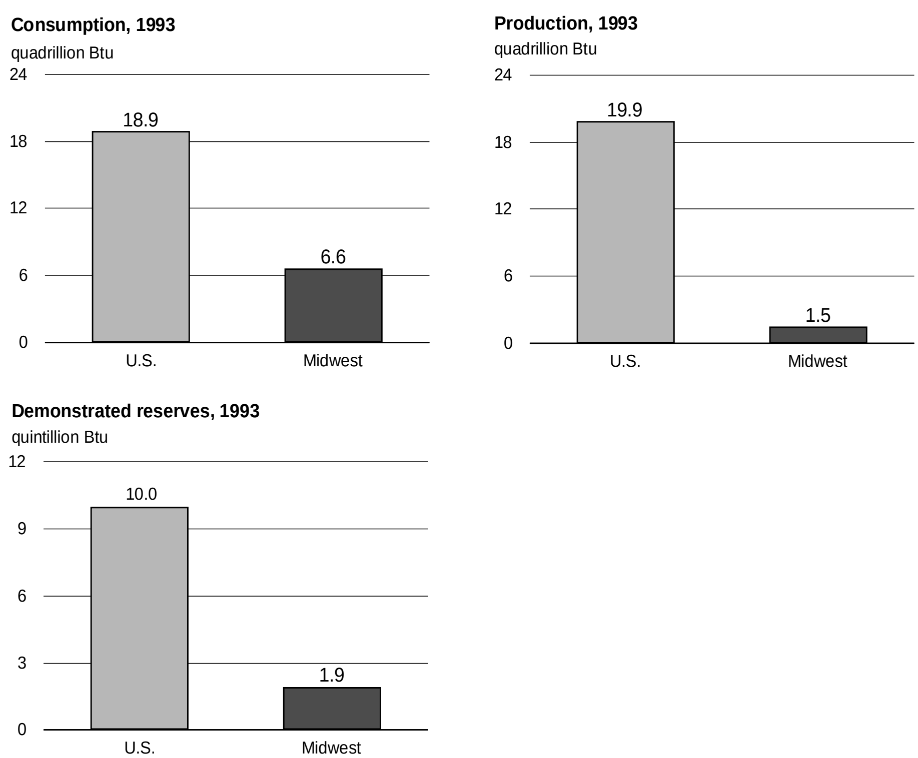
As a consequence, the region's share of the nation's coal production dropped from 14.4% in 1970 to 7.4% in 1993. The region's demonstrated coal reserves are sufficient to meet its consumption needs for the next 500 years. On an energy-equivalent basis, the region's coal reserves are sufficient to cover its energy consumption (at current levels) for more than 150 years.

Changing Trends in Coal Use

Figure 20 [16, 17, 21, 23] shows coal production in the nation, the region, and the three coal-producing regions of the nation (Appalachian, Interior, and Western). National coal production grew by almost 54% from 1970 to 1993, while regional coal production fell by 20.7% during the same period. Appalachian coal production declined by only 4%, while interior coal production rose by 14.2% over the same period. Western coal registers the greatest increase, rising by 933%. The large improvement in Western coal production results from the need for cleaner coal for electrical power generation.

The Midwest region relies on coal for about 30% of its total energy consumption. Some 68% of the region's input to electricity generation is coal. With no new nuclear power plants coming on line, coal will continue holding this market share in the

