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Energy Conservation Indicators

1982 Annual Report

September 1982

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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ENERGY CONSERVATION INDICATORS

1982 Annual Report

David B. Belzer

September 1982

Prepared for
the U.S. Department of Energy
Assistant Secretary for Conservation
and Renewable Energy
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Pacific Northwest Laboratory
Richland, Washington 99352

ABSTRACT

A series of Energy Conservation Indicators were developed for the Department of Energy to assist in the evaluation of current and proposed conservation strategies. As descriptive statistics that signify current conditions and trends related to efficiency of energy use, indicators provide a way of measuring, monitoring, or inferring actual responses by consumers in markets for energy services. Related sets of indicators are presented in some 40 one-page "indicator summaries." Indicators are shown graphically, followed by several paragraphs that explain their derivation and highlight key findings. Indicators are classified according to broad end-use sectors: Aggregate (economy), Residential, Commercial, Industrial, Transportation and Electric Utilities. In most cases annual time series information is presented covering the period 1960 through 1981.

Acknowledgments

A number of individuals assisted in the preparation of this report. J. M. Callaway took a lead role in early efforts to develop indicators in the residential sector. Steven Staloff was primarily responsible for the indicators related to electric utilities. Michael King was instrumental in developing computer software related to data base management and computer graphics. S. Ananda Rao provided general research and programming assistance. Naomi Sherer made a number of helpful suggestions regarding presentation of the indicators in addition to providing general editorial assistance. Dr. Wendy Garling, of Yellowstone Research Corporation, was responsible for the industry case study summaries in Appendix A.

CONTENTS

INTRODUCTION

Pacific Northwest Laboratory early in 1981 began preparation of a series of Energy Conservation Indicators that could be used by the Department of Energy in evaluation of current and proposed conservation strategies. This work has been primarily sponsored by the Office of Policy, Planning, and Evaluation. Out of that preliminary work, a series of briefings were presented to various groups within DOE in the summer of 1981. An interim report was released in June of 1982, which summarized the results of these preliminary development efforts. This report builds upon the interim report in several respects: additional indicators have been constructed (especially for electric utilities) and data in most cases have been revised or updated.

Indicators are descriptive statistics that signify current conditions and trends related to energy conservation and the use of renewable energy resources. They are a way of measuring, monitoring, or inferring actual responses by consumers in markets for energy services. Indicators are not models or forecasts--they are designed to show what has happened with respect to the nation's use of energy, but not necessarily why something has happened.

Indicators can be used to provide rudimentary insights into what is currently happening in the marketplace. These insights are one valuable aid in program planning, policy analysis, and evaluation. Indicators can also be used to validate energy models and to point out areas in which refined data collection is needed. In many cases indicators can provide a base from which forecasts of future energy consumption can be made.

As implied above, conservation indicators are not designed to take the place of formal energy demand models. However, the indicators effort has not been limited to presenting raw data compiled by various statistical agencies. In a number of cases, adjustments have been made to normalize the influence of factors such as weather, capacity utilization, and compositional shifts. These adjustments are intended to allow underlying conservation trends to be more clearly observed over short time intervals.

The conservation indicators program is not designed to substitute for any of the various Energy Conservation Data Books (for buildings, transporta-

tion, industrial) that have been published by Oak Ridge National Laboratory since 1977. These data books are compendiums of information related to energy use by these various end-use sectors. However, they do not directly focus on showing trends in energy efficiency; the emphasis is more on the characterization of energy use and the stock of energy-using equipment. In addition, because these data books are comprehensive in nature, their publication has been somewhat infrequent. Thus, the most recent changes in energy efficiency for most end-uses is often not available in the data books.

This report follows the basic classification of energy use as employed by the Energy Information Administration (EIA). Indicators are presented for five major end uses: Residential, Commercial, Industrial, Transportation, and Electric Utilities. Prior to these sectoral indicators, the second section of the report covers several key aggregate, macroeconomic indicators.

Each of the following sections begins with some general discussion that we have termed "preview and rationale." These introductory remarks help to put the indicators that follow into some context, but do not deal with actual quantitative results. Related sets of indicators in the report are presented in a one-page "indicator summary." Indicators are shown graphically, followed by several paragraphs that explain their derivation and highlight the most important trends or results. A data appendix presents numerical values of all indicators and key supporting data in tabular form. This appendix also contains detailed source and explanatory notes that document the derivation of each indicator.

AGGREGATE INDICATORS

Preview and Rationale

Energy conservation trends for the economy as a whole are shown in this section. Figure A.1 shows energy use as it relates to measures of production that are provided in the National Income and Product Accounts. The Energy/GNP ratio continues to be the most widely used measure of national energy productivity; however, the standard energy/GNP ratio includes household consumption of energy. The problem is that personal consumption expenditures for energy can alter the energy/GNP ratio irrespective of energy efficiency improvements. For example, a decline in driving activity leads directly to a reduction in the energy/GNP ratio, since the ratio of energy (in Btu) to personal consumption expenditures for gasoline and oil (in 1972$) is so much higher than the energy/output ratios for other components of GNP. In Figure A.1 an adjusted energy/GNP ratio is shown that takes into account the changing share of energy personal consumption expenditures to total real GNP.

Another frequently cited aggregate indicator, energy consumption per capita, is shown in Figure A.2. The top graph in the figure is total energy per capita, the sum of direct (i.e., personal consumption) and indirect energy per capita. The bottom graph is an estimate of the direct component, the consumption of fuels for home use plus motor gasoline and oil. As compared to the energy/GNP ratio, the per capita measures cannot claim to reflect changes in energy productivity. Increases in real income to consumers are not accounted for. As total personal consumption rises, both direct and indirect energy use rises as well. This fact should be kept in mind as one studies the movement of this indicator over time.

The third set of aggregate indicators shown in Figure A.3 relate to direct energy use per household. Direct energy is defined to cover consumption expenditure for home use and for personal transportation. This category is broader than residential use, which is direct consumption as defined above, less transportation use. The graphs in Figure A.3 contrast the relative movements of the two major end uses over which the household has control.

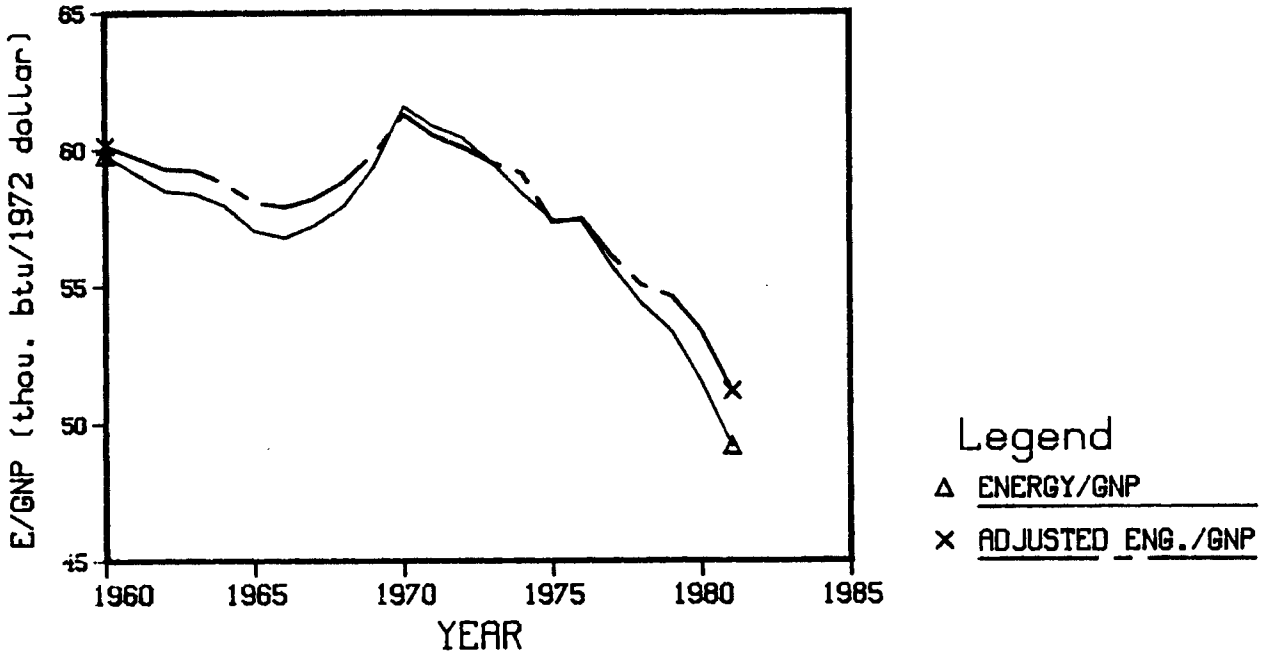


Figure A.1 Energy and Gross National Product

Approach: In using the conventional energy/GNP ratio as an aggregate conservation indicator, household use of energy is not correctly taken into account. As an example, a decline in driving activity would result in a reduction in energy use by households and, thus, a reduction in energy/GNP ratio. This would be considered a curtailment of energy use, not improvement in the efficiency of energy use. However, curtailment would not be applicable if the use of the same number of vehicle-miles were travelled by the use of more fuel efficient automobiles.

To determine how much the change in household expenditures for energy have contributed to the overall energy/GNP ratio, the composition of 1972-dollar GNP expenditures between energy personal consumption and non-energy GNP components was held constant at their 1973 values. In 1973 total GNP was $1254 billion, of which 51 billion was for energy personal consumption (4.1 percent of total GNP). By 1981, energy personal consumption was 54 billion (1972$) compared total GNP of 1503 billion (3.6 percent of total GNP). The adjusted energy/GNP ratio, holding energy personal consumption expenditures at the 1973 fraction of real GNP, is shown in the dashed line in the figure.

Key Findings:

- The energy/GNP ratio declined 17 percent between 1973 and 1981.
- Roughly 20 percent of this drop can be attributed to a smaller percentage of GNP accounted for by personal consumption expenditures for energy.

Sources: Total energy and residential energy use from EIA. Personal use of energy for transportation based on worksheets provided by Bureau of Economic Analysis (BEA). GNP and personal consumption expenditures in 1972 dollars also from BEA. See appendix B for details.

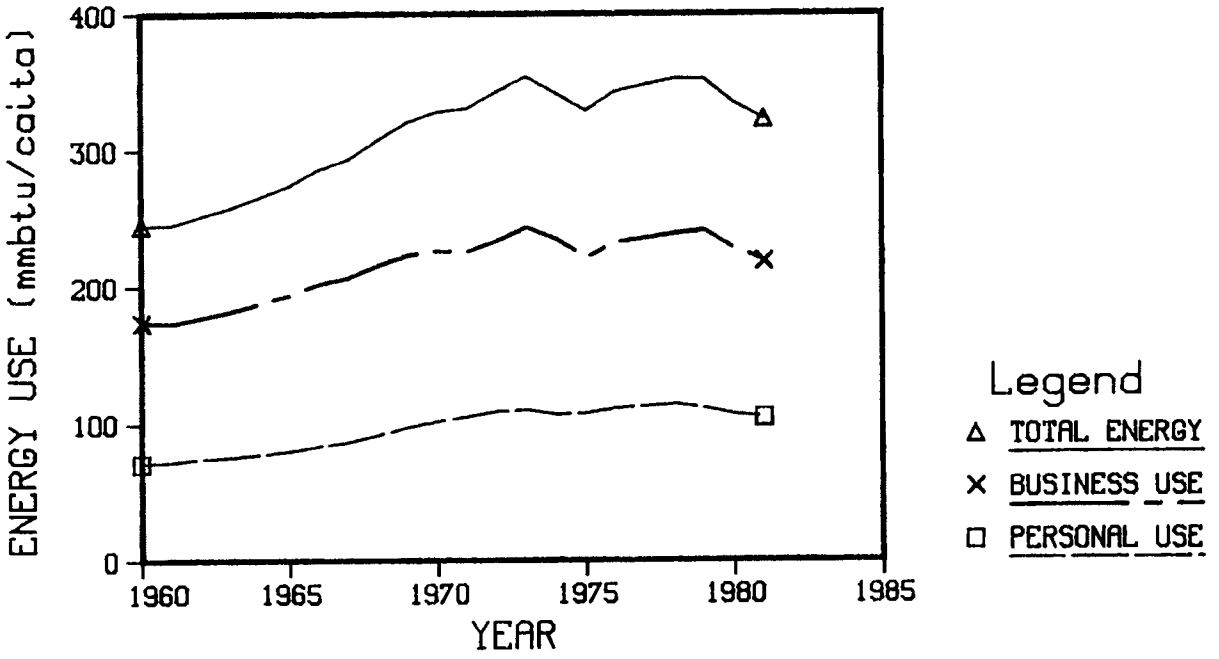


Figure A.2 Energy Consumption Per Capita

Approach: Total energy use per capita was split into two components, "business" and "personal". The middle graph shows an estimate of "business" use (total energy less residential use less personal transportation use) per capita. Energy consumed directly by individuals for household and personal transportation use is shown in the bottom graph. All the graphs show the break in the trend that occurred in 1974 with the oil embargo and accompanying sharp rise in energy prices.

Key Findings:

- 1981 per capita consumption was 9 percent lower than in 1973; this trend is in sharp contrast to the 1960-73 annual growth rate of 2.8 percent.
- Energy consumption per capita for both business and personal use declined in both 1980 and 1981.
- Business use per capita is more volatile than personal use, reflecting more directly general economic conditions.

Sources: Total energy consumption from 1980 State Energy Data Report (SEDR), DOE/EIA, and Monthly Energy Review. Residential portion of personal energy use from 1980 SEDR, and updated through 1981 by PNL. Personal transportation use based on worksheets provided by Bureau of Economic Analysis, used in constructing Personal Consumption Expenditure estimates for "gasoline and oil." Population data for 1971-1981 from revised data based on 1980 census.

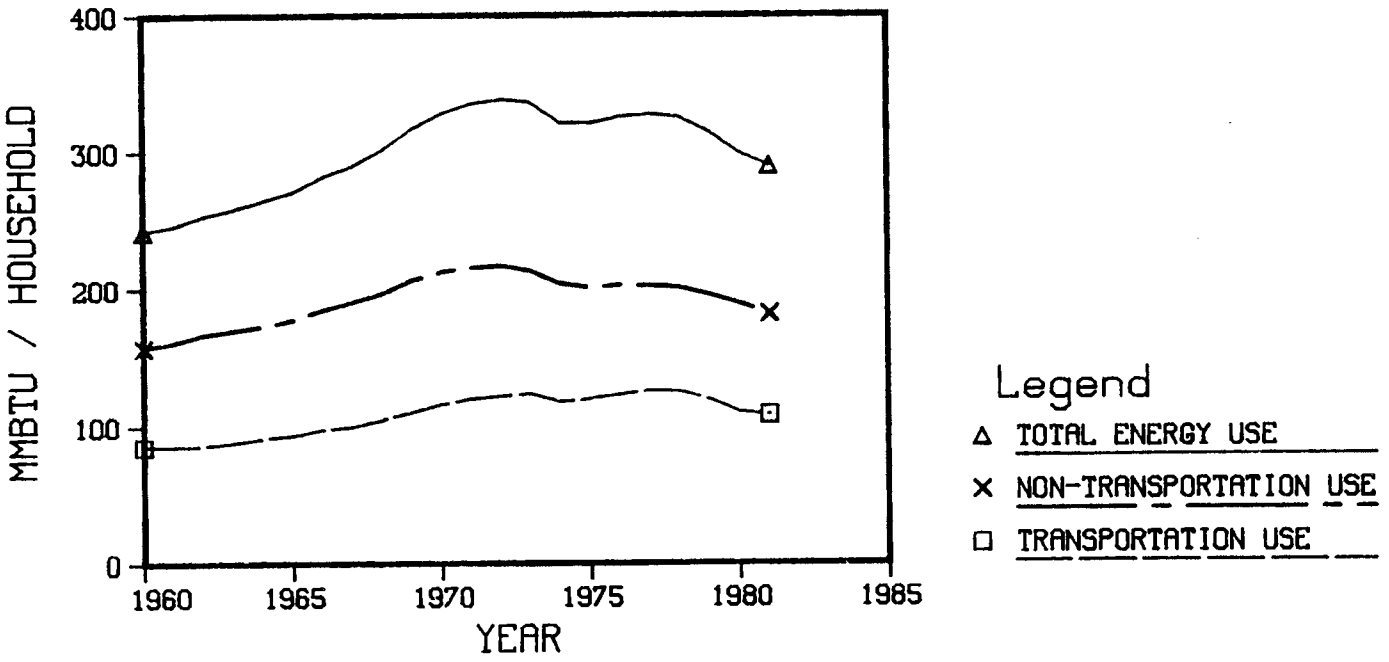


FIGURE A.3 Direct Energy Use per Household

Approach: Trends of energy used directly by households are shown. Residential use covers energy consumed primarily for space heating, water heating, air conditioning, cooking, and clothes drying. Residential consumption also includes those generation and transmission losses of electric utilities that are attributed to residential purchases of electricity. Transportation use includes gasoline and oil consumed in personal passenger vehicles.

Key findings:

- Since 1973, direct energy use per household has dropped by 14 percent.
- Energy consumption per household for residential use is about double that used for personal transportation.
- Since 1978, the percentage decline in transportation consumption was more than double that of residential use.

Sources: Home or "residential" energy use from the 1980 State Energy Data Report and updated to 1981 by PNL. Transportation use based on worksheets provided by Bureau of Economic Analysis, used in construction of Personal Consumption Expenditures estimate for "Gasoline and oil."

RESIDENTIAL

Preview and Rationale

The residential sector accounts for approximately 20 percent of the nation's total use of energy. Most of this energy is used in buildings for space heating and cooling, lighting, and hot water. Since space conditioning represents the dominant proportion of residential energy use in homes, a logical measure of energy productivity is Btu per square foot. In the residential sector, square footage measures of the housing stock are not available. As a proxy for square footage, the amount of housing in use is measured by the number of household units. Unfortunately, only separate metering can really yield good information as to the amount of energy devoted to individual energy services. Thus, although space conditioning may be reasonably correlated with square footage (or number of households if the average dwelling unit size remains constant), hot water and other energy consumption may be more directly related to the number of occupants. By this reasoning, energy use per household would be expected to decline as average household size declined. Another factor affecting national average household energy consumption is the movement of the households to the south and southwest. These factors should be kept in mind while looking at the residential indicators at the beginning of this section.

The first four figures in this section are related to observed energy consumption in the residential sector. Figure R.1 displays indexes of energy use per household over the past two decades. The most obvious indicator is simply an index of total Btu per household, normalized to unity in 1972. In addition to the conceptual issues discussed in the previous paragraph, a deficiency of this index is that it considers only the energy (Btu) content of various fuels. Other attributes such as transportability, cleanliness, safety, etc., are ignored. To the extent that these attributes are incorporated in the prices of fuels, an aggregate energy index using price weights was added to Figure R.1.

Gas consumption per customer is shown in Figure R.2. Since the predominant use of gas is for space heating, the annual observations have been defined to cover years beginning July 1. This indicator should be a fairly valid measure of energy per square foot of residential space as long

as the average home size heated by gas has remained approximately constant. These data cannot distinguish between reduction in energy use caused by lower thermostat settings versus those resulting from improved shell thermal efficiencies of homes. Year-to-year changes in the reported consumption figures are, of course, strongly influenced by weather variation. A simple regression analysis was used to normalize for the effect of heating-degree days. A "weather-adjusted" time series of gas consumption was then developed. The year 1979-80 was used as the reference year, since it corresponded reasonably close to the 50-year U.S. average of heating-degree days.

Figure R.3 changes the focus from gas consumption per customer to fuel oil consumption per customer. These data are based on an annual national survey of fuel oil dealers conducted by Fuel Oil and Oil Heat magazine. Over the years in which the survey has been conducted the number of respondents have ranged from 250 to 300, representing approximately three percent of fuel oil dealers. Unfortunately, the survey methods used by Fuel Oil and Oil Heat are not published, and so estimates of confidence intervals for these data cannot be computed. Nevertheless, the data are used here since they represent the only reasonably consistent time series of average fuel oil consumption in the residential sector. As with the gas consumption data in the previous figure, a simple regression analysis was performed to adjust for year-to-year variation in heating-degree days.

Energy consumption in relation to the consumption of all other goods and services, rather than on a per household or per customer basis is shown in Figure R.4. The data were taken from the personal consumption estimates available from the National Income and Product Accounts (NIPA). The ratio of residential energy consumption (covering NIPA categories, fuel oil and coal, gas, electricity) to total personal consumption expenditures is computed in both current and constant dollars. The ratio in current dollars, cannot be used to infer trends in energy conservation, but does, of course, indicate the increasing importance of residential energy expenditures relative to the total household budget.

We depart from the general topic of energy efficiency in Figure R.5 to display residential fuel prices over the past two decades. Consumer price indexes for gas, electricity, and fuel oil have all been divided by the total

CPI, and then normalized to 1.0 in 1972.

Estimates of the trend in energy efficiencies of energy-using durables used by the household are shown in Figures R.6 and R.7. Since both are based on one-time surveys and computer models, the estimates must be termed as only suggestive. However, these estimates at least provide rough indicators in an area where there is absence of comprehensive surveys conducted over a continuous interval.

An estimate of an efficiency index of appliance stock (including space conditioning equipment) over the period 1972 through 1980 is shown in Figure R.6. Efficiencies of various appliances for years 1972 and 1978 were provided in a DOE survey of appliance manufacturers (CS-179) conducted in 1979. Manufacturers also provided estimates as to what efficiencies would pertain to projected sales for 1980. These data were incorporated in a special version of the ORNL Residential Energy Use Model developed by the Lawrence Berkeley Laboratory. Runs of the model were made first by holding the appliance efficiencies at 1972 levels and then allowing the efficiencies to change based on the survey data (and interpolation). The model output was converted to the aggregate efficiency index that is plotted in Figure R.6.

Figure R.7 makes use of a national residential survey (National Interim Energy Consumption Survey, NIECS) that was conducted by EIA in 1979. Information collected in the survey related to engineering characteristics of the home as well as the year in which it was built. The engineering data were then used as input to the DOE-2 energy use computer model to provide an estimate of the thermal efficiency of the dwelling unit. After conversion of these efficiencies to index form, they are plotted relative to the year in which the home was built.

The final group of figures related to the residential sector deal primarily with fuel switching. The first of these figures, R.8, simply shows how the shares of total residential consumption by fuel type have changed over time (using data from EIA's State Energy Data Report). The trends in this figure reflect more than just fuel switching; e.g. the electricity share has grown significantly as a result of higher usage of home appliances and air conditioners. The next four figures, R.9 through R.12, display fuel switching trends in new residential construction. All data are from the

Bureau of Census as part of their survey on the Characteristics of New Housing. However, some of the information shown here was collected in response to a DOE contract with the Census Bureau to expand the scope of questions related to energy use. Unfortunately, due to budget cutbacks, this contract has expired and the future availability of this data is in question. The data shown in this report extend through the third quarter of 1981.

The last two figures of this group, R.13 and R.14, show conversions to and from fuel oil in existing residential and commercial units. Figure R.13 shows the conversions between fuel oil and gas. Figure R.14 shows conversions between either electricity or a combined coal/wood category. These data are based on the survey, conducted by Fuel Oil and Oil Heat magazine, that was discussed above in relation to Figure R.3.