Figure 19 Supply and Demand: Coal

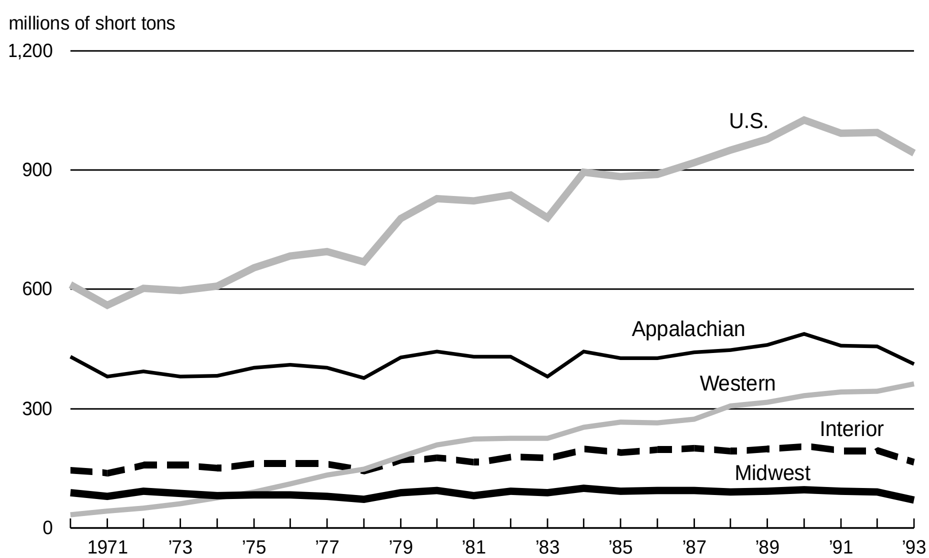


foreseeable future. Coal is the region's only indigenous energy source, and in terms of market price for delivered energy it is also the least expensive energy source, providing economical energy for electric power and industrial needs.

The Midwest region's coal consumption shows an increase of 20.2% in the period 1970-1993 (figure 21 [16, 17, 19, 21, 23]). At the national level, coal consumption grew by 54.1% during the same period. However, this growth in coal use is not being shared by all coal-producing states. This is brought out in figure 20, which shows coal production by the three major coal-producing regions of the country and the Midwest region. It is clear that the increases in coal use have been supplied primarily by the Western region, while coal production in the Midwest region shows a decrease. This pattern is the result of the environmental constraints that have been placed on the burning of high-sulfur coal, such as the coal of the Illinois basin. Western coal and eastern Appalachian coals, with a low-sulfur content, have captured an increasing share of the market.

This trend toward low-sulfur coal is better illustrated in table 1 [15, 19] which shows the magnitude of Western coal imports and Midwest coal deliveries at electric plants in the states of the Midwest region in 1993. More than 80% of coal deliveries in the Midwest region are used in the generation of electricity. However, Illinois, with the largest bituminous coal deposits in the nation, imported from the West 42.9% for its electric plant coal requirements. About 44.8% of deliveries were Illinois coal and 4.9% came from Indiana. Indiana, the largest coal consumer and the second largest coal producer in the Midwest region, imported 32% of its coal requirements from the West,

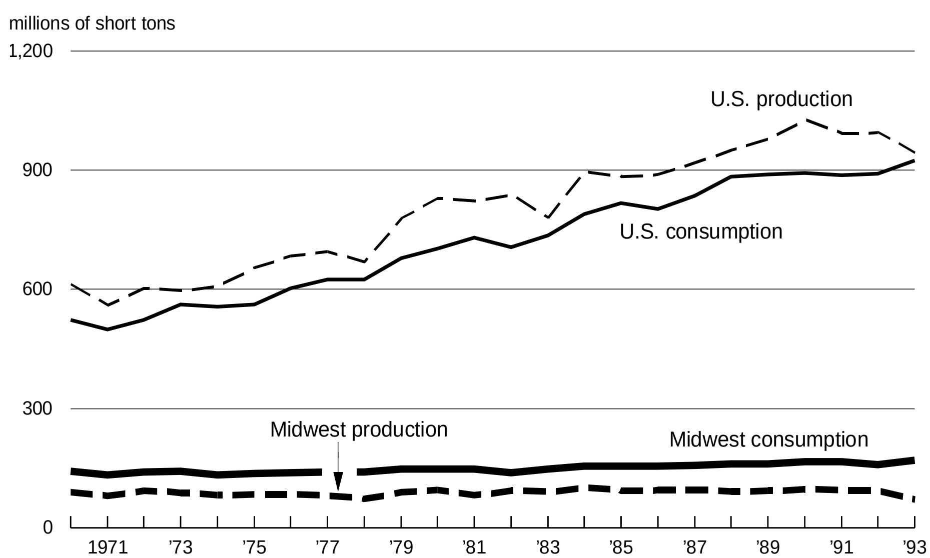
Figure 20 Coal Production by Coal-Producing Region



while Midwestern coal accounted for 56.5% (42% from Indiana and 14.5% from Illinois). Iowa imported 94.2% of its coal requirements from the West and only 5.4% from Midwestern states (mostly Illinois and Indiana). Electric plants in Michigan imported 53.3% of their coal requirements from the West and less than 1% from Indiana, which produces high-sulfur coal. The remaining coal delivered to power plants in Michigan came mostly from the Appalachian region. Wisconsin, which like Michigan has no coal production, imported 87.8% of its coal from the Western region and only 5.6% from Illinois and Indiana. This pattern, while bringing prosperity to Western and Eastern states, creates economic concerns in the coal mining regions of Illinois, Indiana, and in lesser degree Iowa. The future of the coal industry in these Midwest states is critically dependent on a number of factors, including: the Clean Air Act legislation; the global warming debate; the future growth of electric utilities; the public attitude toward nuclear power; and the development of overseas markets.

A major environmental challenge to coal use are the Clean Air Act Amendments of 1990 [1, 5, 6, 7, 8]. The Clean Air Act Amendments (CAAA) are aimed at strengthening the Clean Air Act, which was last revised in 1977; the legislation targets toxic air pollution and urban smog as well as acid rain. Canada and legislators from the northeastern United States have long contended that sulfur emissions from coal-burning electric power plants are responsible for the acidification of lakes and streams in their region. Consequently, the CAAA limits the emissions of nitrogen oxides (NO_x), sulfur

Figure 21 Coal Production and Consumption, U.S. vs. Midwest



dioxide (SO_2), and other emissions from existing electric utility boilers. The major impact of this legislation will be felt most strongly in the high-sulfur coal producing states of the Midwest region.

The acid rain provisions of CAAA require utilities to reduce SO_2 emissions to an approximate level of 2.5 lbs/million Btu by 1995. Phase II further reduces allowable emission levels to 1.2 lbs/million Btu by the year 2000. Units using clean coal technology will be granted an extension in Phase II for repowering technologies. The legislation also, in general, will require utilities to cut NO_x emissions by approximately 2 million tons by the year 2000. Nitrogen oxide emissions, a contributor to ozone formation, can be substantially reduced with new burner technologies and other emission controls. Technological improvements have reduced significantly the environmental impacts of coal combustion; today's technology can capture up to 95% of sulfur dioxide emissions and 99.5% of particulates released by coal combustion. However, the abundance of cheap, low-sulfur coal and the current low cost of emission credit trading makes it highly unlikely that there will be a shift back to high-sulfur coal indigenous to the Midwest region.

The air toxics section of CAAA puts forth a "set schedule" for reductions in public health risk from emissions of 189 toxic chemicals by 75% to 90%. The EPA is to define the "Maximum Achievable Control Technology" (MACT), where existing sources which emit 10 tons/year of one or 25 tons/year of any combination of listed hazardous chemicals must achieve the same emissions standards as those achieved by the best-performing plants now operating. Existing sources have three years to comply, while new sources would be subject to even tougher standards.

Table 1 Imports of Western and Midwestern Coal at Electric Plants in 1993

	Western coal (thousand short tons)	Midwestern coal (thousand short tons)	Percent of western coal to deliveries	Percent of midwestern coal to deliveries
Illinois	12,051	13,962	`42.9%	49.7%
Indiana	13,961	24,684	32.0%	56.5%
Iowa	14,850	855	94.2%	5.4%
Michigan	14,855	167	53.3%	0.6%
Wisconsin	15,763	1,003	87.8%	5.6%
Midwest Region	71,480	40,671	53.6%	30.5%