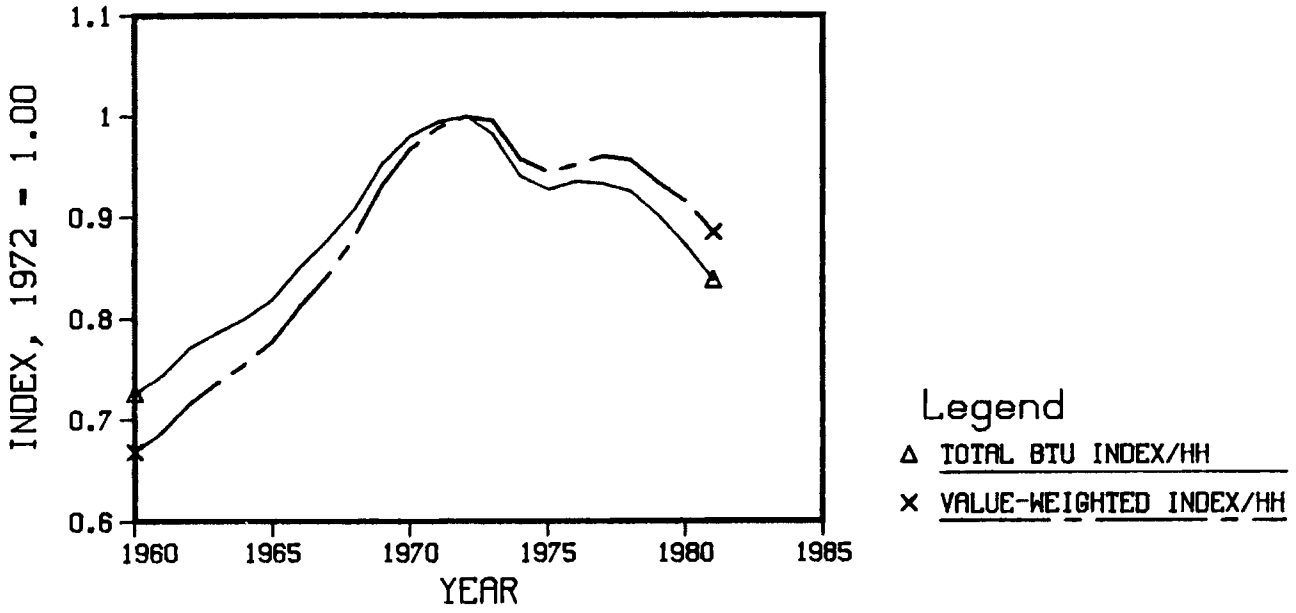


Figure R.1 Btu and Value-weighted Indexes of Energy Consumption per Household

Approach: The most commonly used measure of total energy is in terms of Btu content. An alternative measure, a value-weighted index, was computed and compared with a Btu index on a per household basis. A value weighted index addresses the diversity of characteristics of energy--transportability, cleanliness, safety, and storage requirements--not simply energy content as measured in Btu. To the extent that price differentials reflect these other attributes, measurement of energy consumed in monetary terms provides a means of representing the value of the fuels bundle used by households.

The value-weighted index shown above is based on 1972 average prices for the major fuels consumed by households. It was constructed by computing the cost to consumers of each year's consumption of fuels, assuming constant 1972 prices per Btu for each fuel. This dollar cost summed across all fuels was then divided by the number of households and normalized to equal 1.0 in 1972.

Key Findings:

- Between 1972 and 1981 average energy per household, measured in Btu, fell roughly 15 percent.
- Throughout the 1960-1981 period the value-weighted index has been rising relative to the index based on total Btu, reflecting the increasing share of household energy use from electricity (which has a higher cost per Btu than direct consumption of oil or gas).

Source: Energy consumption in Btu from EIA's 1980 State Energy Data Report, updated through 1981 by PNL. Residential prices from various sources, see Appendix B.

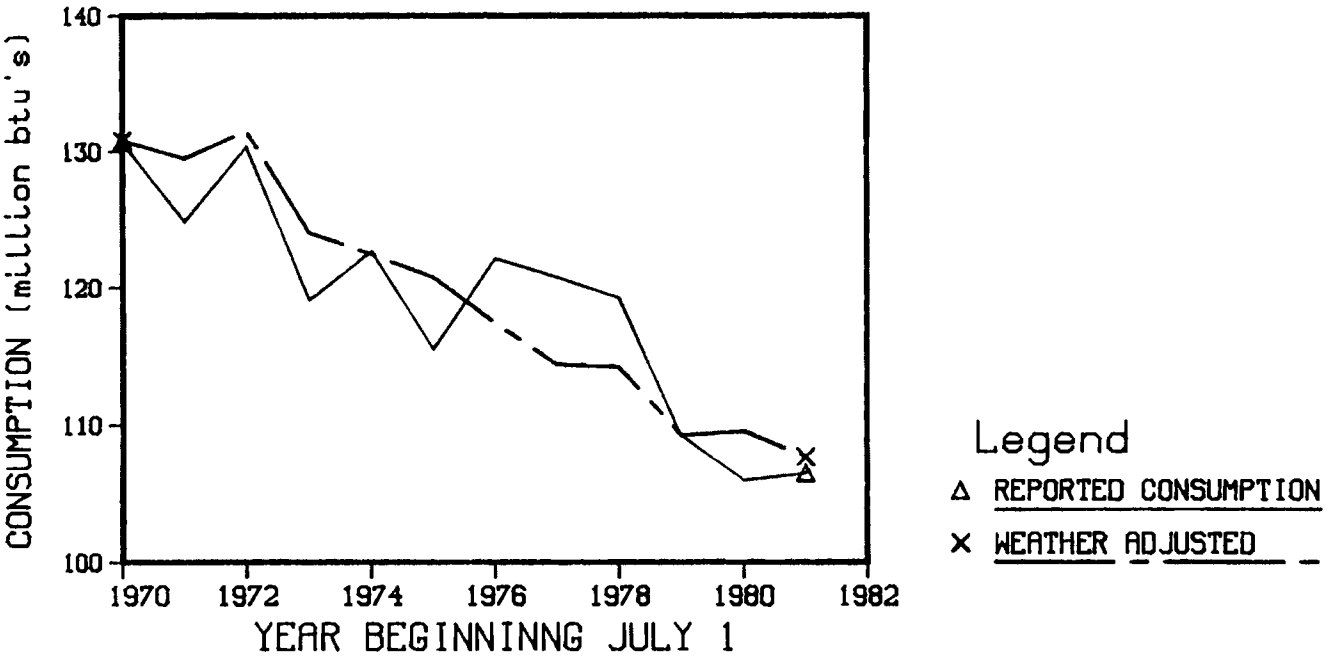


Figure R.2 Natural Gas Consumption per Customer

Approach: Data from the American Gas Association were used to compute average gas consumption per customer over the past decade. In order to isolate heating seasons, annual periods are defined in years starting July 1. Thus, the first year plotted is from July 1, 1970 - June 30, 1971.

A simple regression approach was used to adjust the reported consumption data for weather variation. Quarterly average consumption data were regressed against real gas prices (i.e., divided by the total CPI) and the population-weighted heating-degree days (HDD). The estimated coefficients on HDD were then used to normalize the data to the heating season 1979-80. (HDD for this period were very close to 50-year averages for the total U.S.).

Key Findings:

- Average natural gas consumption per customer has fallen approximately 17 percent compared with the years immediately preceding the 1974 oil embargo.
- Some deceleration of the decline since 1973 is suggested by the data for the two most recent heating seasons, 1980-81 and 1981-82. This may reflect fuel switching by consumers who previously used oil.

Source: Gas consumption and customer data from the American Gas Association. Price variables in regression adjustment from the CPI.

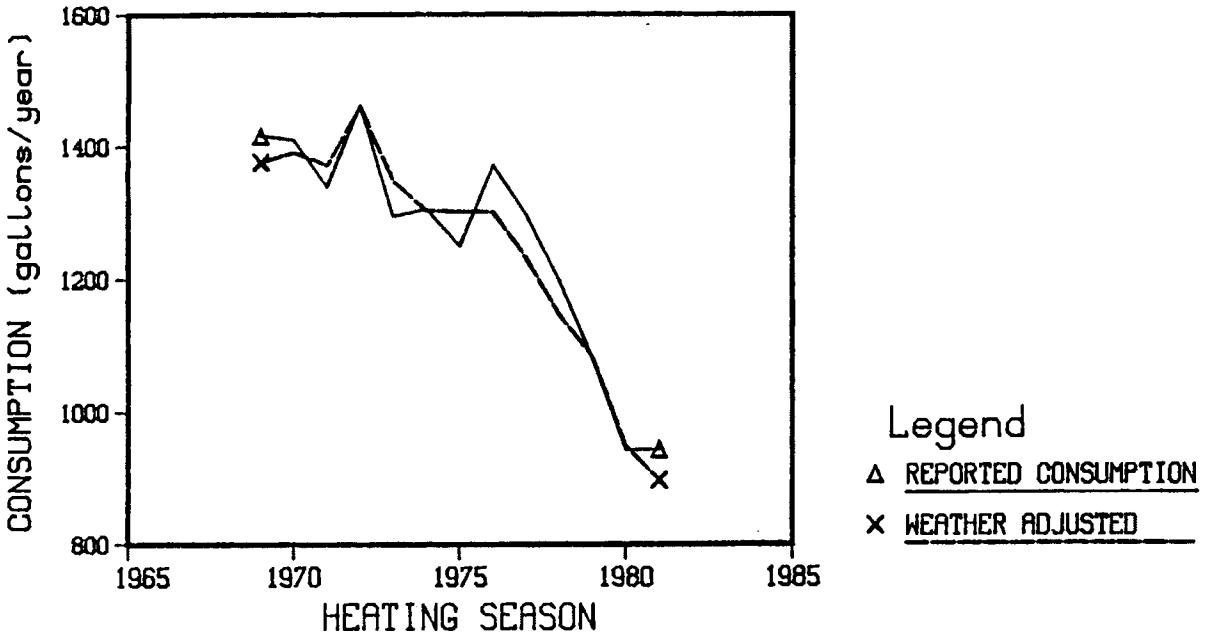


Figure R.3 Fuel Oil Consumption per Customer

Approach: Data from Fuel Oil and Oil Heat magazine were used to compute average fuel oil consumption per customer since 1970. The beginning year of each heating season is shown on the horizontal axis; heating seasons are defined by Fuel Oil and Oil Heat to run between September 1 and May 1.

A simple regression approach was used to crudely adjust the reported consumption data for weather variation. Annual average consumption data were regressed against real fuel oil prices (i.e., divided by the overall CPI) and national population-weighted heating degree-days. The estimated coefficient on heating-degree days was then used to normalize the data to the heating season 1979-80. (The number of heating degree-days for this period was close to the 50-year average for the U.S.)

Key findings:

- Average fuel oil consumption per customer has fallen by over 30 percent compared with the years immediately preceding the 1974 oil embargo.

- Consumption per customer continued to drop on a weather-adjusted basis over the 1981-82 heating season, even as fuel oil prices began to fall slightly starting in February of 1982.

Source: Commercial and Residential Fuel Oil Consumption Trends: 1970-1980, Vol. II, Centaur Associates, Inc., March 1982, p. II-44. Original data taken from Fuel Oil and Oil Heat, (various issues).

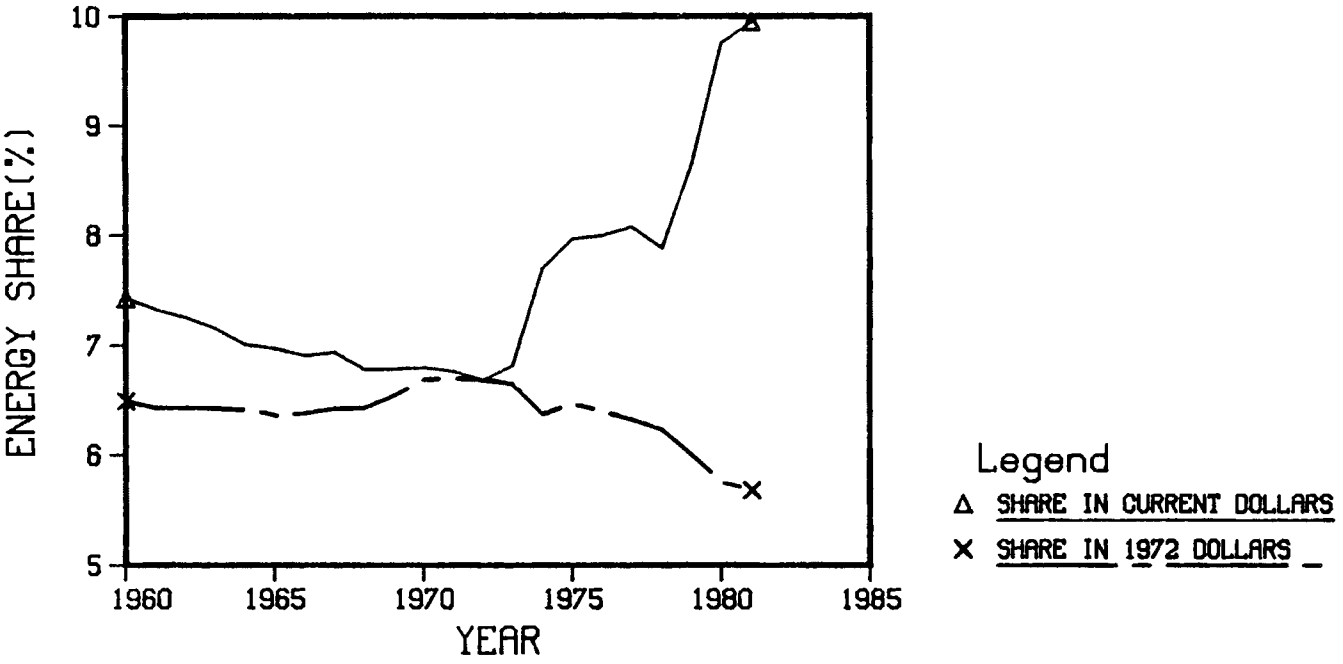


FIGURE R.4 Energy and Total Personal Consumption

Approach: Budget shares related to energy were computed with data from the U.S. National Income and Product Accounts. Energy expenditures cover Gasoline and oil, Fuel oil and coal, Gas, and Electricity.

The top graph shows the budget share as conventionally measured in current dollars. The sharp increases in petroleum prices experienced in 1974 and 1979 are clearly reflected in the figure.

The lower graph measures the budget share in "constant" 1972 dollars. Energy expenditures deflated to 1972 dollars were divided by total "real" (1972 dollars) personal consumption expenditures. This series thus provides a measure of how energy consumption has moved relative to total consumption of goods and services, after the effects of price changes since 1972 are removed.

Key findings:

- The share of consumers' budgets devoted to energy increased nearly 50 percent between 1973 and 1981.
- Relative to total real personal consumption expenditures, energy consumption in 1972 dollars fell by approximately 9 percent between 1978 and 1981.

Source: National Income and Product Accounts, Survey of Current Business, Tables 2.5 and 2.6 in July issues. Data for 1976-81 from July 1982 issue.

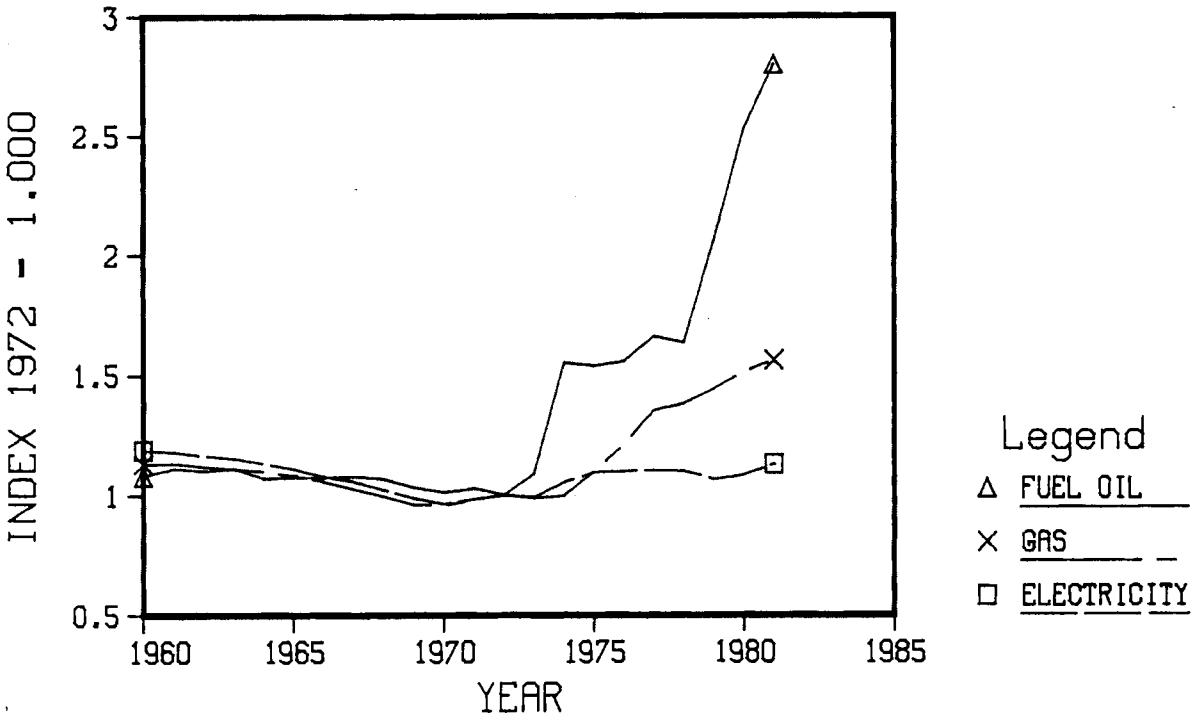


Figure R.5 Real Residential Fuel Price Indexes, 1960-81

Approach: "Real" price indexes were computed for the major residential fuels: fuel oil, natural gas, and electricity. All data were taken from the Consumer Price Index (CPI); each energy price was divided by the CPI for all goods and services and then normalized to a 1972 base.

Key findings:

- Prices for fuel oil have increased the most dramatically since 1972, almost tripling relative to the total CPI by 1981.
- The increase in gas prices (relative to the CPI) slowed slightly in 1981 as compared to 1980; however, this pause may be temporary as gas decontrol proceeds.
- The rise in average U.S. electricity prices since 1972 has been much smaller than gas or oil, increasing only around 13 percent relative to the CPI by 1981. However, the 4.4 percentage jump from 1980 to 1981 was the largest since 1974.

Sources: 1978 Handbook of Labor Statistics, Table 122. 1979-81 data from CPI Detailed Report, various monthly issues (Bureau of Labor Statistics, U.S. Department of Labor).

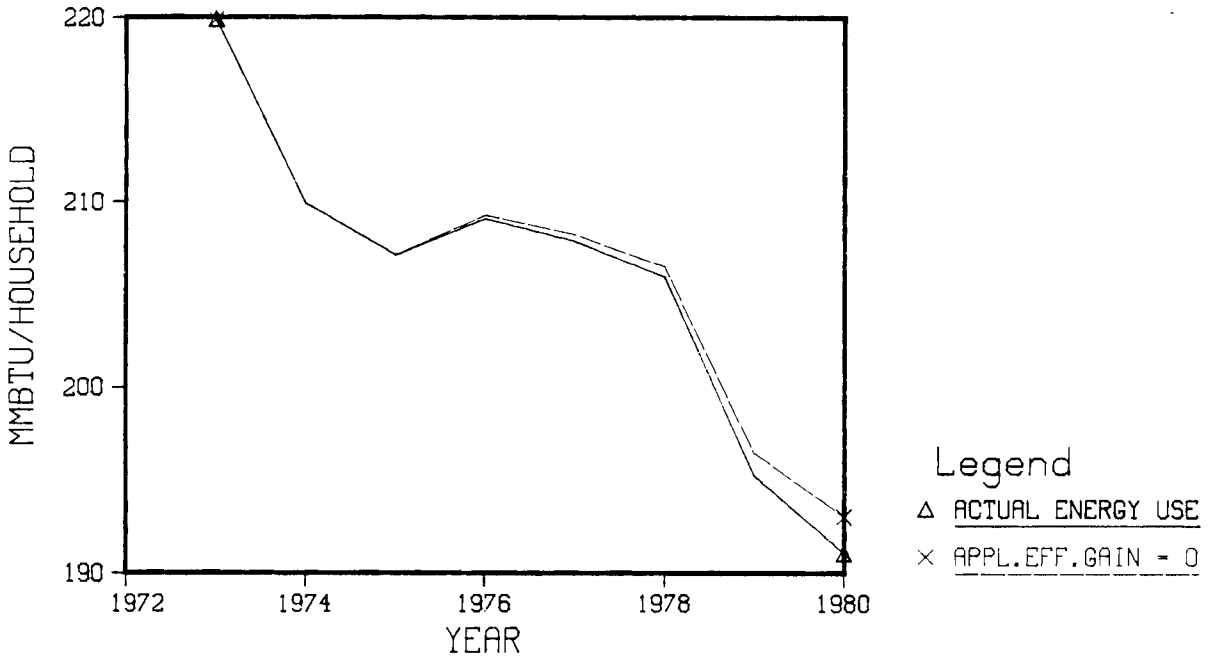


Figure R.6 Appliance Efficiency Index, 1972-1980

Approach: An estimate was developed of the contribution of improved appliance efficiencies to the reduction of household energy use. 1972 and 1980 energy efficiencies for various major energy-using appliances (weighted by sales) were provided in a survey of manufacturers (CS-179) conducted by DOE in 1979. These data were then incorporated in the Lawrence Berkeley Laboratory's version of the Oak Ridge National Laboratory (ORNL) Residential Energy Use Model. The ORNL Residential Model breaks down energy consumption by major end-uses and keeps track of appliance stocks by vintage.

The ORNL model uses 1977 as a base year. Assuming 1977 usage rates for appliances, energy consumption was computed for each appliance over the years 1972-1980 both by assuming constant 1972 efficiencies and then by allowing efficiencies to change as reflected in the CS-179 survey. Energy consumption was then summed over all appliances for the two cases and an index was computed by dividing the "constant efficiency" estimate of consumption into the survey-based estimate. This index, in turn, was divided into actual energy per household, to yield an estimate of what energy consumption would have been given constant 1972 energy efficiencies.

Key Findings:

- Based on the ORNL Residential Model and available survey data, residential energy use dropped approximately 0.3 percent between 1972 and 1978 due to improved appliance efficiencies. Total energy use per household dropped about 8.0 percent over the same period.

Source: Lawrence Berkeley Laboratory Version of the ORNL Residential Model. Efficiency index constructed by PNL.

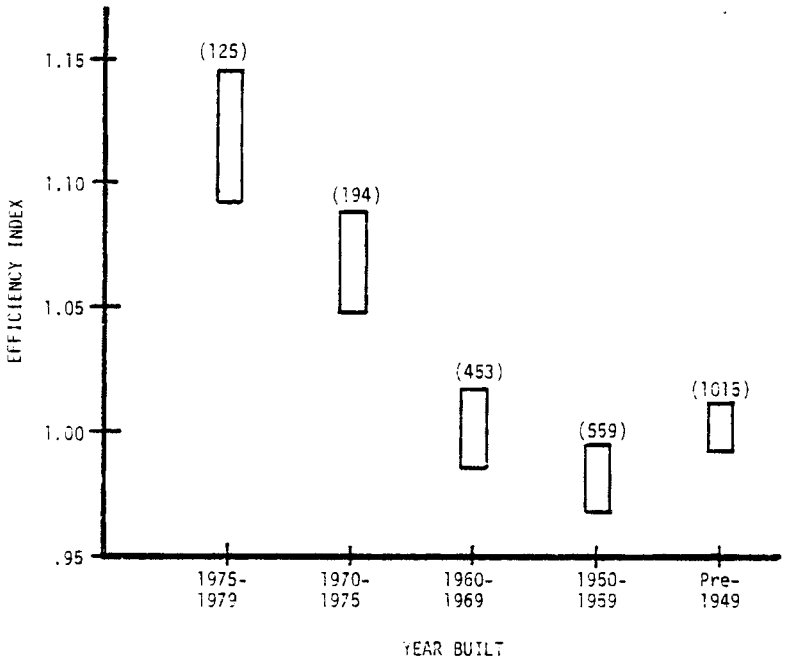


Figure R.7 Interval Estimates of Mean Shell Efficiency

Approach: Interval estimates for the average shell efficiency of single-family detached residences in five different age groups were made by running building characteristics, as collected in the National Interim Energy Consumption Survey (NIECS), through the DOE-2 engineering-energy use model. The number of buildings in each category is shown above the 95 percent confidence interval for the mean efficiency. The statistically significant difference in the average efficiency between the 1950-1959 and pre-1949 groups could be due to differences in the geographic distribution of households in these two age groups, more extensive retrofitting in older homes, or in original construction practices.

Key findings:

- The shell efficiency of single-family detached residences built in the 1970s improved significantly over those built in the previous two decades.
- Very old homes, i.e., those constructed prior to 1949 may be slightly more efficient than those built during the 1950's.

Source: National Interim Energy Consumption Survey, DOE/EIA.