The urban smog section of CAAA requires approximately 3% per year reduction in mobile sources of pollution for urban areas until a predetermined attainment goal has been reached by the year 2000. Nine cities have been cited as having especially serious problems in smog-forming emissions and will probably be given more time to reach attainment. These include Los Angeles, Houston, New York, and Chicago. This part of the Clean Air Act Amendments would establish programs to encourage the use of vehicles operated on clean-burning alternative fuels such as methanol, ethanol, natural gas, electricity, propane, reformulated gasoline, or other comparable low emission fuel. In the nine major urban areas where the greatest ozone concentrations occur, the plan calls for the phase-in of clean-fuel vehicles at the rate of 500,000 vehicles in 1995, 750,000 in 1996, and one million vehicles each year from 1997 through 2004. If any of the nine cities can reach attainment through other measures, they may "opt out" of the clean-fuel vehicle and alternative fuels program.

Assuming that the coal industry can adjust to the Clean Air Act Amendments, there is another environmental issue on the horizon which would have a devastating effect: global warming. Most scientists now concede that the increasing concentration in the earth's atmosphere of so-called greenhouse gases, including carbon dioxide, will lead to increases in the global temperature. There is considerable debate, however, about the rate of change of the earth's temperature and even more debate about national and international policies needed to respond to the problem. Some countries are proposing a tax on CO_2 emissions to reduce the amount of this gas added to the global environment. This directly affects the use of coal. Indeed, for coal to have a long-term future, it must either be demonstrated that the global temperature effects of CO_2 are minimal or, alternatively, a technical solution to the problem of global warming must be found.

Even if these complex environmental problems are overcome, the future of the coal industry in the Midwest region will still largely be dependent on the national growth rate of electricity. This is because the major use of coal (82.6%) is for the production of electricity, with 16.8% being used in industry and the remaining for commercial and residential use. The only other domestic sector with the possibility for expansion of coal use is the industrial sector. The growth rate of the electrical sector (energy input to electrical generation) averaged about 2.6% per year during the past 23 years, but recently this growth has been sustained with relatively little increase in installed capacity. This reflects the industry's concern about the changing environmental laws placed on coal-fired plants coupled with the changing safety constraints placed on nuclear power facilities. The accidents at Three Mile Island and Chernobyl exacerbated the already difficult problem of public support for the nuclear option. The electric utility industry today is at a crossroads: it needs new capacity to meet the growing demands while facing deregulation that opens the industry to competition. As a transition, it is highly likely that natural gas will become the fuel of choice for new electrical capacity during the 1990s. The longer term option remains coal-fired plants using clean coal technology. New generations of nuclear plants with improved safety features are another possibility even though new federal funding has not been approved for R&D. How this plays out will depend on many complex factors, including economics, public acceptance, national environmental laws, and other public policy decisions. Clearly the coal industry has a major stake in the outcome.

In the meantime, there is little doubt that the Midwest region will experience the most severe economic impacts from the clean air legislation, principally because the region maintains the greatest number of high-sulfur coal-burning power plants. The House Energy Committee [7] has issued a list of the 111 dirtiest power plants currently in operation. Indiana is tied for the largest number of plants on the list with 15. Given that the state has an active high-sulfur coal industry, it is not likely that it will consider switching to low-sulfur coal, but will rather rely on expensive high technology solutions such as stack gas scrubbers or the purchase of emission allowances. The economic costs of such solutions to the industrial ratepayers relying on those utilities for service will be considerable. Switching to a low-sulfur coal could reduce this impact, but this option may not be politically possible in some states because such a switch could put thousands of coal mine workers out of work. Essentially, ten states bear 80% to 90% of the cost to achieve a mandated 10-million-ton SO_2 reduction. These states include Illinois, Indiana, Michigan, and Wisconsin in the Midwest region. Within these states the coal-burning utilities will bear the brunt of the costs.