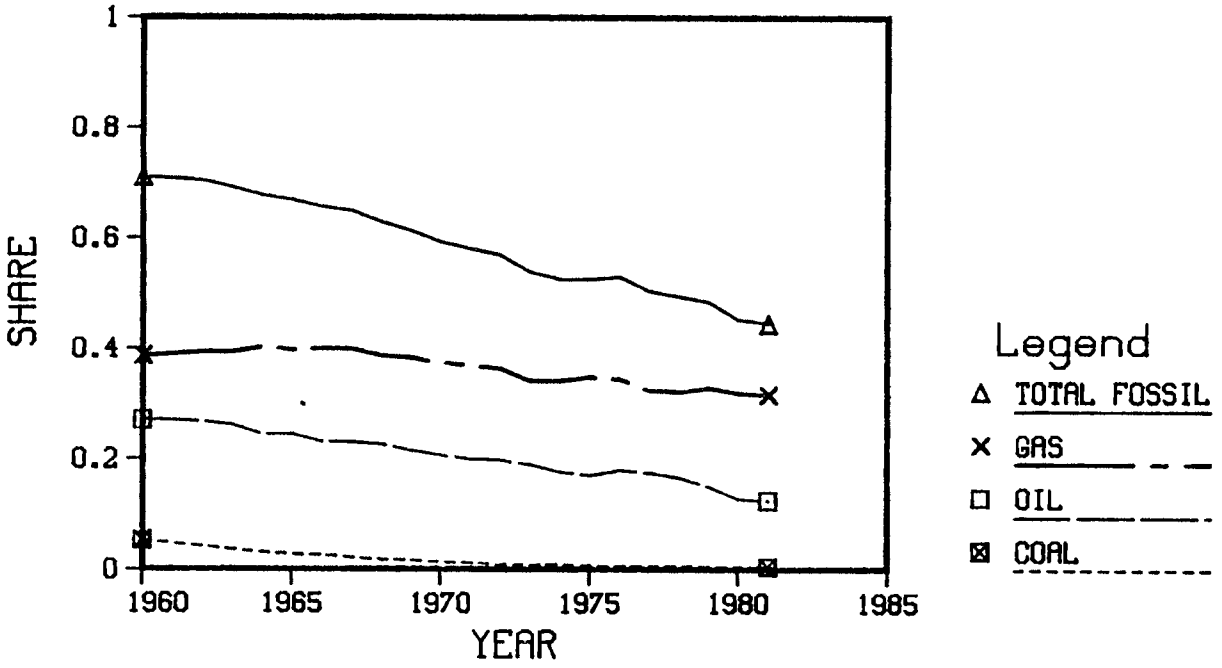


Figure R.8 Fuel Mix in Residential Sector

Approach: Data from the Energy Information Administration were used to compute fuel shares (measured in Btu) for the residential sector. The electricity share is not plotted; the area above the top graph (fossil) represents the share of total energy consumption attributable to electricity (including generation and transmission losses by the electric utilities).

Key findings:

- Energy in the form of electricity now makes up nearly half of all energy consumed by the residential sector, up from 30 percent two decades ago.
- The share of total residential energy consumption supplied by gas has stabilized over the past 5 years at roughly 36 percent.
- The share of total energy consumption supplied by oil fell 3 percentage points between 1978 and 1981; accelerating a declining trend that has been exhibited since 1960.

Sources: 1980 State Energy Data Report, and Monthly Energy Review, DOE/EIA.

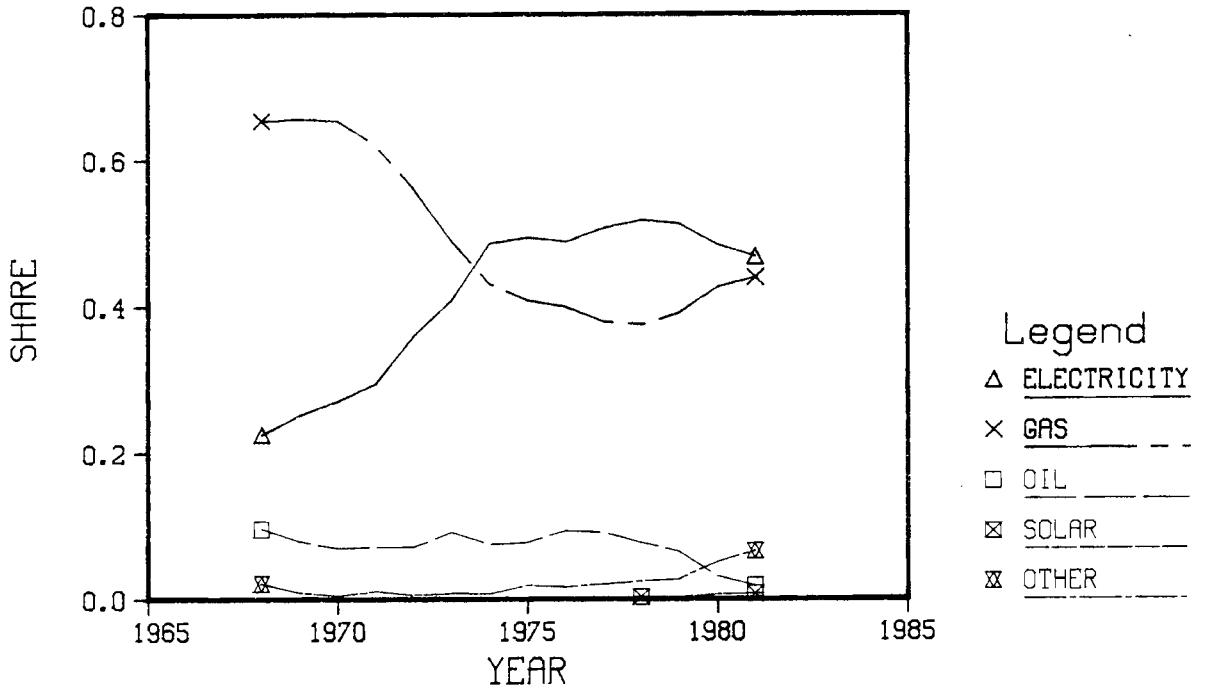


Figure R.9 Space Heating, Fuel Mix in New Single Family Units

Approach: Trends are shown in the mix of primary fuels used for space heating in new single family homes. The percentage shares were calculated by holding the regional (major census regions: Northeast, North Central, South, and West) distribution constant at their 1978 annual values. The regional weights were held constant to eliminate the variance in the data caused by changes in the distribution of regional construction activity.

The category labeled "other" contains wood and solar prior to 1978--unfortunately, this component cannot be disaggregated to the respective components. As the primary energy source, solar has not yet (and would not be expected to) displaced other fuels to a great extent, but its share is now approaching one percent. The "other" category, which consists principally of wood, made up 6.5 percent of new units in 1981 (based on data for the first three quarters of the year).

Key Findings:

- The percentage of homes heated by fuel oil is declining rapidly due to the large increases in oil prices in 1979 and 1980.
- The share of new homes using wood as a primary heat source is continuing to rise.
- Fuel oil and electricity are being replaced by gas, wood, and solar in that order.

Source: Buildings Energy Use Data Book , Edition 2, Oak Ridge National Laboratory, and unpublished survey data from the Bureau of Census.

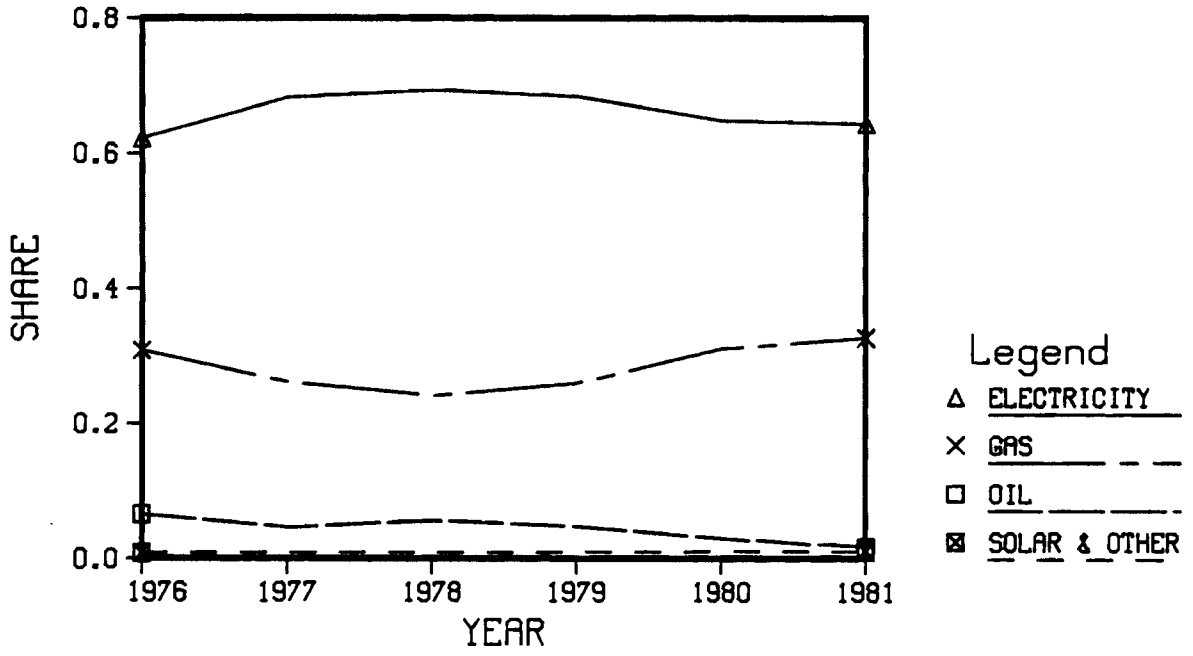


Figure R.10 Distribution of Fuel Sources for Space Heating in New Multi-Family Housing Units

Approach: Recent trends are shown in the distribution of fuels used for space heating in new multi-family housing units. The percentage shares have been calculated by holding the regional (major Census regions: Northeast, North Central, South, and West) starts constant at annual 1978 values. This procedure eliminates changes in the national shares that are due solely to shifts in the distribution of regional construction.

Key Findings:

- In 1981, the percentage of new multi-family units using oil fell to roughly 1.7 percent, approximately one-third of the 1978-1979 average.
- Comparing the year 1978 and the first three quarters of 1981, the share of new multi-family units using gas rose by 37 percent.

Source: Characteristics of New Housing; 1980 , U.S. Bureau of the Census, Construction Report--Series C25, 1981 data from unpublished Census data made available to Energy Information Administration by special arrangement.

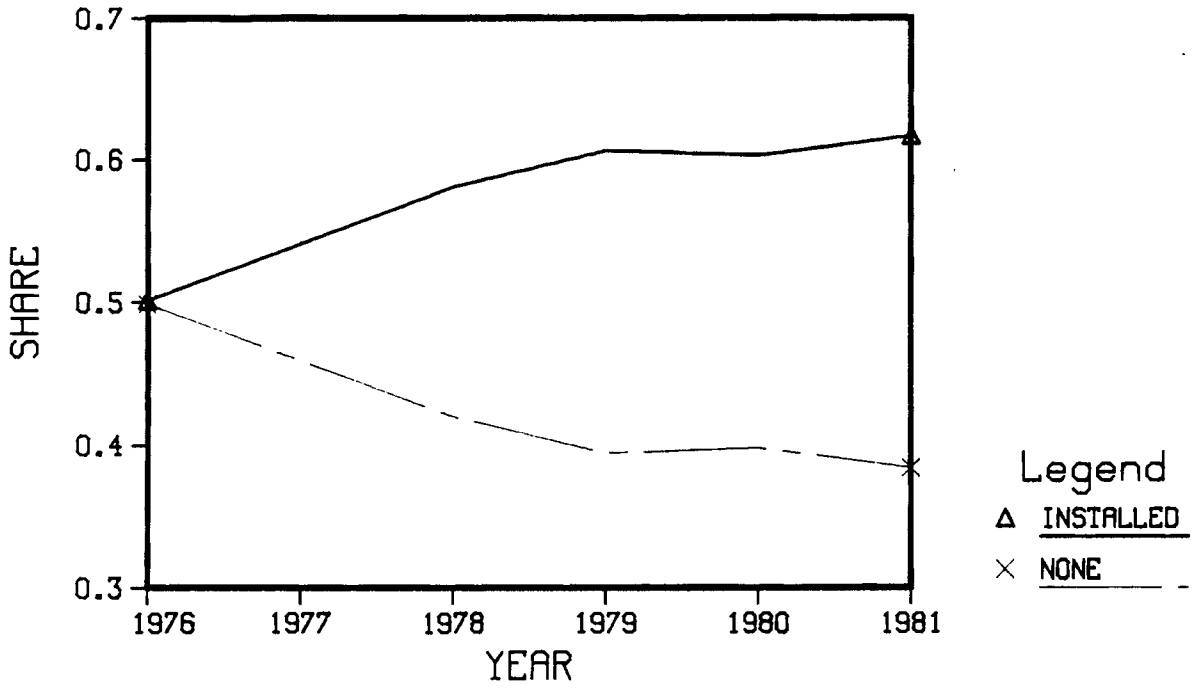


Figure R.11 Central Air Conditioning, Installation in New Single Family Housing Units

Approach: Recent trends are shown in the installation of central air conditioning in new single family homes. The percentage shares have been calculated by holding the regional (major Census regions: Northeast, North Central, South and West) distribution of housing starts constant at annual 1978 values in order to control for differences in regional construction. The regional shift effect is mainly attributable to the relative increase in construction activity in the south, where approximately 85 percent of all new single family homes have central air conditioning.

The trend toward installation of central air conditioning seems to have slowed in the past three years. With record high mortgage costs the distribution of housing starts during this period may have favored lower priced units, lacking central air conditioning, not a regard for energy conservation.

Key Finding:

- Adjusted for shifts in regional construction, the percentage of new single-family houses with central air conditioning increased by 10 percentage points since 1976, but has leveled off since 1979.

Source: Characteristics of New Housing; 1980 , U.S. Bureau of the Census, Construction Report--Series C25, 1981 data from unpublished Census data made available to Energy Information Administration by special arrangement.

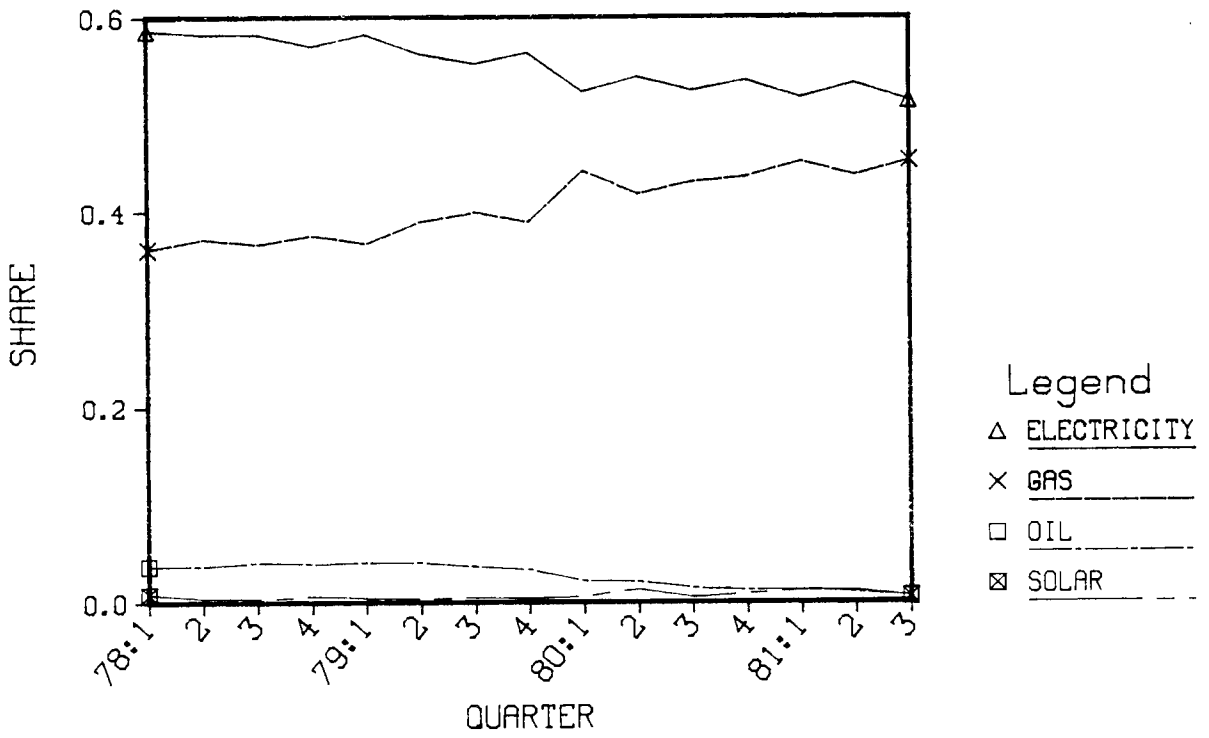


Figure R.12 Distribution of Fuel Sources for Water Heating

Approach: Quarterly trends are shown in water heating fuel shares in newly constructed single family residential units during the period 1978:1 through 1981:3. The regional distribution of construction has been fixed at 1978 annual values in the calculation of the national shares. As was true for space heating, the combined shares of electricity and fuel have fallen significantly over the last two years. Because the number of homes using solar or other fuels (principally wood, not shown in figure) for hot water is very small, the quarter-to-quarter movements are larger, reflecting a relatively large sampling variances. However, in a comparison of 1978 annual averages with 1981 averages, the shares of both solar and wood have both roughly doubled. Each source now accounts for approximately one percent of new single family homes built.

Key Findings:

- The replacement of electricity and fuel oil by gas continued in 1981--nearly half of all new homes are now using gas for hot water reflecting the increased availability of natural gas as a result of partial decontrol.
- In 1981 nearly 2 percent of new homes used solar or wood as the principal energy source for hot water.

Source: Unpublished quarterly survey data from Bureau of Census, U.S. Department of Commerce, made available to Energy Information Administration by special arrangement.

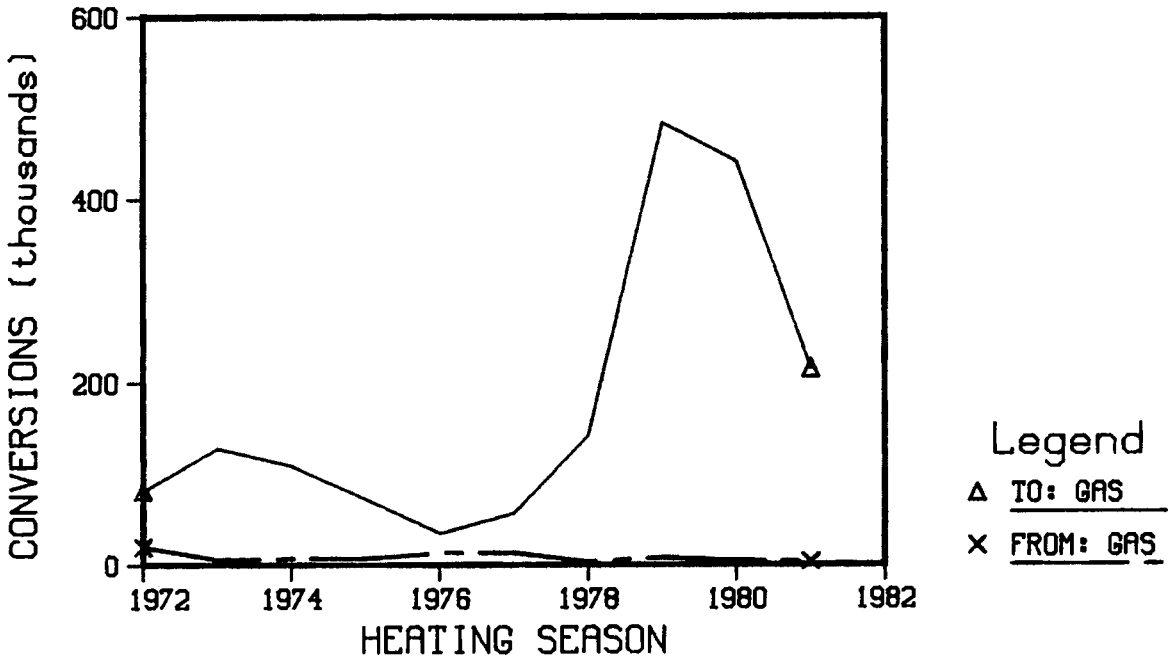


Figure R.13 Fuel Oil Conversion: To and From Natural Gas

Approach: Surveys by Fuel Oil and Oil Heat magazine provide a measure of fuel switching into and out of fuel oil by residential and commercial customers. The beginning year of each heating season is shown on the horizontal axis; heating seasons are defined by Fuel Oil and Oil Heat to run between September 1 and May 1.

The number of customers who used fuel oil as a primary heating fuel in 1979 is estimated to have been roughly 18 million. According to the Census Bureau's Annual Housing Survey, 17 million residential units used oil as their principal heating fuel. EIA's Nonresidential Buildings Energy Consumption Survey reported that in 1979 some 800,000 buildings used fuel oil for heating. Assuming each building represented a single customer, the total number of residential and commercial customers using oil was nearly 18 million in 1979.

Key findings:

- Over 400,000 customers switched from oil to natural gas in both the 1979-80 and 1980-81 heating seasons.
- With decreased uncertainty over availability and moderating price increases of oil, the number of conversions to gas fell to just over 200,000 in the 1981-82 heating season.

Source: Commercial and Residential Fuel Oil Consumption Trends: 1970-1980, Volume II, Centaur Associates, Inc., March 1982, p. II-29. Original source: Fuel Oil and Oil Heat (FOOH) magazine. Data for 1981-1982 heating season from FOOH .

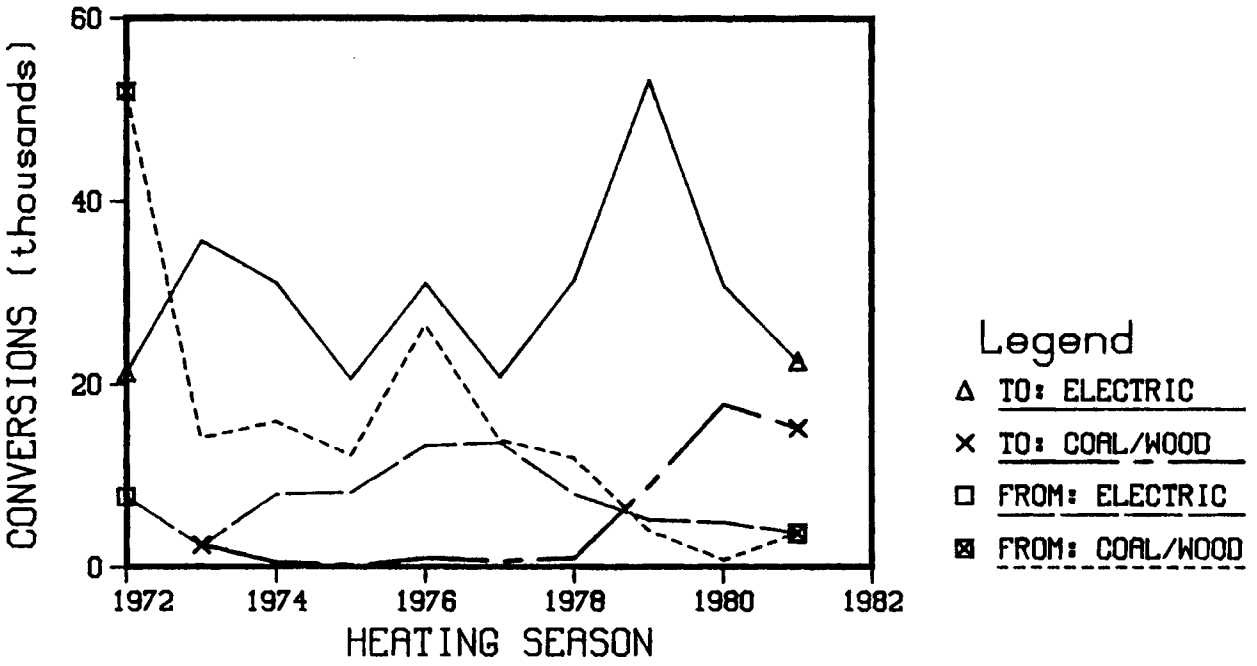


Figure R.14 Fuel Oil Conversion: To and From Electricity and Coal/Wood.

Approach: Surveys by Fuel Oil and Oil Heat magazine provide a measure of fuel switching into and out of fuel oil by residential and commercial customers. The beginning year of each heating season is shown on the horizontal axis; heating seasons are defined by Fuel Oil and Oil Heat to run between September 1 and May 1.

The number of customers who used fuel oil as a primary heating fuel in 1979 is estimated to have been roughly 18 million. According to the Census Bureau's Annual Housing Survey, 17 million residential units used oil as their principal heating fuel. EIA's Nonresidential Buildings Energy Consumption Survey reported that in 1979 some 800,000 buildings used fuel oil for heating. Assuming each building represented a single customer, the total number of residential and commercial customers using oil was nearly 18 million in 1979.

Key findings:

- Over 50,000 customers switched from oil to electricity in the 1979-80 heating season (compared to over 400,000 who switched to oil in the same period, see Figure R.13). This behavior was likely strongly influenced by uncertainty over availability of oil since the number of conversions to electricity fell sharply in the succeeding two years.
- Nearly 20,000 oil customers have switched to coal or wood in the past two heating seasons. Conversions from coal or wood have dropped to negligible magnitudes in the same period.

Source: Commercial and Residential Fuel Oil Consumption Trends: 1970-1980, Volume II, Centaur Associates, Inc., March 1982, p. II-29. Original source: Fuel Oil and Oil Heat (FOOH) magazine. Data for 1981-1982 heating season from FOOH .

COMMERCIAL

Preview and Rationale

The commercial sector accounts for approximately 15 percent of national energy consumption, primarily for use in buildings. Since the largest proportion of building energy is usually allocated to space conditioning, a logical measure of energy productivity is Btu/square foot. The principal problem is to obtain a reliable measure of the stock of (occupied) floor space in commercial buildings. We have chosen to use a set of national estimates constructed by Oak Ridge National Laboratory as part of their Commercial Energy Demand Model.* This series is probably the best that is presently available, although current opinion at ORNL is that the level of the stocks is probably underestimated. The energy per square foot calculations shown in Figure C.1 also require data on commercial sector energy consumption. These data were taken from the 1980 State Energy Data Report, DOE/EIA. An estimate of 1981 commercial sector energy use was derived by splitting the residential/commercial energy consumption as published in the Monthly Energy Review (see Methodological note to Figure A.2 in Appendix B).

Figure C.2 uses the same data from the 1980 State Energy Data Report to show how the shares of commercial energy consumption by fuel type have changed over time. The growth of the electricity share is dramatic, stemming largely from the increased use of air conditioning in commercial buildings.

*The estimates from ORNL were from 1970-1977. On the basis of data on additions and assumed retirement rates, this series was extended by PNL to span 1960-1981.

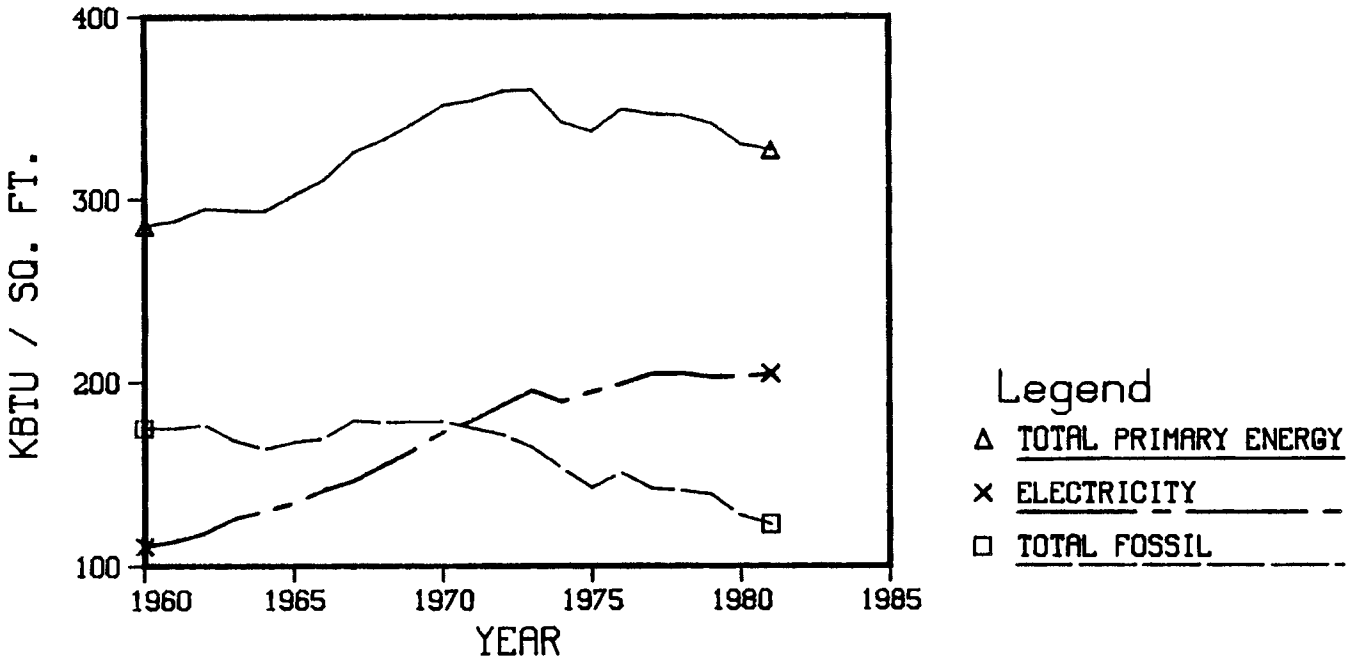


Figure C.1 Energy Consumption Per Square Foot in Commercial Buildings

Approach: Various measures of energy consumption per square foot were constructed for commercial sector buildings. Aggregate data on commercial sector energy consumption were divided by estimates of total commercial floor space. Since no comprehensive survey of commercial floor space is available, the estimates are based on a perpetual inventory accounting procedure, and, as such, no level of confidence can be attached to the absolute levels of the floor space used.

Key findings:

- Direct fossil fuel consumption per square foot in 1981 was approximately 25 percent lower than in 1973.
- Electricity consumption per square foot rose after 1973 by approximately 5 percent, but has remained relatively constant over the past five years.

Source: Square footage data from ORNL for 1970-1977. Other years were estimated by PNL on the basis of additions to stock from F.W. Dodge and assumed retirement rates. Energy data from 1980 State Energy Data Report, DOE/EIA; updated by Pacific Northwest Laboratory for 1981--see notes in Appendix B.

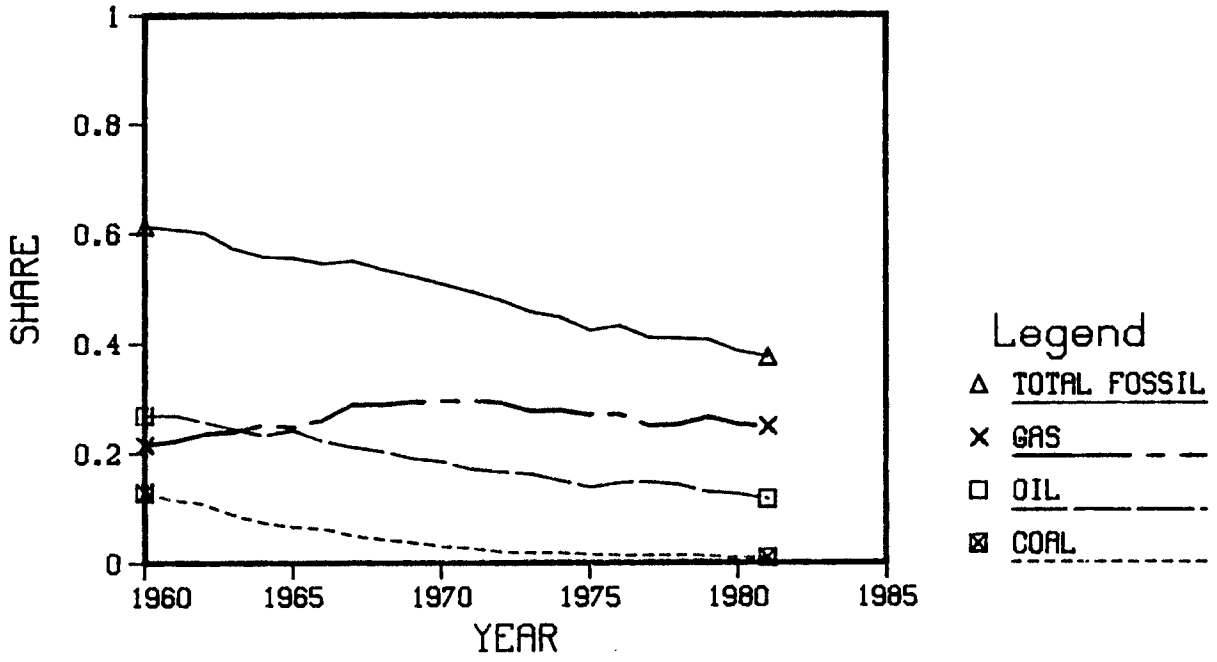


Figure C.2 Fuel Mix in the Commercial Sector

Approach: Data from the Energy Information Administration were used to compute fuel shares (relative to total consumption measured in Btu) for the commercial sector. The electricity share is not plotted; the area above the top graph (total fossil) represents the share of total energy consumption accounted for by electricity (including generation and transmission losses by the utilities).

Key Findings:

- Energy consumed in the form of electricity now makes up nearly 60 percent of all energy consumed by the commercial sector, up from 40 percent in 1960.
- Energy from coal made up over 10 percent of commercial energy consumption in 1960; by 1980 that figure had fallen to less than 1 percent.
- With the exception of increases in 1965 and during the 1975-1977 period, the share of commercial energy consumption from oil has fallen steadily for the past two decades. No significant break in the rate of decline appears after the 1973 embargo.

Source: 1980 State Energy Data Report, DOE/EIA. 1981 data estimated by Pacific Northwest Laboratory--see notes in Appendix B.

INDUSTRIAL

Preview and Rationale

The industrial sector of the economy accounts for approximately 35 percent of domestic energy consumption. In comparison with the other broad end-use sectors, the task of measuring energy productivity in the industrial sector is somewhat easier because of availability of data. The industrial sector is extensively monitored by the Department of Commerce (particularly the Census Bureau) and the Federal Reserve Board to determine the nation's economic performance. The Census of Manufactures has included questions regarding energy use since 1954 and each Annual Survey of Manufactures since 1974 has included a section on purchased fuels. Moreover, relatively few industries account for the bulk of energy use. Over one-half of total industrial energy use can be attributed to chemicals, iron and steel, paper, aluminum, petroleum refining, and cement.

The first three figures are key industrial indicators. Figure I.1 shows an aggregate industrial intensity index based on EIA energy data and Federal Reserve Board industrial production indexes. A key feature of the Figure is the presentation of an industrial production index whose components are weighted by relative energy use. This measure was developed by Robert Marlay in DOE's Office of Policy, Planning, and Analysis. The measure helps to distinguish those movements in aggregate industrial energy intensity that are due to process efficiencies versus those movements that are caused by a change in the composition of industrial outputs. Figure I.2 employs EIA published data to plot relative shares of industrial energy supplied by different fuels. The trend in total fossil fuel consumption (coal, gas, and oil) is clearly shown in contrast to the trend in electricity consumption. Figure I.3 plots 1972-1979 energy intensity changes with capital investment activity over the same period for 10 major energy-using industries. The purpose of this indicator is to show whether the data suggest that relatively high levels of investment have contributed to improvement in energy efficiency. Data on energy intensity change were taken from DOE's Industrial Energy Efficiency Improvement Program.

The remainder of the industrial section presents selected indicators based on the National Energy Accounts (NEA). The National Energy Accounts consolidates data from numerous sources into systematic set of energy

production and consumption accounts for the U.S. economy. The consumption account measures the use of various energy products for approximately 115 sectors for 1947, 1954, and 1958 through 1977. Data are presented in physical units, Btu, and purchaser's value.

NEA energy use data in manufacturing is provided primarily by the Census and Annual Survey of Manufactures. This source provides information for energy used for heat and power; other sources are utilized to cover transportation and feedstock use of energy. Data from the 1978 and the 1979 Annual Survey of Manufactures have been used to update the electricity and total fossil fuels categories for heat and power consumption.

Figures I.4 through I.13 show energy intensity trends based on the updated NEA values. Industry outputs are deflated value of production (1972 constant dollars) as developed by the Bureau of Labor Statistics' Office of Economic Growth. All intensities relate to energy used for heat and power. Three intensities are shown for each manufacturing industry: electricity, fossil, and total energy (the sum of electricity plus fossil). Electricity use incorporates an estimate of the generation and transmission losses; the loss rate was computed from aggregate data on the industrial sector provided by EIA's State Energy Data Report.

For each series of energy intensities (E/Q), the following trend regression was run: $\log (E/Q) = a_0 + a_1 \text{ TIME} + a_2 \text{ TIME73}$. TIME is a time trend beginning in 1958 and TIME73 is a trend beginning in 1973. Thus, the estimated coefficient on TIME73 seeks to measure the incremental percentage growth rate in energy intensity over the period 1972 to 1979. The choice of period for the second time trend was dictated by the desire to cover, as well as possible, a full business cycle. A more complete regression model, including capacity utilization, would allow restriction of this second trend to the post-embargo period only. Nevertheless, the approach taken here does provide a rough measure of the change in energy intensity trends since 1973.

Petroleum refining, cement, iron and steel, and aluminum are four industries that have been investigated in some depth regarding recent progress in energy efficiency. These case study summaries are presented in Appendix A.

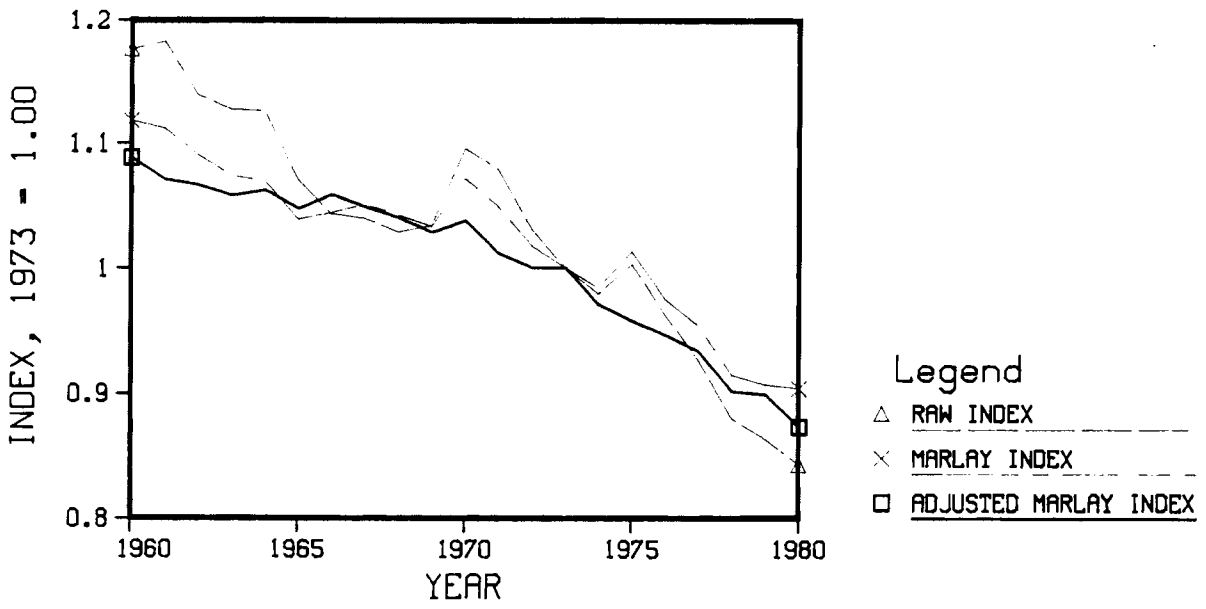


Figure I.1 Comparison of Annual Intensity Indexes for the Industrial Sector

Approach: Energy intensity for the aggregate industrial sector is influenced by both the composition of outputs and capacity utilization. The raw index shown is derived by dividing total industrial energy use by a value-added weighted measure of industrial production (similar to the Federal Reserve production index). The Marlay index replaces the value-added weights in the production index by weights based on the 1967 energy intensity of each of approximately 130 component industries, and, thus, corrects for the effect of output composition on the aggregate intensity measure. The "adjusted" Marlay index corrects for the influence of capacity utilization. This adjustment for capacity utilization reveals a much smoother pattern of changes in energy intensity.

Key Findings:

- Over the period 1972-1980 the raw index shows a decline of around 16 percent; the Marlay index suggests that roughly one-third of this change can be attributed to changes in output mix.
- Although the trend toward greater energy efficiency accelerates after 1973, the intensity index movements do not appear closely related in time to the sharp energy price rises in 1974 and 1979.

Source: The value-added ("raw") and Marlay index were provided by Robert Marlay of DOE's Office of Policy and Evaluation. Capacity utilization adjustment was carried out by Pacific Northwest Laboratory by means of a simple regression model.

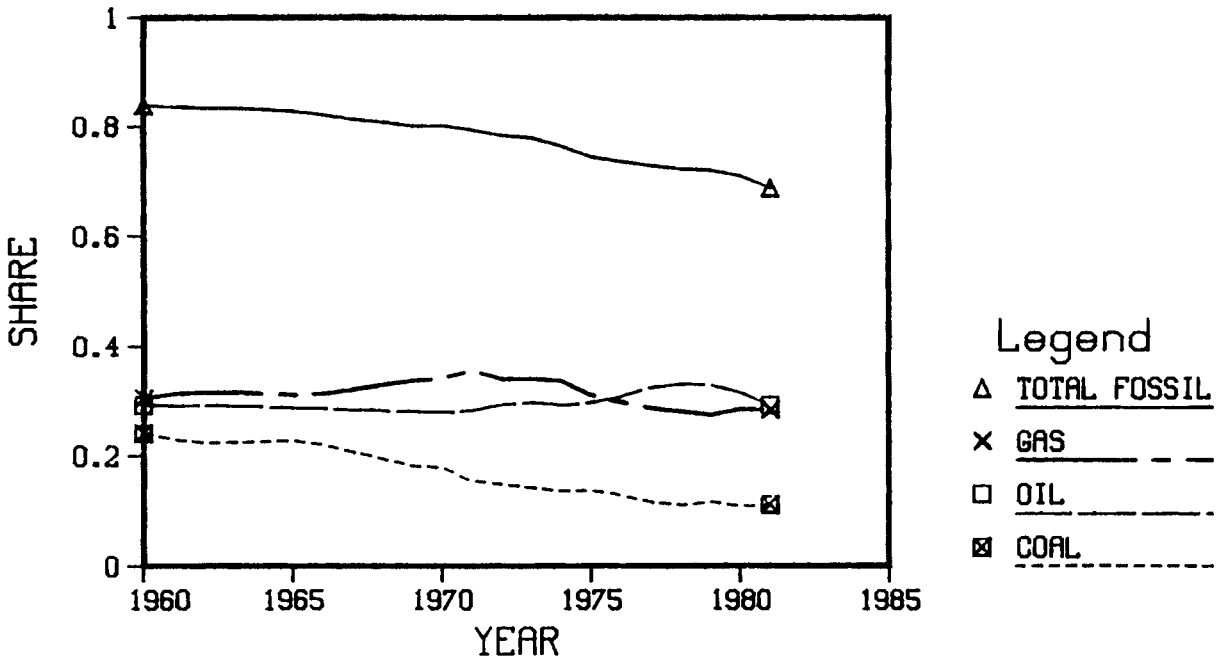


Figure I.2 Fuel Mix in the Industrial Sector

Approach: Data from the Energy Information Administration were used to compute fuel shares for the industrial sector. The area above the top graph represents the share of total energy attributable to electricity, including transmission and generation losses by the electric utilities.

Key Findings:

- A substantial degree of fuel switching has occurred in the industrial sector over the past two decades, especially among the major fossil fuels.
- 1980 and 1981 data suggest a renewed trend toward natural gas, reflecting gas price decontrol and/or sharply higher alternative fuel prices.
- The share of total industrial consumption supplied by electricity has exhibited a steady rise since 1960.

Sources: 1980 State Energy Data Report, July 1982, and Monthly Energy Review, DOE/EIA.

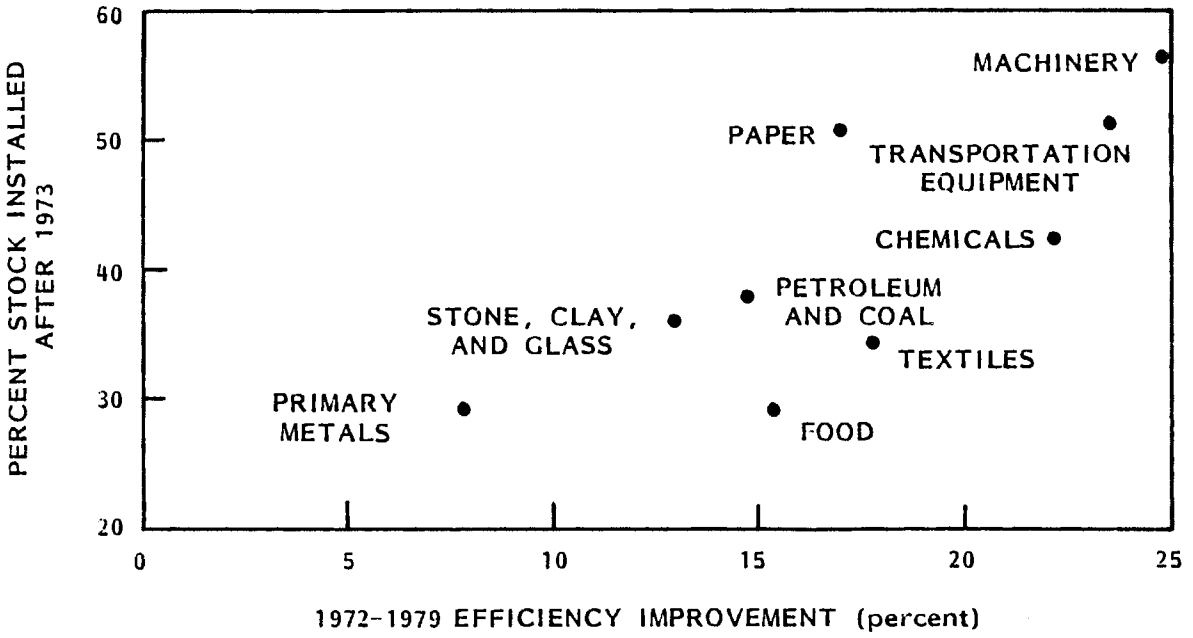


FIGURE I.3 Relationship Between Efficiency Improvement and Post-Embargo Capital Stock

Approach: The Department of Energy's Industrial Energy Efficiency Program (IEEP) reports energy efficiency changes on an annual basis for major (2-digit SIC) manufacturing industries. Efficiency charges since 1972 (base year of the IEEP reporting system) were compared against the fraction of new capital stock installed since 1973. The fraction of new capital was computed by simply summing total gross investment from 1973 through 1979 and dividing this total into an estimate of gross capital stock in place at the end of 1979.

Key Findings:

- Although many variables are ignored, a simple cross sectional analysis supports the conjecture that new capital investment is a principal means of achieving greater energy efficiency within industry.
- Slow growth of new investment in the Primary Metals may be partially responsible for the relatively small gains in energy efficiency since 1972.

Source: The energy efficiency improvement data were taken from the 1979 Annual Report of the Industrial Energy Efficiency Improvement Program. A 1980 report prepared for the Office of Policy, Planning and Evaluation by the MTSC Corporation, "Energy Capital in the U.S. Economy" supplied information regarding the vintage of capital stocks by industry.