In light of the above uncertainties, the region’s coal-producing states are looking to foreign markets. The success of this approach, of course, will depend on many factors, including the development of rail and barge access to Gulf and East Coast ports; the development of port facilities; the competitive position of regional coal relative to coal from such places as Poland, South Africa, and Australia; and the compatibility of the region’s coal with the environmental laws of the prospective foreign customer. All in all, it is clear that the states possessing large deposits of low-sulfur coal will fare well in the immediate future, while the future of the Midwest’s high-sulfur coal industry is more in question and subject to a number of factors which are still being resolved.

The Regional Energy Future—Some Policy Issues

It is clear that the Midwest's regional population growth is not keeping up with that of the nation; this is true in every state in the region. One of the challenges for the region is to reverse the population shift to the Sun Belt, because this trend has negative impacts on the economic vitality of the region. This is already evident in the differential growth rate of the nation’s gross domestic product, rising at an average annual rate of 2.8% compared with the region’s gross state product growth at an average annual rate of only 1.6%. This out-migration, furthermore, will decrease the region’s political presence in the U.S. Congress, just at the time when it needs to have a strong voice in national energy and environmental policy.

The energy statistics reveal that the region, like the rest of the nation, is making real improvements in energy efficiency as demonstrated by the decreasing amount of energy needed to produce a real dollar output of goods and services. If this trend is to continue, regional industry will need to make large financial investments to replace older, less efficient installations. Such changes are necessary not only to improve energy efficiency, but also to improve productivity. Otherwise, the goods produced in the states of the region will not be able to compete with those coming from Japan, Germany, Korea, Taiwan, and other countries or states that have moved to modernize their industrial base, or from developing countries with lower labor costs such as Brazil, Mexico, and China.

There is evidence that the nation and the region have replaced imported oil with indigenous coal for power generation. However, the growth in coal use is not being shared by all coal-producing states. Rather, it has been concentrated in the states producing low-sulfur coal, primarily the Western and the eastern Appalachian regions. With the passage of CAAA, the constraints on sulfur emissions from coal-burning plants has placed the region's coal industry in greater jeopardy. This is perhaps the most important policy issue facing this industry today.

A review of the Midwest region's energy resources points up the region's disadvantages. Its most abundant resource, relatively high-sulfur coal, has not competed well with low-sulfur western coals. And the Midwest has only negligible natural gas and petroleum supplies. Thus, the Midwest must import the overwhelming share of oil and gas consumed in its five states, as well as increasing amounts of western coal.

Although energy statistics in the 1980s and early 1990s indicate that the nation and the Midwest region have reduced, slightly, the share of petroleum consumption in total energy use, the nation is becoming more dependent on imported oil (increasing share of imported oil in petroleum consumption). Also, new on-time inventory management techniques have increased the chances of shortages, such as the 1996 motor gasoline shortages caused by a longer cold season that required the continued refining of heating fuel.

Other issues facing regional policymakers are associated with the electric power industry. The electric power sector is the largest direct energy consumer in the nation and in the Midwest region, where it consumed about 37% of all primary energy in 1993. The electricity industry currently is entering a period of fundamental change. As occurred with the telecommunications and the natural gas industries, most experts foresee that the next few years will bring about a transformation of the electric industry, affecting its organizational structure, the products and services it delivers to customers, and the federal and state institutions that regulate it. The restructuring of the electric industry is expected to increase competition, reduce overall prices, eliminate large disparities in electric rates from utility to utility and state to state, encourage adapting of new low-cost generation technologies which offer cheaper power and increase productivity of existing generation equipment.