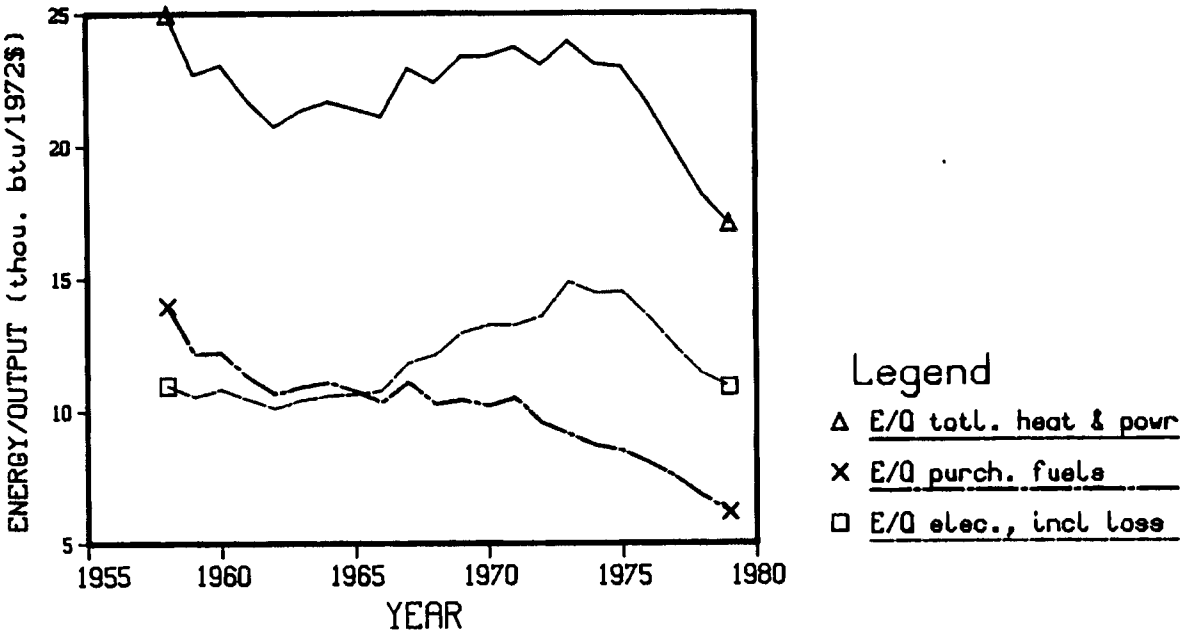


FIGURE I.4 Energy Intensity Trends for Textile Mill Products

Approach: Using trend regressions, annual rates of change of energy/output ratios for the Textile Mill industry were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	0.5	-1.7	2.5
1973-79	-3.7	-6.0	-2.3

Key findings:

- The changes in trends for both purchased fuels and electricity are both approximately 3.8 percent per year.
- The textile industry has been very successful in terms of housekeeping and process changes to reduce consumption for all energy inputs.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 by Annual Survey of Manufactures information. The Textile Mill sector is defined to include SIC's 221, 222, 223, 224, 225, and 228.

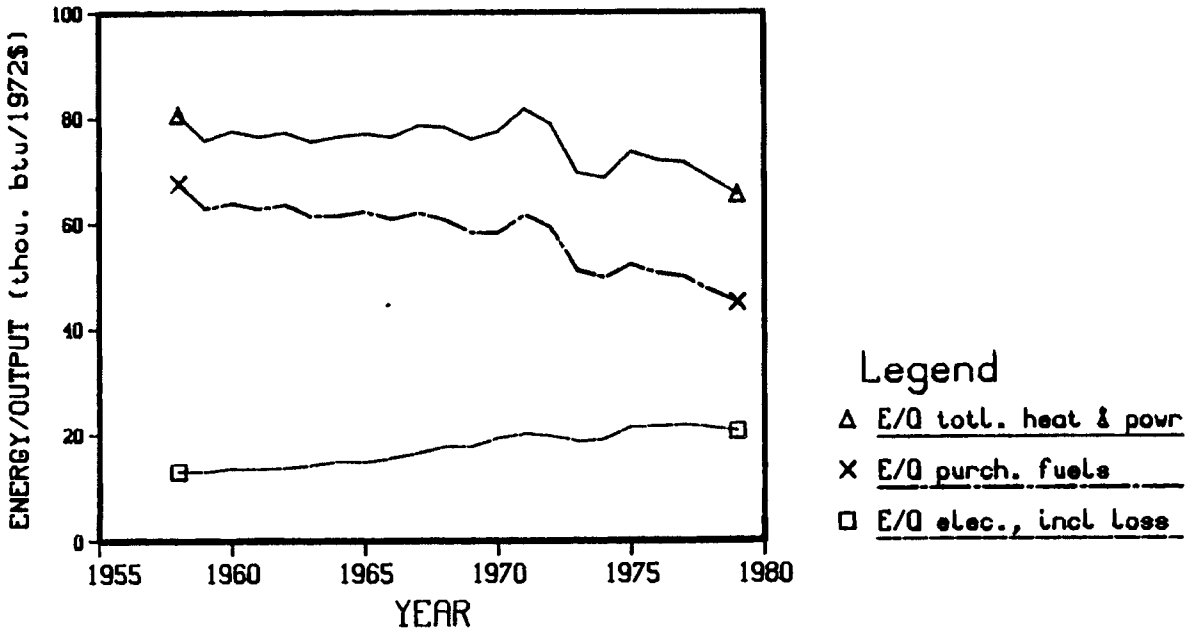


FIGURE I.5 Energy Intensity Trends for Paper Products

Approach: The Paper Products industry is one of the most energy intensive industries in U.S. manufacturing. Using trend regressions, annual percentage rates of change of key energy/output ratios for the Paper Products sector were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	-0.1	-1.0	3.3
1973-79	-1.9	-3.4	-1.4

Key findings:

- Fossil fuel use was declining prior to the 1973 oil embargo, but the rate of decline more than tripled in the succeeding six years.
- Electricity use has continued to grow during the post-embargo period, but only at a little more than half the growth rate up until 1972.
- Energy intensities in the paper industry are highly sensitive to the level of capacity utilization, suggesting caution in making comparisons over short time intervals.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 by Annual Survey of Manufactures information. Paper Products industry is defined to cover SIC 26 excluding SIC 265.

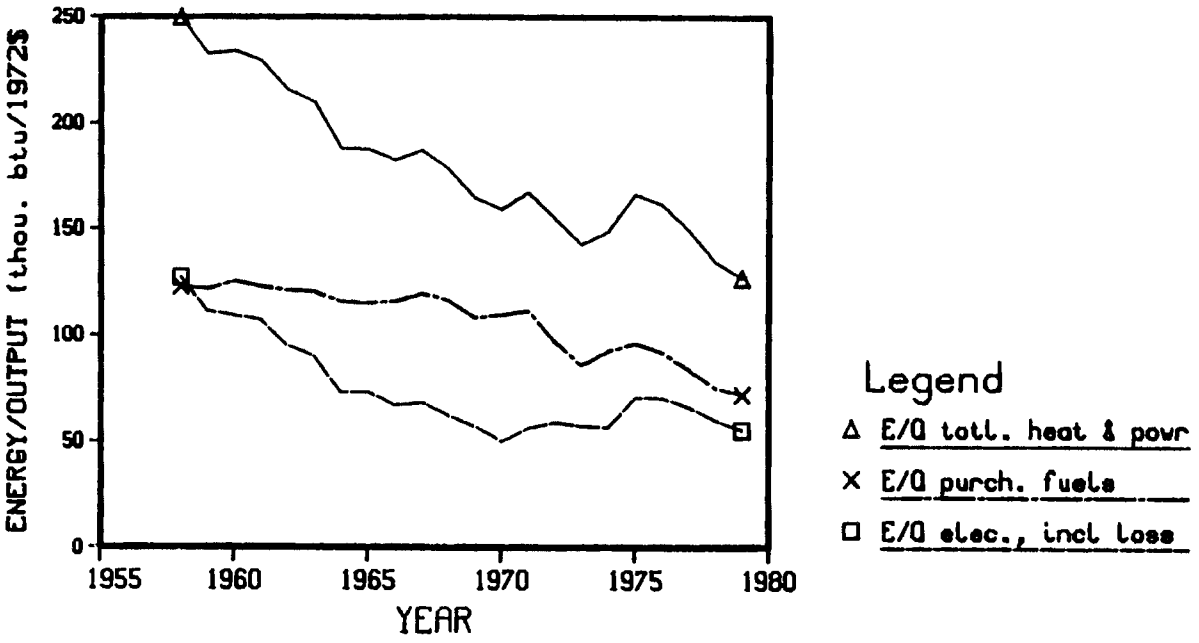


FIGURE I.6 Energy Intensity Trends for Industrial Chemicals

Approach: Using trend regressions, annual percentage rates of change of energy/output ratios for Industrial Chemicals were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	-3.2	-1.4	-5.8
1973-79	-1.6	-4.9	4.2

The results of the simple trend analysis for this sector are difficult to interpret. This likely occurs for two reasons: 1) the composition of outputs may have changed significantly over the time period and 2) the energy intensities are highly sensitive to the level of capacity utilization.

Key findings:

- The use of electricity per unit of constant-dollar output has increased dramatically since 1969, although it appears to have stabilized somewhat since 1975.
- Fossil fuel use shows a decline over the six years ending in 1979 that is triple that of the prior 1958-72 trend.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. The Industrial Chemicals sector includes SIC 281, 2865, and 2869.

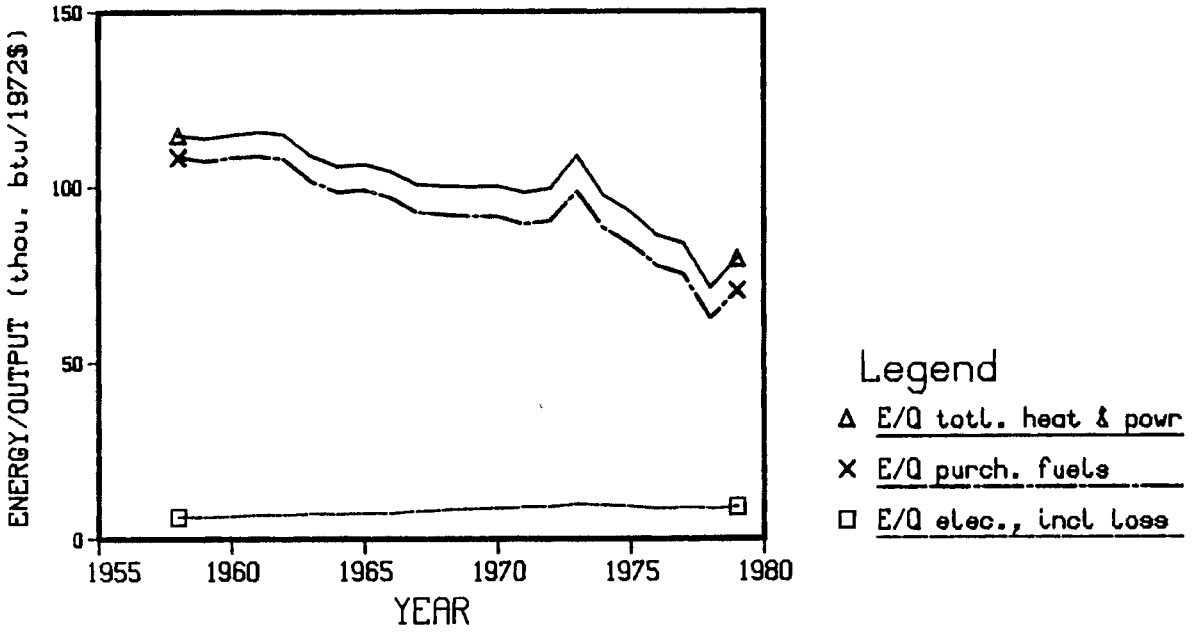


FIGURE I.7 Energy Intensity Trends for Petroleum Refining

Approach: In terms of energy use per 1972 dollar of production, Petroleum Refining, with the exception of the basic iron and steel, is the most energy intensive industry in manufacturing. Using trend regressions, annual percentage rates of change of energy/output ratios for Petroleum Refining were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	-1.0	-1.3	3.0
1973-79	-3.8	-4.3	-0.7

Key findings:

- Since 1973 the change in total energy use per dollar of output has been dramatic, declining by approximately 30 percent.
- The changes in the pre-embargo trends have been roughly equivalent for both fossil fuels and electricity.
- After growing at around 3 percent per year prior to 1973, electricity per dollar of output actually declined in the years following the embargo.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Account updated to 1979 with Annual Survey of Manufactures information. Petroleum Refining includes all of SIC 29.

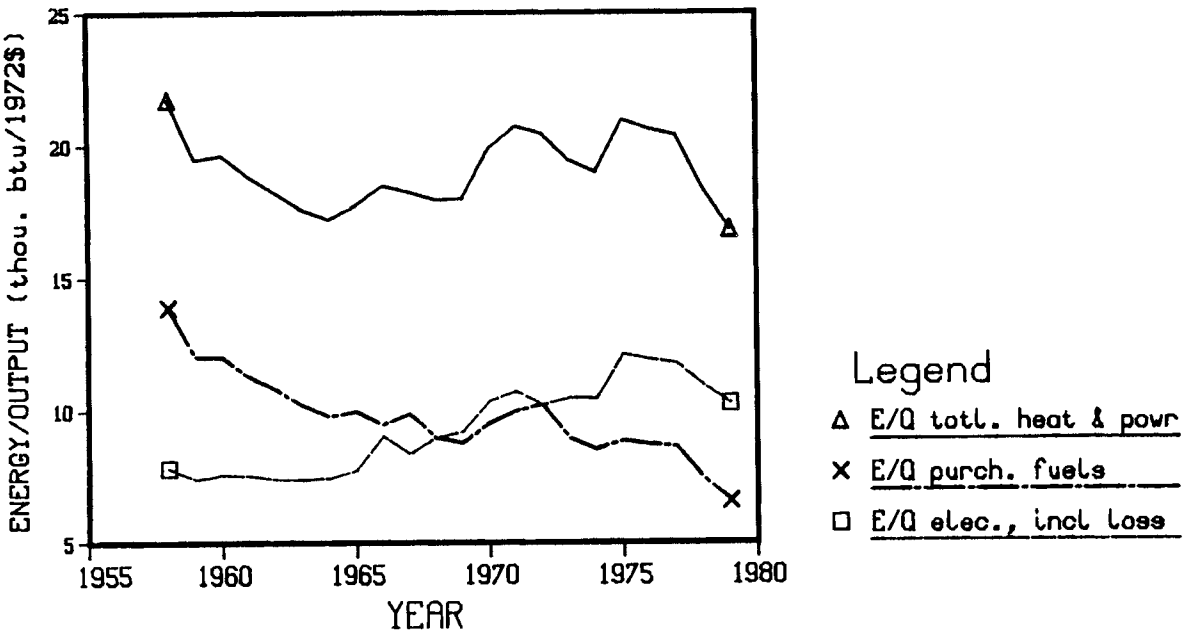


FIGURE I.8 Energy Intensity Trends for Rubber and Miscellaneous Plastics

Approach: Using trend regressions, annual percentage rates of change of energy/output ratios for Rubber and Miscellaneous Plastics were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	0.2	-1.9	2.9
1973-79	-0.4	-3.0	1.4

Lack of changes detected in trend in the post-embargo period may be caused by changes in composition of this industry's outputs. This sector is defined to include all of SIC 30 which includes tires as well as fabricated plastic products. Additional disaggregation and analysis will be required to determine the significance of this factor.

Key findings:

- Trends in energy intensities, as measured by Btu per 1972 dollar of gross output, have not changed significantly in the Rubber and miscellaneous Plastics industry since 1974.
- The time trend variables (starting with 1973) were not significantly different in any of the three regressions run.
- The pre-1973 trends show that the fossil fuel intensity has been declining while the use of electricity per unit of output has been growing.

Source: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. Rubber and Miscellaneous Plastics industry covers all of SIC 30.

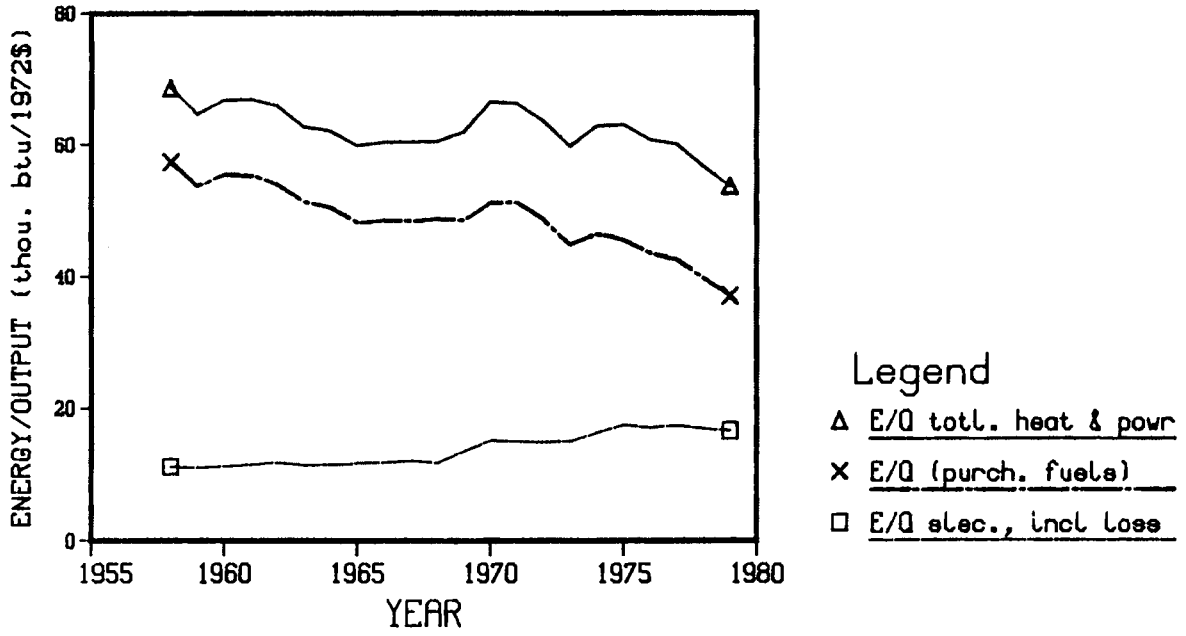


FIGURE I.9 Energy Intensity Trends for Glass Products

Approach: Using trend regressions, annual rates of change of energy/output ratios for Glass Products were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	-0.3	-1.0	2.3
1973-79	-1.4	-3.1	2.9

The glass industry is one of the most energy intensive industries in U.S. manufacturing in terms of energy use per dollar of gross production. The reduction in total energy per 1972 dollar of production has proceeded at only a slightly faster rate since 1972. The estimated coefficient of -0.6 on the 1973-79 trend was not significant at the 10 percent level.

Key findings:

- In the glass industry the rate of increase in electricity use accelerated and the reduction in fossil-fuels energy intensity has more than doubled since 1972.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. The Glass Products sector includes SIC 321 and 322.

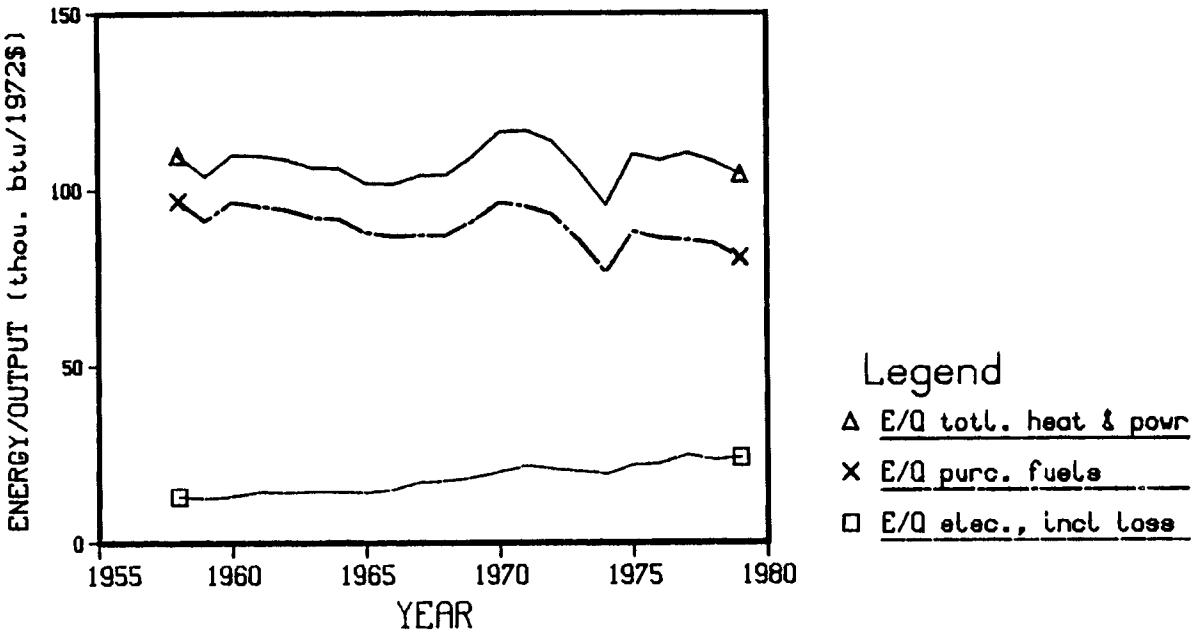


FIGURE I.10 Energy Intensity Trends for Iron and Steel

Approach: Using trend regressions, annual percentage rates of change of energy/output ratios for the Steel industry were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	0.2	-0.4	3.6
1973-79	-0.3	-1.1	2.7

Because of the influence of capacity utilization on energy intensities, one must use caution in the interpretation of trends based on short time series. Although the estimates of the change on trends between the two subperiods were negative, and were statistically significant at the 10 percent level, it is also clear that by inspection of the top two graphs that choice of starting year for the post-embargo trend is very important.

Key finding:

- Progress toward greater energy efficiency in the steel industry has been modest over the post-embargo period.

SOURCES: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. Iron and steel is defined here as SIC 331.

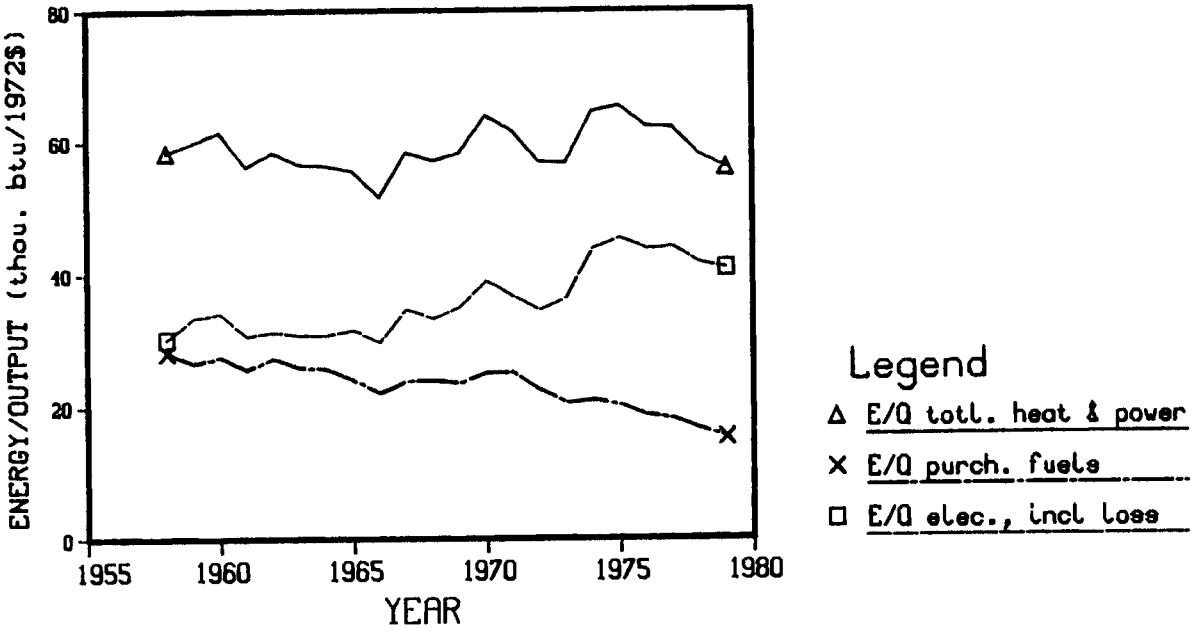


Figure I.11 Energy Intensity Trends for Nonferrous Metals

Analysis: Using trend regressions annual percentage rates of change of energy/output ratios for Nonferrous Metals were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	0.3	-1.3	1.5
1973-78	0.2	-5.4	2.9

Key findings:

- Electricity/output ratios are highly cyclical in the Nonferrous Metals sector, reflecting the importance of primary aluminum in this sector. (In 1977, primary aluminum accounted for some 90 percent of electricity consumption in this sector).
- For the seven-year period ending in 1979, the rate of decline in use of fossil fuels was nearly triple that of the previous decade and a half.

Sources: Output data from the Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. Nonferrous Metals sector includes SIC's 333 through 338.

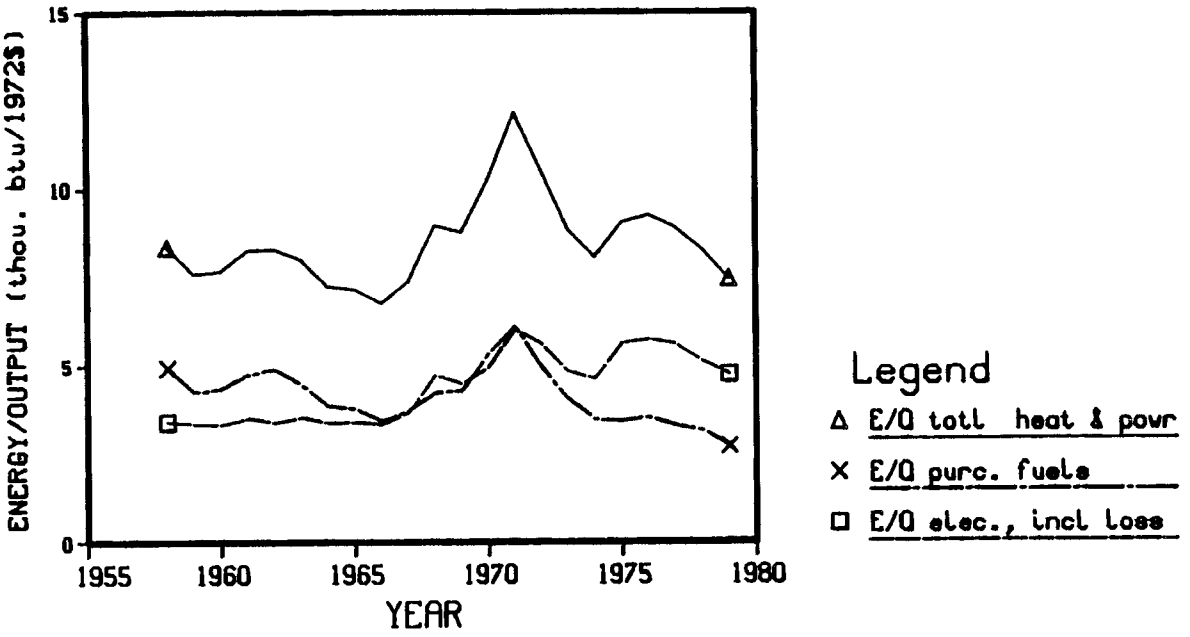


FIGURE I.12 Energy Intensity Trends for Metalworking Machinery

Approach: Using trend regressions, annual percentage rates of change of energy/output ratios for Metalworking Machinery were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	2.0	0.3	3.8
1973-79	-2.7	-7.0	0.2

Metalworking Machinery (SIC 354) is not a relatively energy intensive sector, but it is an important capital-goods industry. Per dollar of gross output, energy requirements in metalworking are roughly a tenth of what they are in iron and steel or petroleum refining. Energy intensities in this cylical industry are heavily influenced by the level of capacity utilization. The cylical volatility of the intensities makes the interpretation of trends based on short time intervals precarious.

Key Findings:

- The trend in the fossil-fuel intensity since 1973 has been clearly downward.
- The pre-1973 growth rate of nearly 4.0 percent per year for electricity has been reduced to around 1.0 percent in the last six years of available data.

Sources: Ouput data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. The Metalworking Machinery sector is defined as SIC 354.

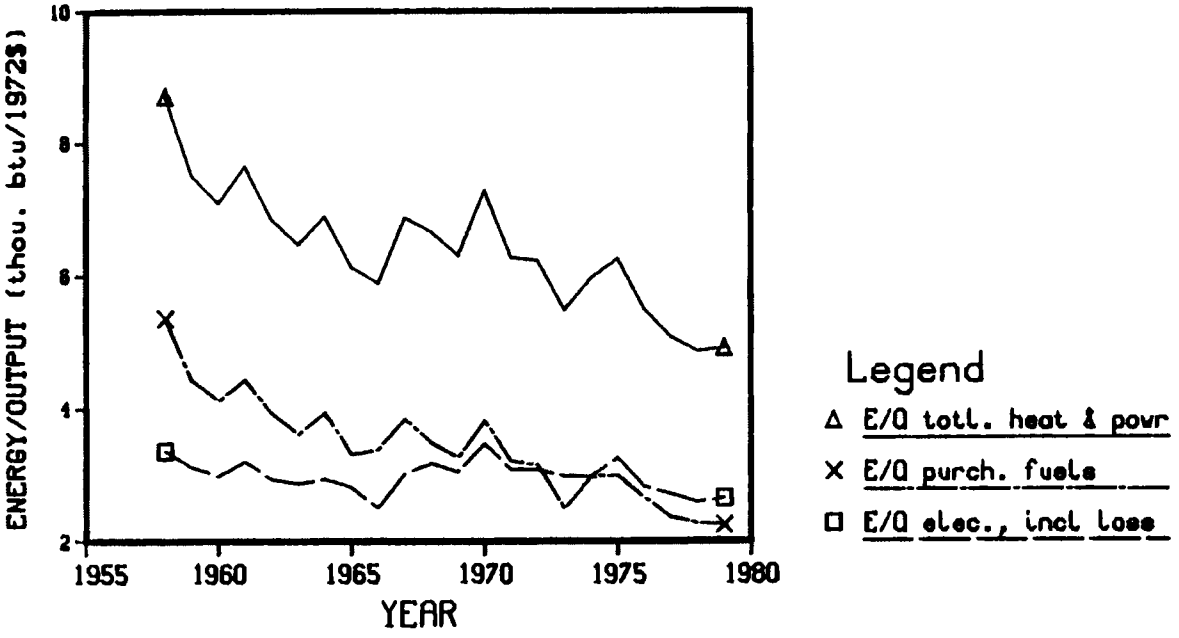


FIGURE I.13 Energy Intensity Trends for Motor Vehicles

Approach: Although Motor Vehicles is not a relatively energy intensive industry, it is a large consumer of energy by virtue of its size. Using trend regressions, annual percentage rates of change of energy/output ratios for motor vehicles were estimated as follows:

Period	Total Energy	Purchased Fuels	Electricity
1958-72	-1.5	-2.8	0.2
1973-79	-3.3	-4.5	-2.0

Key Findings:

- Assuming that 1972 and 1979 represent roughly equivalent phases of the business cycle, (and, therefore, the trend over the 1972-1979 period is not distorted significantly by capacity utilization influences) the rate of decline in total energy per unit of output more than doubled during the 1973-79 period relative to the prior fifteen years.
- The achievements in greater efficiencies appear to have affected both fossil fuels and electricity about equally; the change in trends between the two sub-periods are both around -2.0 percent.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information. The Motor Vehicles sector is defined as SIC 371.

TRANSPORTATION

Preview and Rationale

Transportation accounts for roughly one-quarter of all energy used in the U.S. Passenger automobiles are the dominant consumer of transportation energy; in 1979 the share of transportation energy attributable to passenger cars is estimated to have been 49 percent. Trucks are the next largest consumer of energy, responsible for some 24 percent of 1979 transportation energy. The remainder of transportation energy use was split among railroads, airplanes, and ships.

The first two figures are devoted to looking at recent trends in passenger automobile fuel efficiency. Figure T.1 plots average on-road fuel efficiency for the existing stock of cars from two sources. A time series from 1967 to 1981 on average MPG is from the Federal Highway Administration (FHWA). FHWA MPG figures are derived by dividing estimates of gasoline consumption into estimates of aggregate vehicle-miles traveled (VMT). The data on gasoline consumption is judged to be reasonably accurate, since it is based on state gasoline sales tax data collected at the wholesale level. More in question, however, are figures for vehicle-miles traveled. The basic problem is that FHWA collects the data from individual states that do not use a consistent collection method. However, since the FHWA is the only source for a comprehensive, national estimate of VMT, we display here the MPG figures derived from its use.

A second source on average MPG is from a computer model developed by Energy and Environmental Analysis, Inc. (EEA) for DOE's Office of Policy, Planning and Analysis. The average MPG figures generated by this model are based on assumptions about the use patterns of vehicles of various ages as well as characterization of the various vintages of automobiles by their fuel efficiency.

Figure T.1 also shows the average on-road fuel for new cars as estimated from the EEA model. The on-road MPG figures are developed by applying correction factors to the EPA mileage ratings according to engineering characteristics of cars of various models.

Average new car fuel efficiencies have obviously increased in recent years. Figure T.2 sheds some light on whether this result is primarily due to sales shifts among various classes of cars or whether it is due to technological improvements on the part of manufacturers. Results of a decomposition analysis on EPA fuel efficiency data for new cars performed by Oak Ridge National Laboratory (ORNL) is shown for model years 1980 and 1981.

The same type of decomposition analysis has been performed to study changes in fuel efficiency of commercial airlines. Energy and Environmental Analysis, Inc. analyzed the factors behind the reduction in fuel use per passenger-mile in the U. S. airline industry. Figure T.3 shows the relative contributions of load factor, mix of airplane types, technical and operating efficiency, and seat capacity to the changes in fuel/passenger-mile since 1967.

Figure T.4 shows recent trends (since 1970) in energy intensities for various freight transportation modes. With the exception of trucking, these intensity measures have been developed by Oak Ridge National Laboratory. A major problem is that it is difficult to maintain these indicators on an up-to-date basis. Because of the publication lag of the various regulatory agencies, most of these intensities can be calculated with no less than a two year lag.

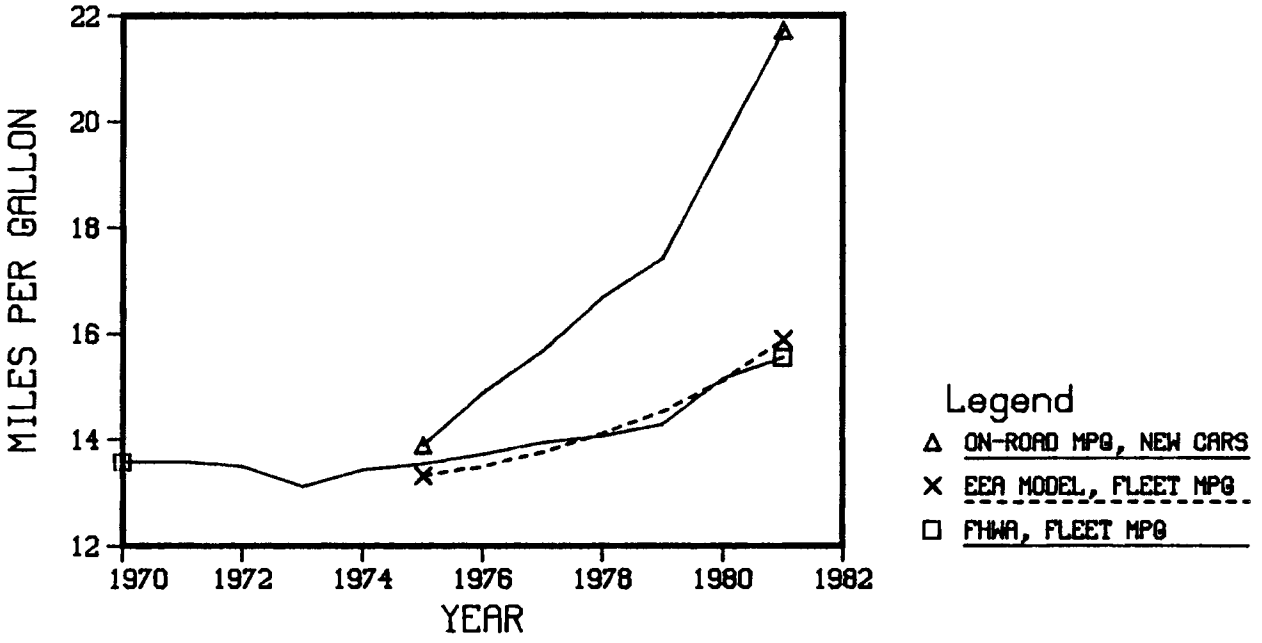


Figure T.1 On-Road Fuel Efficiency of U.S. Passenger Cars

Approach: Recent trends in the on-road efficiency of new and existing passenger automobiles were developed and compared. The estimates for on-road (combined city and highway) efficiency of new cars (both imported and domestics) over calendar years 1975 through 1981 were constructed by Energy and Environmental Analysis, Inc. (EEA) for DOE's office of Policy, Planning, and Analysis. The EEA model also provides estimates of average on-road efficiency of the existing fleet of U.S., passenger cars (based on assumptions about the relative vehicle-miles driven by automobiles of various ages). Over the period 1975 to 1981, the model results correspond quite well to average MPG figures as provided by the Federal Highway Administration (FHWA).

Key Findings:

- In 1975 (the first year for which data were available from the EEA model), average new car fuel efficiency was only slightly above the fleet average of 13.8 miles per gallon.
- In 1981, the estimated on-road efficiency of new cars was over 20 MPG for the first time.
- Average gasoline consumption per vehicle could be cut by at least 25 percent in the long run, even if new car efficiencies did not improve beyond those achieved in 1980 with complete turnover of existing stock.

Sources: EEA model data taken from quarterly reports of The Highway Fuel Consumption Model prepared by Energy and Environmental Analysis, Inc. for DOE's Office of Policy, Planning, and Analysis. Federal Highway Administration data on average MPG published in Highway Statistics, (Annual).

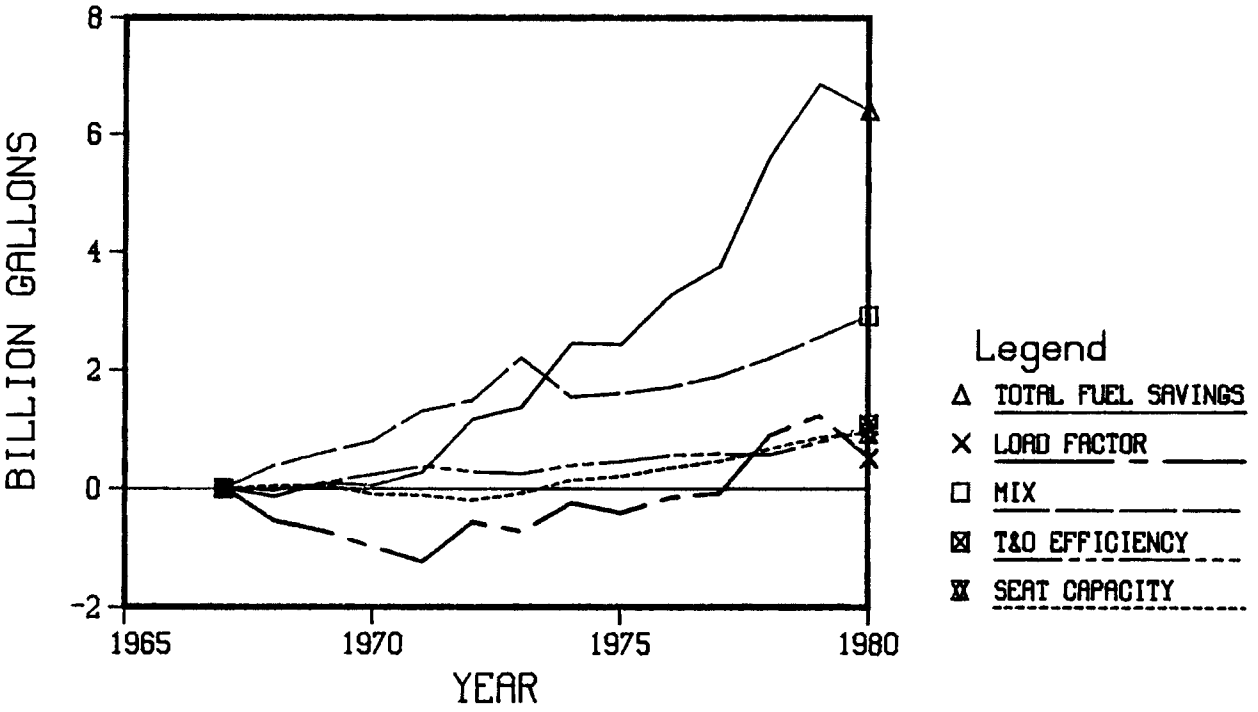


Figure T.3. Sources of Change in Commercial Airline Energy Efficiency

Approach: An analysis was performed by Energy and Environmental Analysis, Inc. to decompose the changes in commercial airline efficiency between 1967 and 1980. Actual fuel use was subtracted from a "baseline", in which fuel use per revenue-passenger mile was held at its 1967 value. This difference is shown as "Total Savings" in the graph. The contributions of five factors were then computed by comparing the amount of fuel that would have been used had each factor remained at its 1967 value (with all other factors taken at their current year values) and the actual level of fuel consumption. "Load factor" relates to the pecentage of airline seats that are occupied. "Mix" refers to the changing composition of aircraft, which became particularly important with introduction of wide-body jets in the early 1970's. "T & O (Technical and Operating) Efficiency" basically measures the technical efficiency in terms of gallons of fuel consumed per aircraft mile. "Seat Capacity" measures the effect of increased number of seats per plane.

Key Findings:

- At 1967 levels of fuel consumption per passenger-mile, the commercial airline industry in 1980 would have used roughly 64 percent more fuel than it actually did, representing a savings of some 6.4 billion gallons.
- Relative to 1967 the changed mix of aircraft types has contributed the largest percentage of savings, approximately 46 percent in 1980.
- The airline industry has made significant improvements in its operating procedures since 1978. The savings attributable to "T & O Efficiency" jumped from .57 billion gallons in 1978 to more than a billion in 1980.

Source: "Fuel Demand and Fuel Efficiency in the U.S. Commercial Airline Industry: An Analysis of Trends and Implications," Energy and Environmental Analysis, Inc., prepared for DOE Office of Policy, Planning and Analysis, May 1982.

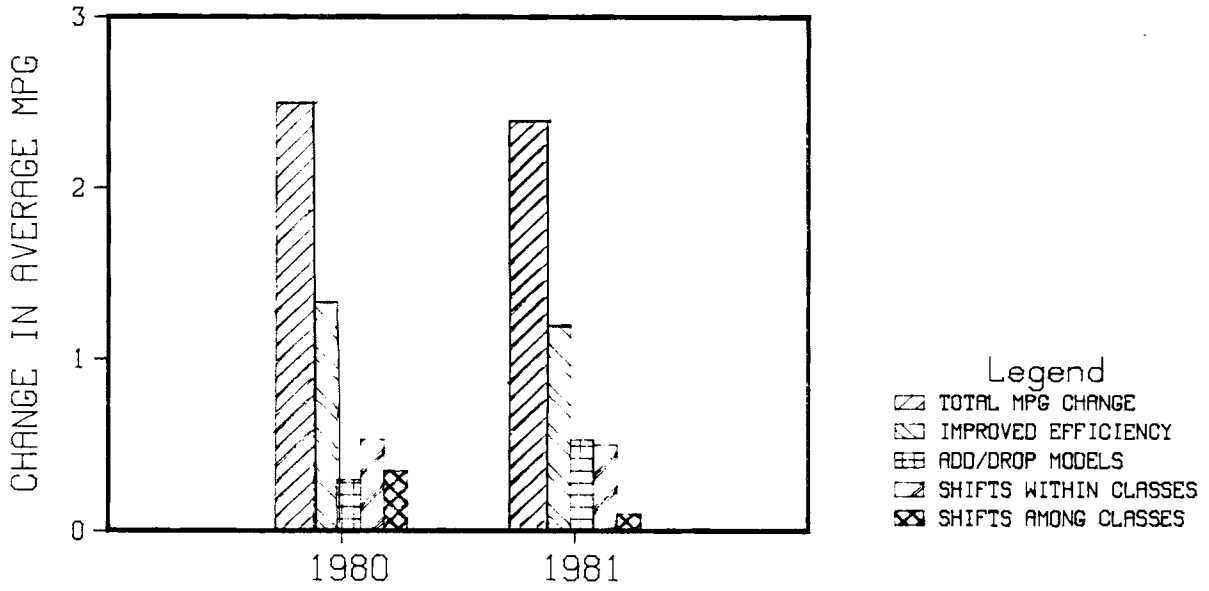


Figure T.2 Determinants of Improvements in New Auto Fuel Efficiency

Approach: An analysis was performed at Oak Ridge National Laboratory to decompose the changes in average new car fuel efficiency for model years 1980 and 1981. The "Total MPG Change" refers to the EPA mileage ratings averaged over all new domestic and imported cars sold in each model year. "Improved Efficiency" refers to the increased MPG ratings within the same model classes (EPA model classes: large, mid-size, compact, sub-compact, minor-compact, two-seater). "Add/Drop" Models" reflects the impact on the average MPG ratings due to the adding and dropping of models by manufacturers. "Shifts Among Classes" shows how much average MPG has changed as consumers have changed their buying habits among cars within the same class. "Shifts Among Classes" refers to the impact on average MPG, as consumers shifted their composition of new car purchases among classes.

Key Findings:

- Average new car fuel economy has increased in the past two model years primarily due to technological change that leads to improved MPG ratings in all categories.
- The shift to smaller cars, as represented by shifts across EPA classes, accounted for only a small fraction of the average MPG change in model years 1980 and 1981.

Source: Motor Vehicle Quarterly MPG and Market Share Newsletter , Oak Ridge National Laboratory, October, 1981.

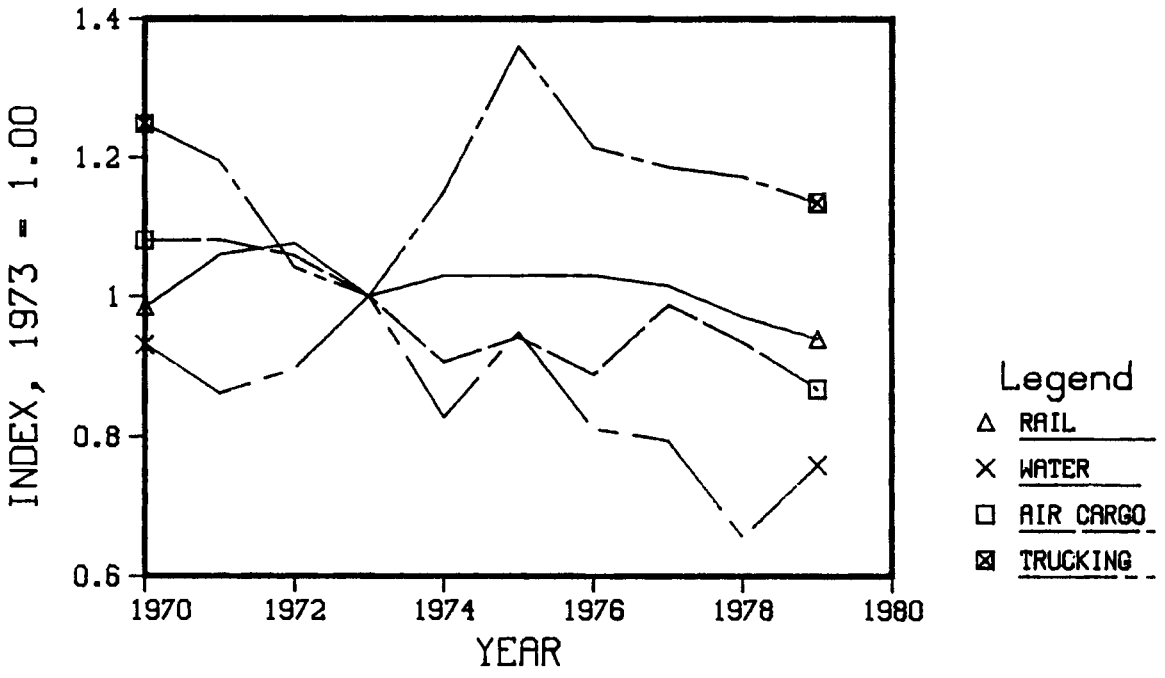


Figure T.4 Energy Intensity Indexes for Freight Transportation

Approach: Figure T.4 compares energy intensity indexes (defined as Btu/ton-mile) for various freight modes. Trucking is restricted to "combination trucks" as defined by the Federal Highway Administration. Although the category of trucks accounts for only about 30 percent of total fuel used by all trucks, it accounts for over 80 percent of ton-miles in trucking. Intensity measures for rail, water, air were constructed by Oak Ridge National Laboratory.