The passage of the Public Utility Regulatory Policies Act (PUPRA) in 1978 has opened the electric industry to competition from nonutility electric generation sources. The process of resolving issues associated with today's wholesale transmission market began with passage of the Energy Policy Act of 1992 (EPACT). In March 1995, the Federal Energy Regulatory Commission (FERC) instructed the nation's public electric utilities to open their transmission lines to competitors. Two closely related final rules and a Notice of Proposed Rulemaking (NORP) have been issued by the Commission. The first rule, Order No. 888, addresses both open access and stranded-cost issues. It requires public utilities owning, controlling, or operating transmission lines to file nondiscriminatory open access tariffs that offer others the same transmission service they provide themselves. Order No. 888 is expected to bring lower-cost power to electric consumers; ensure continued reliability of the electric power industry; and provide for open and fair electric transmission services by public utilities. The second rule, Order No. 889, known as the Open Access Same-Time Information (or OASIS), requires utilities to establish electronic systems to share information about available transmission capacity. It also establishes standards of conduct and procedures to ensure that transmission owners and their affiliates do not have an unfair competitive advantage in using transmission to sell power. Order No. 889 requires public utilities to obtain information, such as available capacity, in the same way their competitors do—via an OASIS on the Internet—and to completely separate their wholesale power marketing and transmission operating functions. The NORP proposes to establish a new system for utilities to use in reserving capacity on their own transmission lines and the transmission lines of others.

In addition to FERC, other initiatives in many states are driving the process to a point where alternative structures of the electric industry can be envisioned and issues are clarified. For example, the California Public Utilities Commission in May 1995 issued a proposal for comments that would provide California electric customers "direct access" through a wholesale power pool referred to as "poolco." Issues to be clarified and resolved include stranded costs, transmission access, dispatch, extent of retail access, competition in generation, capital investments, unbundling, demand-side management, and conservation programs. The ultimate outcome of the unfolding process of restructuring the electric utility industry is still highly uncertain, but it is critical that the region maintain adequate electric capacity to support a strong industrial and commercial base.

It is not possible to talk about the electric industry and the related sitting problems without bringing up the question of the future of nuclear power. Since the Three Mile Island and the Chernobyl nuclear accidents, nuclear power issues are even more carefully scrutinized by the public, and the added safety requirements have modified the economic position of nuclear power relative to coal. An especially sensitive issue related to nuclear power is waste transportation and disposal of both high-level and low-level radioactive wastes.

At this point in history it would be extremely risky to abandon the nuclear option, which now constitutes as much as 30% of the input to electrical generation in the Midwest region. However, many of these plants are approaching the end of their current license terms. Many of these plants are expected to seek renewed licenses from the Nuclear Regulatory Commission (NRC). Other plants will close at, or even before, the end of their current license terms. The challenge to policymakers is to keep the nuclear option and the nuclear industry viable until a new generation of four NRC-certified advanced light-water reactor designs with passive safety systems and simplified construction and operation is available in the marketplace in 1999. However, the competitive environment created by the deregulation of the electric industry may be an additional impediment to the nuclear power generation option. Few power-generation companies will be willing to accept the financial risks associated with building nuclear power plants (a process that can take up to ten years) without the safeguards offered by the current guaranteed return-on-investment of the regulated electric industry.

Another consequence of electric industry deregulation may be the convergence of electric and natural gas industries. Natural gas has fewer harmful effects on the environment than other fossil fuels. Natural gas has virtually no sulfur emissions, lower NO_x and extremely low particulate emissions. On an energy-equivalent basis, natural gas has 30% lower carbon dioxide emissions than oil and 45% lower emissions than coal.

During the past two decades, natural gas markets have become increasingly competitive because of deregulation of wellhead prices and the opening of interstate transportation to third parties. The transmission segment of the gas industry was separated from the gas merchant function by open-access transmission. Transmission services were unbundled and information is now available to customers through electronic bulletin boards. Spot market transactions have grown as a futures market and transportation hubs have become new elements of the gas transmission business. Gas marketers have rebundled gas sales and transportation services as gas-to-gas competition has helped keep prices low, especially for larger, noncore customers.

The restructuring of the gas industry may continue with open access at the distribution level. Local distribution companies are already reducing their operating costs, becoming more customer focused and seeking new business opportunities both inside and outside their service territories. Currently, natural gas is entrenched in the residential, commercial, and industrial markets. New gas-fired space air-conditioning equipment for residential and commercial applications and high-efficiency industrial boilers, burners, and gas turbines with low NO_x emissions will allow natural gas to maintain and expand its market share. In addition, low gas prices and the expanded use of new gas turbine and boiler technology (for emissions control) have allowed natural gas to become a major fuel for power generation.