Key Findings:

- Compared with 1973, fuel efficiency in the trucking industry has actually declined, stemming primarily from a shifting mix of new trucks towards heavier less fuel efficient vehicles. Although not shown in the figure, Energy and Environmental Analysis, Inc. estimated the fuel demand was 5.5 percent lower in 1980 than what would have occurred if truck freight transportation had maintained its 1967 efficiency.
- Energy use per ton-mile by air cargo carriers dropped by 15 percent in the period 1977-1979, accomplished primarily by substituting more fuel efficient aircraft and general route restructuring.
- Energy use per ton-mile by domestic waterborne carriers fluctuate greatly on a year-to-year basis, but the overall trend since the early 1970's is downward.
- Railroads have exhibited approximately a 7 percent decline in energy intensity from 1975 to 1979.

Source: Trucking data from "Fuel Demand and Fuel Efficiency in the U.S. Commercial Airline Industry and the Trucking Industry: An Analysis of Trends and Implications", Energy and Environmental Analysis, Inc, May 1982. Other data from Oak Ridge National Laboratory, Energy Intensity and Related Parameters of Selected Transportation Modes: Freight Movements, updated by ORNL, and the Federal Highway Administration, Table VM-1.

ELECTRICITY GENERATION

Preview and Rationale

Production of electricity accounted for 27 percent of the energy consumed in the United States in 1980. Electricity generating public utilities accounted for 6.8 percent of petroleum consumption, 18.5 percent of natural gas consumption and 81.0 percent of coal consumption in the United States in the same year. The generating industry is special in that it only converts energy from one form into another and distributes it. Ideally, 100 percent of the input energy would be transformed into electricity and distributed to customers without loss. However, the losses are large; the realized overall efficiency of the conversion of potential energy into delivered electricity is about 35 percent. The efficiency of electricity production varies with the mix of fuels and changes in the technologies employed. In this section we explore the sources of changes in efficiency.

Since utilities are regulated, more detailed information is available to the public than is the case for most other industries. The data used in this section are taken from the EIA's 1981 Annual Report to Congress. The fuels used by utilities are divided here into fossil fuels and others. The discussion focuses on the post-embargo trends in the utilization of fossil fuels.

The figures in this section display time series from 1960 to 1981. The first figure (U.1) shows the total quantity of electricity generated in the U.S., the quantity sold, and the quantity generated from fossil fuels. The difference between the total- and fossil-generated quantities is nonfossil generation, while the difference between the total generated and the total sold are transmission losses. The second figure (U.2) shows the ratio of sales to total generated in the form of a percentage, which can be interpreted as the overall transmission efficiency.

The third through fifth figures focus on the efficiency of fossil-generated power. Figure U.3 shows the quantities of each fossil fuel input to the electric utility industry in quadrillion Btu. The fourth figure (U.4) uses this same data to show the share of each fossil fuel in the aggregate fossil generation. Figure U.5 shows fossil fuel efficiencies (for each fuel and total fossil) defined as ratios of electricity generated to the potential

energy input. These figures show the pattern of offsetting trends that left the average efficiency of utilization of fossil fuels roughly unchanged between 1970 and 1981, despite changes in the utilization efficiencies of each fuel and the changing fuel mix.

Figure U.6 shows the ratios of capacity to annual output for all fuels and total fossil, scaled to 1973=1. The ratios have been increasing in recent years. It was expected that when the ratios increased there would be decreased utilization of less efficient plants leading to increased fossil efficiency. However, no correlation was found between the capacity-output ratios and fossil utilization efficiency in this aggregate data.

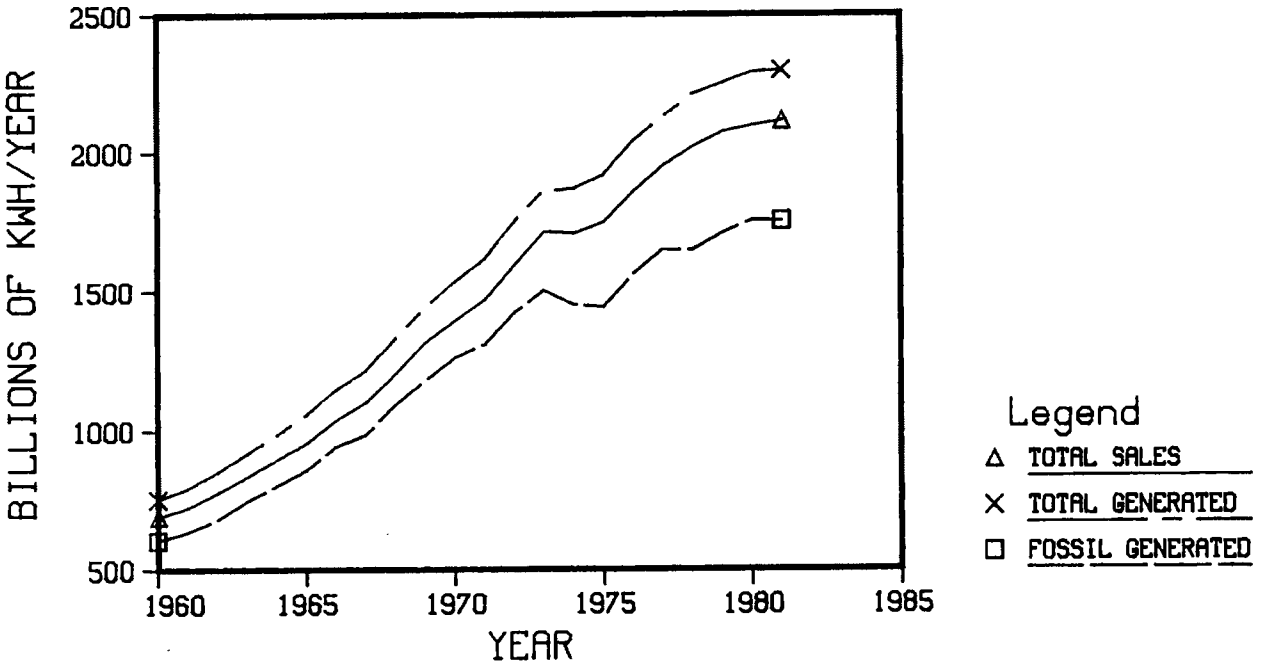


Figure U.1 Generation and Sales of Electricity

Approach: Figure U.1 shows trends of electricity generation from all sources and fossil fuels, and total sales from 1960 to 1981. Note that the trends rise continuously until 1973, but that in 1974 they temporarily stop rising, and in the case of fosssil fuels, decline. After 1973, the average annual percentage increase in electricity sales is only about 40 percent of the pre-embargo trend.

The share of electrical generation from fossil fuels declined from 81.2 percent in 1973 to 76.5 percent in 1981. This drop stems largely from the nuclear-based generation, rising from 4.5 of total generation in 1973 to 11.9 in 1981.

The differences between the total sales and total production of each year are distribution losses. These losses cannot be assigned to any single fuel type, though they will differ with transmission distance and may tend to improve the economics of local fossil plants over more distant hydro or nuclear sources.

Key findings:

- As the price of electricity rose relative to income after the embargo, the growth rate of electricity declined.
- The 1960-1973 annual increase of 7.0 percent slowed to 2.6 percent per year between 1973 and 1981.
- The share of total electrical generation supplied by fossil fuels declined from 81.2 percent in 1973 to 76.5 percent in 1981, primarily due to growth in nuclear generation.

Source: 1981 Annual Report to Congress, DOE/EIA. Total sales from T. 67, (p. 155); Total Generation from T. 66, p. 453. Fossil generation from Table 65, p. 151.

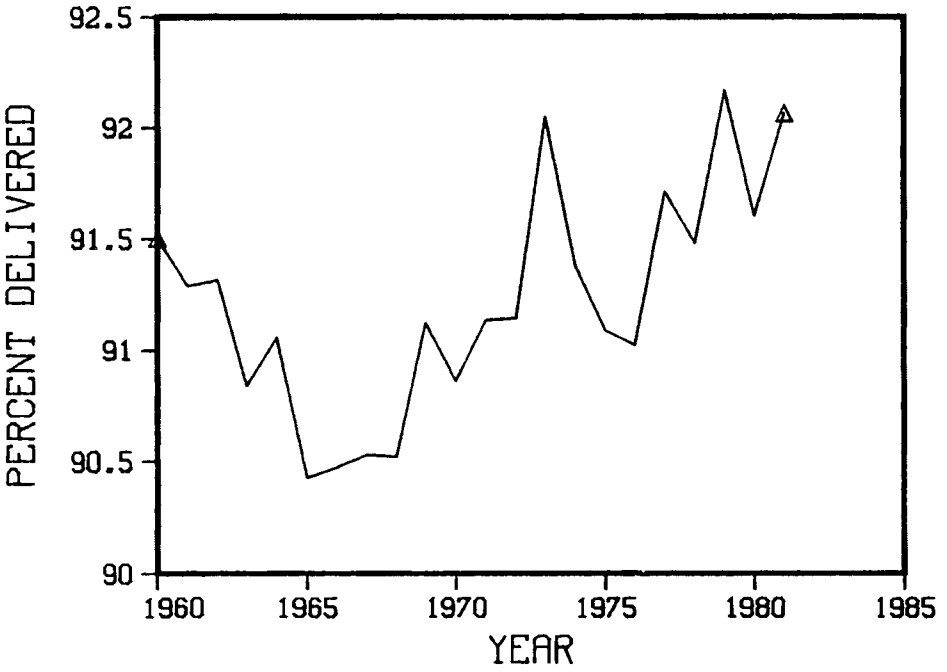


Figure U.2: Transmission Efficiency

Approach: Transmission efficiency was computed as the ratio of electricity sold to that produced. In 1981 92.1 percent of the electricity generated reached users. Between 1960 and 1981 the lowest transmission efficiency occurred in 1965 (90.4 percent) and the highest efficiency occurred in 1979 (92.2 percent). Over the 1960-1981 period transmission efficiency increased by about 0.7 percent.

Key findings

- Since 1965, the transmission efficiency has increased almost 2 percent.
- The rise in real electricity prices since the 1973-74 embargo has not had any obvious impact on transmission efficiency.
- Transmission efficiencies appear to be sensitive to general business conditions; declines in efficiencies were observed in 1970, 1975, and 1980, all recession years.

Source: 1981 Annual Report to Congress, DOE/EIA. Total sales from T. 67 (p.155); total generation from T. 66, (p. 153).

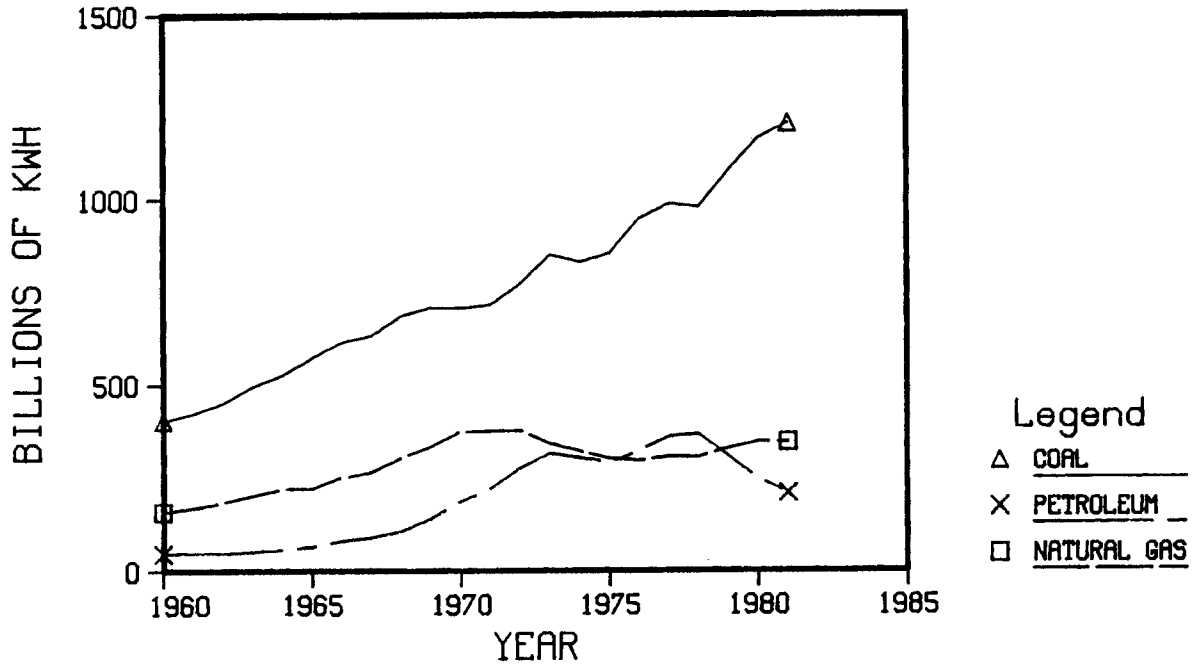


Figure U.3: Amount of Fossil Generation by Fuel

Approach: Figure U.5 shows the quantity of electricity generated from each fossil fuel. The growth in the use of all fossil fuels for generation has slowed since 1973, but the growth patterns of the individual fuels differed markedly. The offsetting patterns of growth seem to reflect substitution between the fossil fuels.

Key Findings

- The amount of electricity generated from the use of oil dropped by 44 percent between 1978 and 1981.
- The growth pattern in the use of fossil fuels taken together has been smooth because there has been substitution among of the component fuels.

Source: 1981 Annual Report to Congress, DOE/EIA, Table 65 (p. 151).

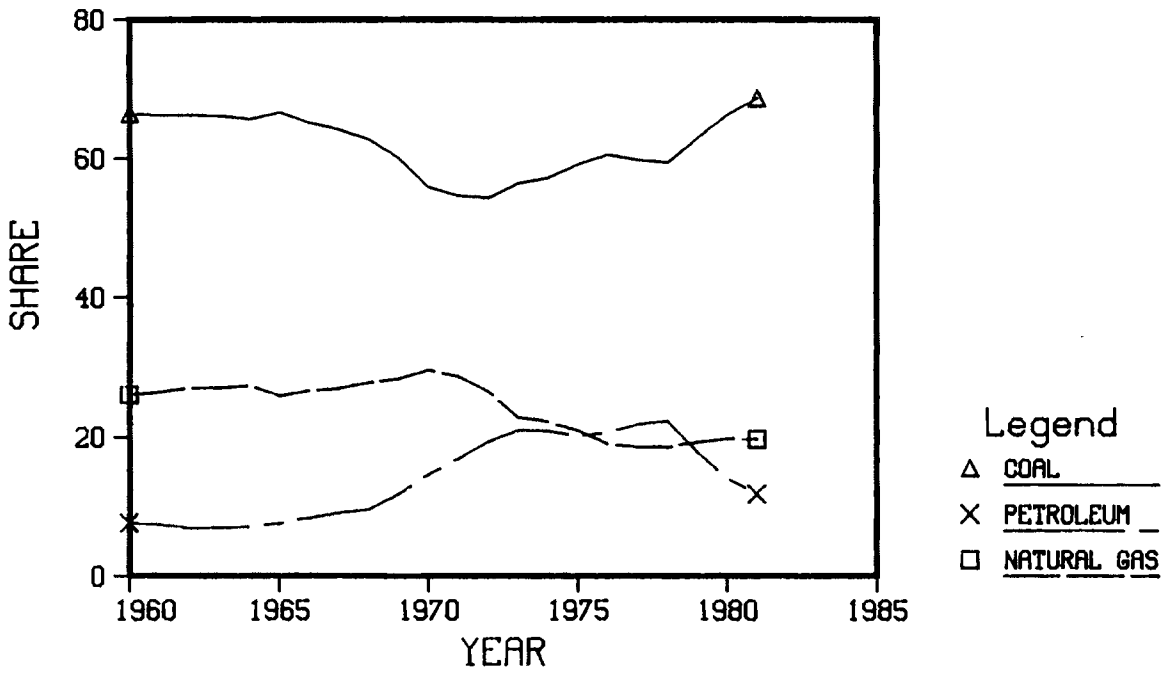


Figure U.4 Fossil Generation Share Distribution

Approach: Data from EIA's 1981 Annual Report to Congress were used to compute percentages of total fossil-generated electric power supplied by each major fuel.

Key Findings:

- The share of fossil generation supplied by coal in 1981 (68.5 percent) was higher than in any other year over the past two decades.
- The share of fossil generation supplied by oil dropped by nearly 50 percent between 1978 and 1981; substitution was primarily toward the increased use of coal.
- The share of fossil generation supplied by gas peaked in 1970 at 29.5 percent. Since 1976 the share has remained fairly stable in the range of 18 to 20 percent.

Source: 1981 Annual Report to Congress, DOE/EIA, Table 65 (p. 151).

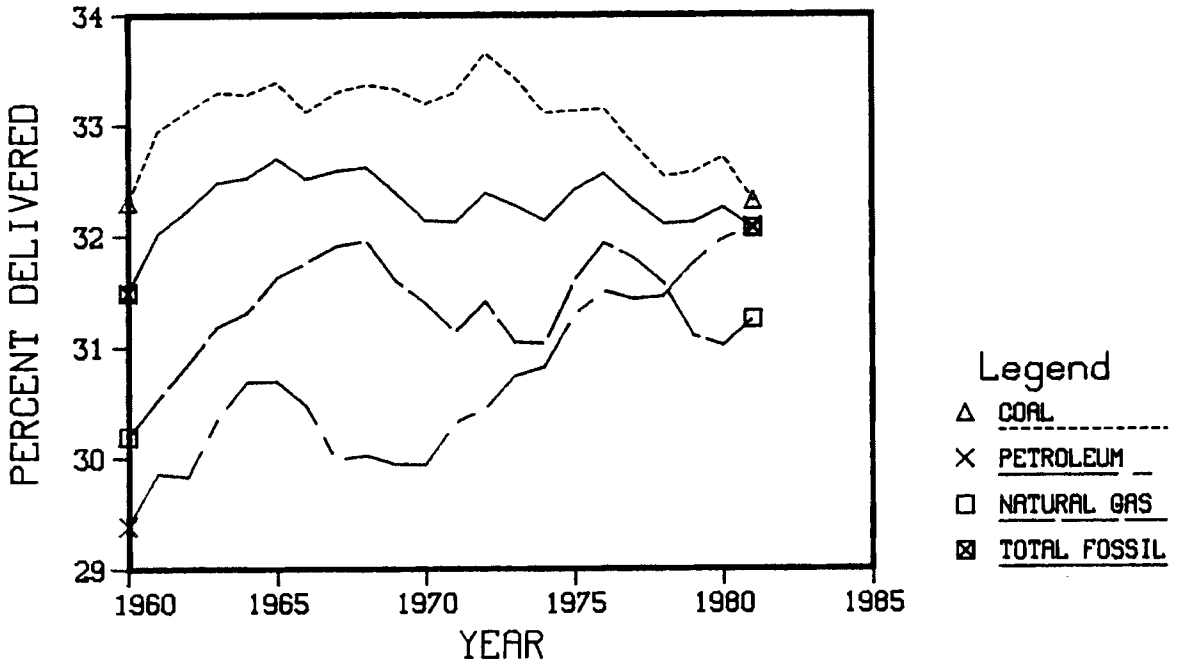


Figure U.5: Efficiency of Electricity Generation From Fossil Fuels

Approach: Figure U.3 shows the percentages of electricity generated to input energy (both expressed in Btu) by various fossil fuels. Note that the percentage of coal-generated electricity delivered has been decreasing since 1973, while the percentage of petroleum-derived electricity has been increasing, and that of natural gas has been variable. The overall efficiency of fossil generation has had no discernible trend since 1970. Thus the decrease in the average utilization efficiency for coal from 1973 at 33.4 percent to 1980 at 32.7 percent was offset by a rise in the utilization efficiency of petroleum from 30.7 percent in 1973 to 32.0 percent in 1980 leaving the overall efficiency unchanged at 32.3 percent in both 1973 and 1980.

The decrease in the efficiency of coal utilization started after the passage of the Clean Air Act, and may be correlated with the use of low sulfur coal and scrubbers.

Key Findings:

- Average efficiency of utilization of coal has decreased about 3.3 percent since 1973.
- Average efficiency of utilization of petroleum has been increasing fairly steadily since 1970.
- Average efficiency of the utilization of all fossil fuels in aggregate has remained nearly constant since 1970.

Source: 1981 Annual Report to Congress. Energy input data calculated from T. 68, p. 156, and energy conversion factors on pp. 218, 220, 221. Generation by fossil fuels from T. 55, (p. 151).

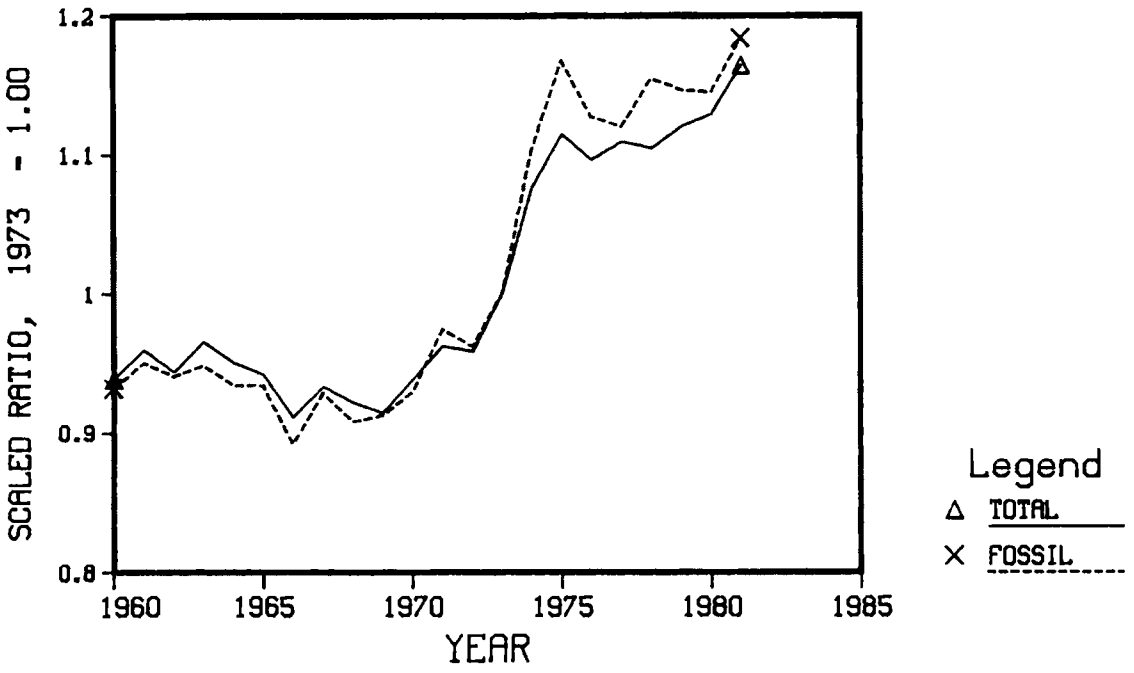


Figure U.6: The Ratio of Capacity to Production

Approach: Capacity/Generation ratios were computed for electricity generated from all sources and from fossil fuels only. Maximum generation potentials were computed by multiplying end-of-year capacities (in Kw) by 8760 (number of hours in a year). These values were then divided by actual production in Kwh, and normalized to equal 1.0 in 1973. The inverse of these ratios provide a rough measure of capacity utilization in the electric utility industry, compared to 1973.

Based on the assumption that an increase in the capacity/production ratio permits the use of the most efficient plants in the system, an attempt was made to find a correlation. The attempt to find the expected correlation included a number of formulations, but no correlation was found between changes in the efficiency of fossil fuel utilization (see Figure U.5) and either measure of capacity utilization.

Key Findings:

- The growth of demand for electricity has been below that expected by the utility industry, and has lead to record average capacity to production ratios.
- On an aggregate level, this extra capacity has not been correlated with any improvement in generation efficiency.

Source: 1981 Annual to Congress, DOE/EIA. Production data from T. 65, (p.151). Capacity information from T. 70, p. 159.