Natural gas use for both utility and independent power generation has been substantial in recent years, and it continues to grow. Most of the growth has occurred because electrical utilities have moved away from small numbers of large coal-fired base-load plants toward larger numbers of simple and combined cycle gas turbine units which are dispersed geographically. This process is called distributed generation.

Distributed generation is considered a more cost-effective or efficient means of meeting local demand for small amounts of electric power compared with building large central power stations. Although distributed power is based on such varied technologies as small gas turbines, fuel cells, photovoltaic, solar, or wind technologies, most distributed power is gas fueled. Local distributed generation saves on expensive transmission and distribution upgrades; its facilities are cheaper and faster to build and allow utilities greater flexibility by operating only units needed to meet local demand. In addition, large commercial and industrial companies are increasingly entering the power conversion business by using sufficiently large generators to achieve competitive gas-to-electric conversion efficiencies. Furthermore, the increased cost of complying with government mandates in coal-fueled power plants will make gas a more cost-effective option, thus displacing coal (at least high-sulfur coal) in several regions of the country.

It is reasonable to expect that, as natural gas starts replacing coal for electricity generation, the increased demand for natural gas will cause the price of natural gas to increase. This will also increase the energy cost in the Midwest region, especially in the residential and commercial sectors that are heavily dependent on natural gas.

Proven reserves of fossil fuels are sufficient to the world's energy needs for many more years. However, "proven reserves" merely refer to the already known reserves of fossil fuels that energy firms reckon they can extract without losing money. Higher fuel prices and advanced technology would allow the firms to bring to the market reserves previously too expensive to exploit. Such "ultimately recoverable" fossil-fuel reserves, the World Bank says, may contain over 600 years' current production.

Reliance on fossil fuels, however, brings up the "green argument" of the creation of unsightly and unhealthy smog in cities and global warming. Gas, itself a fossil fuel, is relatively clean. Compared with oil and coal, its use reduces carbon dioxide emissions dramatically. However, there are not sufficient reserves of natural gas to supplant both coal and oil. "Clean" energy sources are not available without drawbacks. Nuclear power poses a danger of nuclear accidents and can be used in the production of nuclear weapons. Hydroelectric power also has its disadvantages. Dams uproot people and animals, and rotting vegetation in dam reservoirs may give off substantial amounts of greenhouse gases. Both nuclear power and hydroelectric dams require high capital investments and take time to construct. The cost of thermal electricity (sunlight used to heat air or water) has fallen, as has that of biomass power (plant matter burnt to make energy). But the most enticing technologies for the future are photovoltaic (PV) cells and wind power. Photovoltaic cells, which generate electricity directly from sunlight, generate electricity at a significantly higher cost than fossil-fuel-generated power (30-60 cents per kWh, compared with 3-6 cents). Photovoltaic cells are often competitive in areas where electricity grids from fossil-fuel plants to new consumers are expensive to build. Wind-power prices have fallen significantly in the past 20 years, as wind turbines have become larger and blades have been designed to catch the wind more efficiently, from 30 cents per kWh to 5-6 cents in the best sites. However, wind power and photovoltaics can not provide a reliable energy source because the sun does not always shine nor the wind always blow. Fossil fuels, for the foreseeable time, will continue to provide the largest part of the world's energy.

There are many energy policy questions relating to such topics as the future of regional transportation systems, including mass transportation, the railroads, and the waterways; land-use planning and natural resources; automobile fuel economy standards; and priorities in energy research and development, to name a few. Their omission from this paper does not suggest that they may not be as important as the issues discussed here.

Footnotes

[1] Natural gas prices showed higher increases in real terms but were still below the prices of petroleum products and electricity when compared on a Btu basis. For example, the price of natural gas in 1983 in current dollars per million Btu was $4.72 compared to $18.62 for electricity, $9.12 for motor gasoline, and $7.32 for distillate fuel. The price of coal was $1.71 per million Btu [20].

[2] Figures do not include the interstate flow of electricity.

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