APPENDIX A

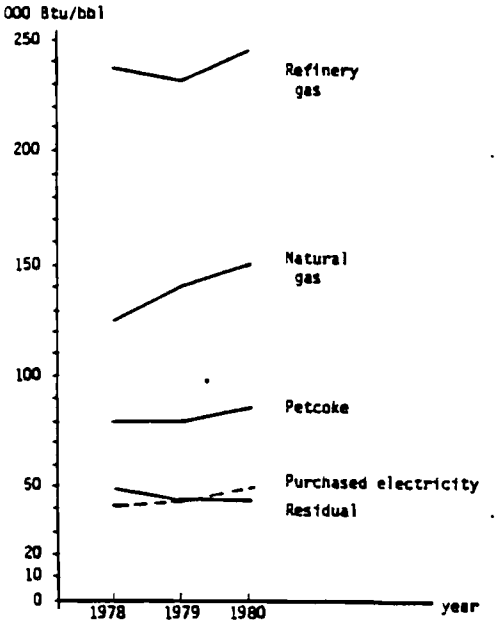
INDUSTRY CASE STUDY SUMMARIES

Petroleum Refining: Case Study Summary

In nearly all petroleum processing, energy is required in the form of direct heat to raise the temperature of the oil being processed. Additional energy is required for mechanical drives to force the oil through the process. The basic distillation operation, which separates the crude into lighter or heavier fractions, is the least energy intensive of the refining processes. Crude distillation uses less than 15% of the total energy required by a modern refinery. As more gasoline, jet fuel, and distillate are produced in addition to or in place of heavy residual oils, more cracking, reforming, alkylation, and other processing is required.

Sixty-two refining companies, of 65 surveyed by the American Petroleum Institute, reported adoption of significant energy conservation measures during 1979, and 55 firms (of 61 surveyed) reported such adoption in 1980. The most common measures were process heater and boiler efficiency improvements, steam system improvements, heat exchange applications, insulation, and improved waste heat recovery. Other measures reported included:

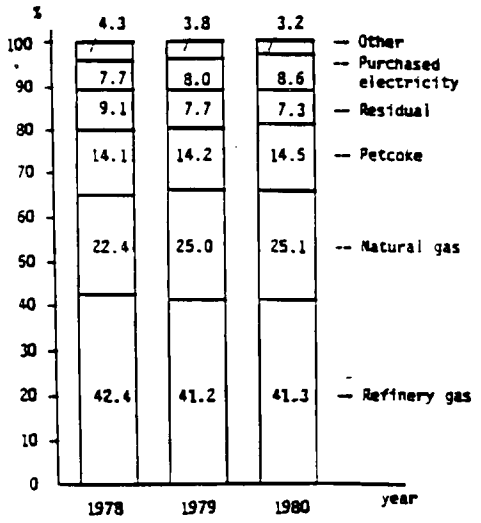
- air coolers
- fractionation efficiency improvements
- pump and compressor efficiency improvements
- vacuum system improvements
- pressure energy recovery from process streams
- instrumentation and computer control
- process heat integration
- miscellaneous process developments and modified operating techniques
- refinery loss control
- housekeeping measures



ENERGY CONSUMPTION IN PETROLEUM REFINING, BY SOURCE (per barrel crude)

Notes: Based on API data for these years. 1978 data are the annualized data from the July-December 1978 report.

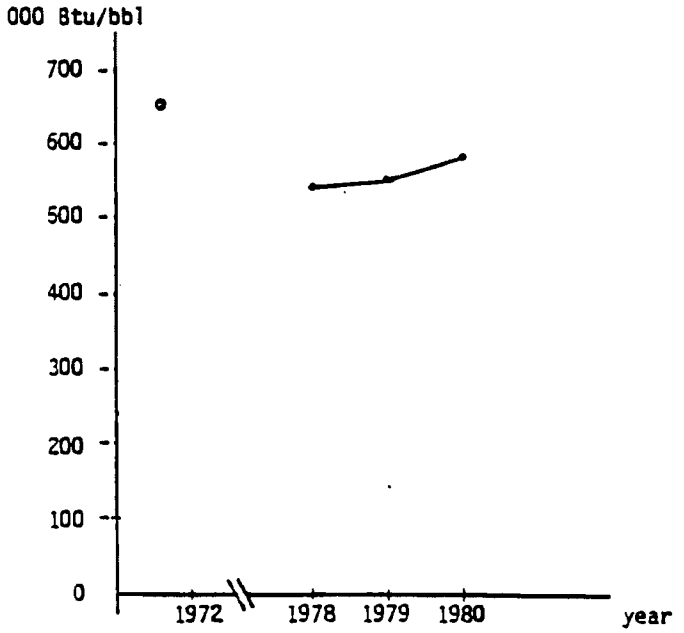
Purchased electricity, petcoke, and natural gas have increased as percentages of total energy consumed. Shares of refinery gas and residual oil have fallen. Some of these changes are substantial for a three-year period.



PERCENT ENERGY CONSUMPTION BY SOURCE SELECTED YEARS AND SOURCES

Notes: Based on API data for these years. 1978 data are the annualized data from the July-December 1978 report.

Few consistent data points are available for energy consumption in petroleum refining. Below, API data for four years are presented. This figure shows that, while energy consumption per barrel of crude dropped from 1972 to 1978, the trend since 1978 has been slightly upward.



TOTAL ENERGY CONSUMPTION IN PETROLEUM REFINING, SELECTED YEARS (per barrel crude)

Notes: Based on American Petroleum Institute data, received for these years only. These data unadjusted for changes in product mix and other processing changes. 1978 data are based on reporting of 52 companies (91% of U.S.) capacity); 1979 data on reporting of 65 companies (93%); 1980 data on reporting of 61 companies (93%).

Cement: Case Study Summary

In cement manufacture, most of the energy is consumed in raw material grinding, kiln operation, and clinker grinding. Kiln operation takes about 80% of total energy, with 10% required for each of the grinding processes. Most of the fuel is used to supply heat to the kiln, while most electricity is used in grinding the incoming ore and finished clinker.

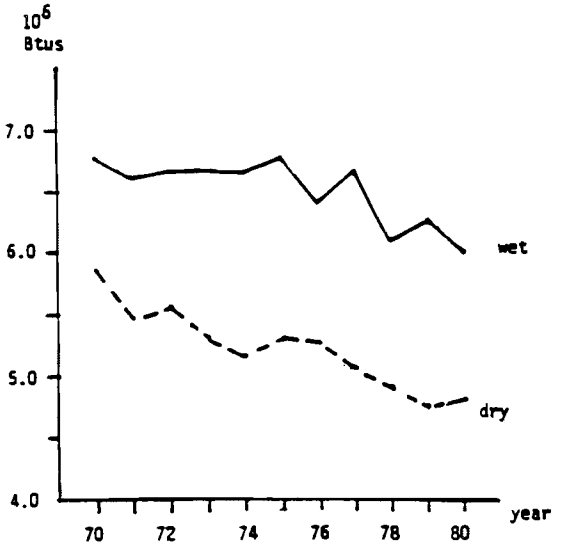
DOE's cement industry energy consumption target was a 15.7% reduction in 1980, over 1972. According to the U.S. Bureau of Mines, energy consumption per ton was reduced by 9.8% in 1978 and by 8.2% in 1979 (1972 base year). The industry consumed about 490×10^{12} Btu in 1979.

In general, energy conservation must involve modernization of plant. Much of the cement production capacity is quite old. As of 1974, 48% of operating kilns were 20 years old or older, although much expansion and modernization has occurred since then. Greatest energy reduction potential is offered by the substitution of dry for wet process kilns and the use of preheaters. In 1979, average fuel consumption per ton of clinker produced was 4.76 million Btu for the dry process, and 6.27 million Btu for the wet process. Dry plants are more commonly built now, but as of 1980 there were still more wet plants operating than dry: 88 wet and 64 dry. Six plants produced cement by both wet and dry processes.

Preheating involves reusing exit gases from kilns to preheat the ground ores and evaporate moisture from them. The U.S. Bureau of Mines in 1977 estimated that kilns using suspension preheaters burned an average of 4.77 million Btu/ton of clinker production, those with traveling grate preheaters burned 5.86 million Btu/ton, and those kilns without preheaters used 6.95 million Btu/ton.

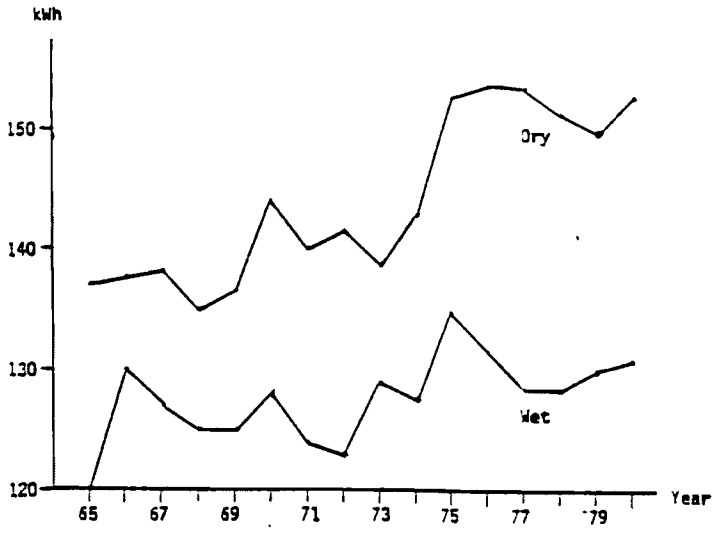
Other energy conservation measures in the cement industry include improvements to kilns (chain section design inside the kiln, improved sealing and insulation), use of additives in the cement, and improving the efficiency of the grinding processes.

Energy conservation is reflected in the trends in per ton fuel consumption during the 1970s. Both the wet and dry process have become less energy intensive. Because of the energy intensity of cement manufacture, energy prices were of concern in the industry well before 1973.



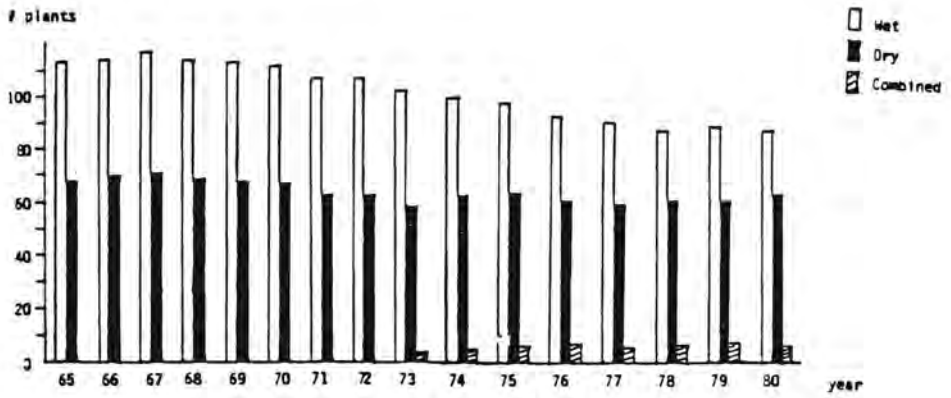
APPROXIMATE TOTAL FUEL CONSUMPTION PER TON OF CLINKER PRODUCTION, BY TYPE PROCESS

In contrast to fuel consumption, per unit electric consumption has been increasing. However, increased electrical use is very small relative to the

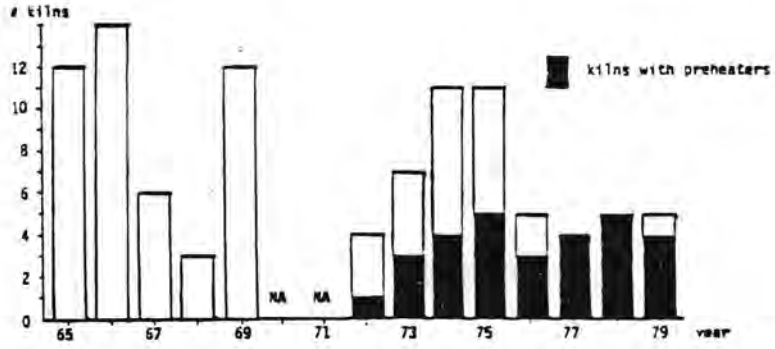


ELECTRIC ENERGY CONSUMED PER TON OF FINISHED CEMENT, BY PROCESS

Slowly but steadily the cement industry is investing in major capital improvements: additional dry process plants, and use of suspension preheaters.



NUMBER OF CEMENT PLANTS, BY TYPE PROCESS



NUMBER OF KILNS INSTALLED AND NUMBER OF KILNS INSTALLED INCLUDING SUSPENSION PREHEATERS

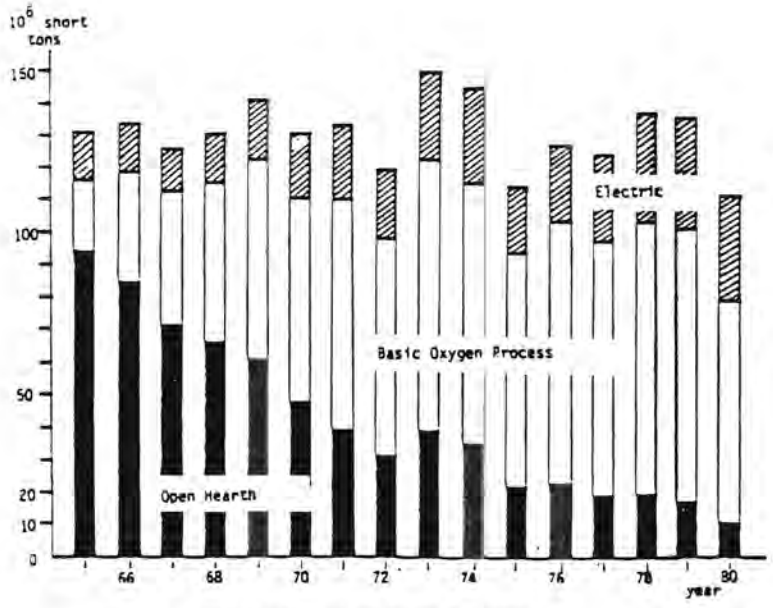
Note: Data for preheaters unavailable before 1972; no data on number of kilns installed for 1970, 1971.

Iron and Steel: Case Study Summary

The iron and steel industry consumes more fuel and electric energy in its production processes than any other U.S. industry. In 1980, it consumed approximately 2.67 quads, equal to 8.8% of all industrial energy consumption and 70% of the energy consumed by the primary metals industry (SIC 33).

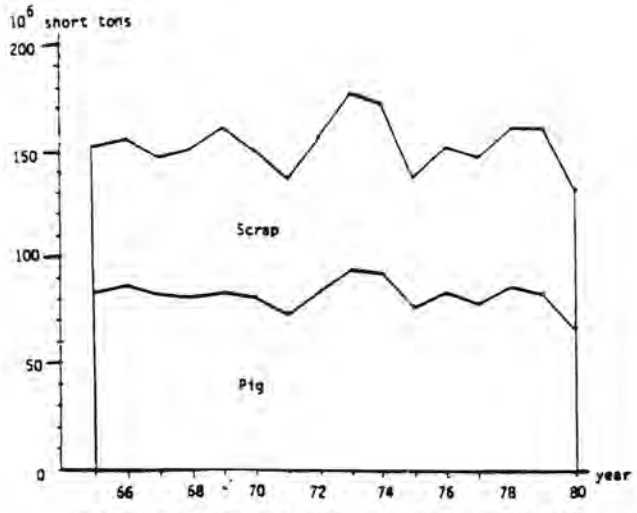
Many of the fuels used for heat and power are produced as byproducts. These fuels include (in the order of predominance) coke and coke screenings, coke oven gas, blast furnace gas, and other byproduct fuels. "Other" includes tar and pitch obtained in the coking process. Purchased fuels include bituminous, anthracite, and lignite coal; coke and breeze; fuel oil (both distillate and residual); natural gas; and LPG. About one-third of all fuels are consumed in blast furnaces, and a little over one-third in heating and annealing furnaces. Under 5% of industry fuel consumption is in the steel melting furnaces, and the remainder is used in other processes. Electricity consumption depends largely on the type of steel furnace (electric versus basic oxygen or open hearth) being used.

Most large energy conservation opportunities in the iron and steel industry involve capital-intensive modernization of facilities. In 1979, nearly 46% of all coke ovens and 100% of the open hearth furnaces were over 20 years old. The two major areas in which energy conservation opportunities exist are increased used of (1) more energy efficient furnaces (both oxygen and electric), and (2) continuous casting. The basic oxygen process is about 55% more efficient than the open hearth, and produces higher quality steel with less pollution. The electric furnace is the most energy efficient furnace of the three types. It operates on scrap steel. The proportion of steel produced by the old open hearth furnaces has steadily declined from the 1960s; since 1957, all new furnaces have been oxygen or electric.



RAW STEEL PRODUCTION BY TYPE OF FURNACE
Note: Bessemer included with open hearth

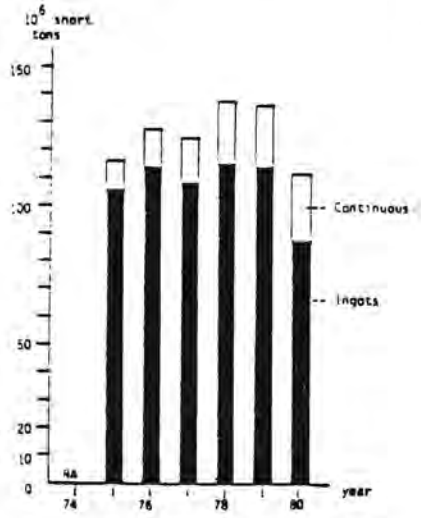
Scrap consumption relative to that of pig iron has slowly been increasing, due to increased use of electric furnaces. Use of scrap improves energy efficiency since it eliminates the energy-intensive production of the pig in blast furnaces. In 1965 consumption of scrap was 83% that of pig; in 1980 the two were equal.



TOTAL SCRAP AND PIG IRON CONSUMED. SHORT TONS

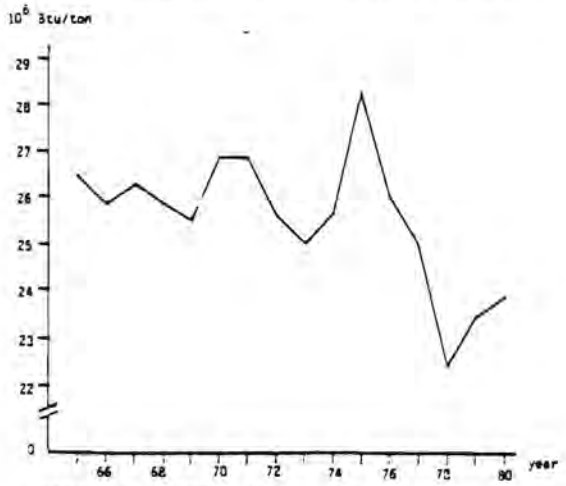
Continuous casting conserves energy through both elimination of energy intensive processes, and increased yield. Yield loss is 11-21% for the ingot method, and only 5% or less in continuous casting. One estimate is that 60-80%

less energy than with the ingot method is required, and that for each percentage increase in the rate of continuous casting to total steel produced, there is an absolute saving of 9020 Btu/ton of steel. The amount of steel continuous cast has slowly increased but still remains at around 18% of the total. Nonintegrated facilities, built relatively recently, are ahead in terms of continuous cast production (over 50% of nonintegrated production).



RAW STEEL PRODUCTION BY TYPE CAST

Total per unit energy consumption in the steel industry fluctuates substantially with percent of capacity utilized. After the 1975 peak, energy consumption per unit of production dropped rapidly, but troughed in 1978 and rose again in 1979 and 1980. Total energy use is dominated by the consumption of coal for coke. Fuel oil use per ton of production peaked in 1978, but is low compared to coal, natural gas, and other (generated) fuels used.



ENERGY CONSUMPTION PER TON OF RAW STEEL PRODUCTION

Aluminum: Case Study Summary

In 1979, the U.S. aluminum industry consumed just over one quad of energy (1.041×10^{15} Btu) to produce 54 million tons of aluminum metal (192.4 million Btu/ton). Sixty-eight percent of this energy was in the form of electricity, used almost entirely in smelting. The electrical energy for smelting was derived 41% from coal, 38% from hydropower, 14% from natural gas and oil, and 7% nuclear. By process, smelting accounted for 70%, fabricating for 19%, and bauxite and alumina production for 11% of total energy consumed.

Aluminum manufacture from scrap is much less energy intensive than processing from ore. About 6-25 million Btu are required to recover one ton of aluminum-base scrap, on the average only 5% of that needed to produce the molten metal from bauxite. The high of the range in scrap processing reflects the energy required to melt contaminated scrap, where recoveries may be only 60-70%.

Because the reduction process (smelting) accounts for more than two-thirds of the industry's energy requirements, it has been a primary focus for improvement. Since World War II energy usage in this process has been reduced nearly 33%. Recent or current conservation projects focused on the standard Hall-Heroult electrolytic reduction process include improvement of reduction lines, lowering of operating temperatures, new furnace designs, and improved insulation. Examples of alternative reduction processes being developed are the ALCOA $AlCl_3$ Electrolysis Process, the Toth Chemical Process, and the Plasma Reduction Process.

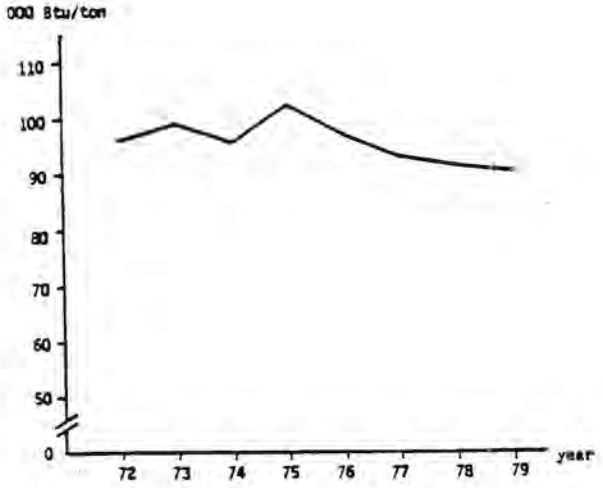
Examples of conservation projects in other areas of aluminum processes include the following:

- o Bauxite Mining and Aluminum Production:
  - optimization of ore combinations through computerization
  - cogeneration
  - improvement of digester heat exchange
  - heat recuperation
  - improved combustion control
- o Holding, Casting, and Melting:
  - heat recuperation
  - improvements in combustion and flame management
  - new furnace designs
  - preheating

- increased adoption of continuous casting

- Fabrication:
  - housekeeping measures
  - new furnace designs
  - preheating
  - heat recuperation
  - improved combustion and flame management
  - computerized controls

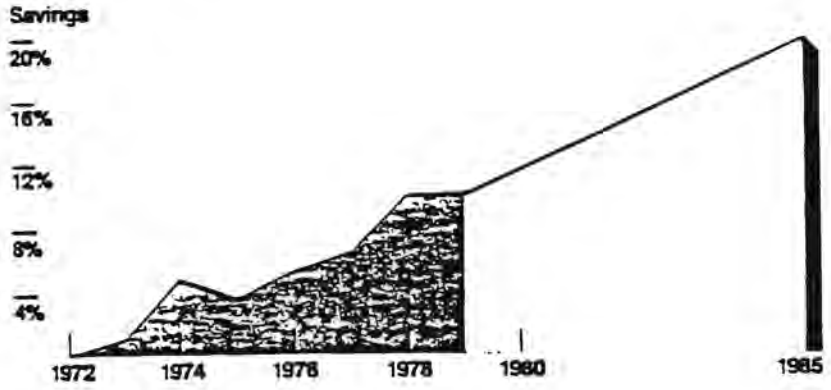
Due to conservation measures implemented in the 1970s, per unit energy consumption in aluminum processing has been decreasing since 1975. The peak in per unit energy consumption in 1975 reflects the operation of machinery at low levels of capacity, as production plunged 21% during that year.



ENERGY CONSUMPTION PER TON OF PRIMARY ALUMINUM* PRODUCED

*Includes energy consumed in bauxite and alumina production, smelting, holding, and casting.

According to the Aluminum Association, the aluminum industry exceeded its DOE goal of 10% energy efficiency improvement by 1980 (over 1972). A 20% efficiency improvement through 1985 is projected. If new facilities are built by the year 2000, using best available technology, the AA estimates potential savings at 36% (relative to 1972). However, tremendous amounts of capital investment will be needed.



ALUMINUM INDUSTRY PROGRESS UNDER THE VOLUNTARY INDUSTRIAL ENERGY CONSERVATION PROGRAM

Source: The Aluminum Association, Energy Conservation in the Aluminum Industry, September 1980

Smelting energy efficiency has been steadily improving, and consumption currently is an average of 8 kW/lb of metal produced. This average is an improvement of 8.2% over 1975. The newest plants use about 6 kW/lb; the new ALCOA process uses under 5 kW/lb.

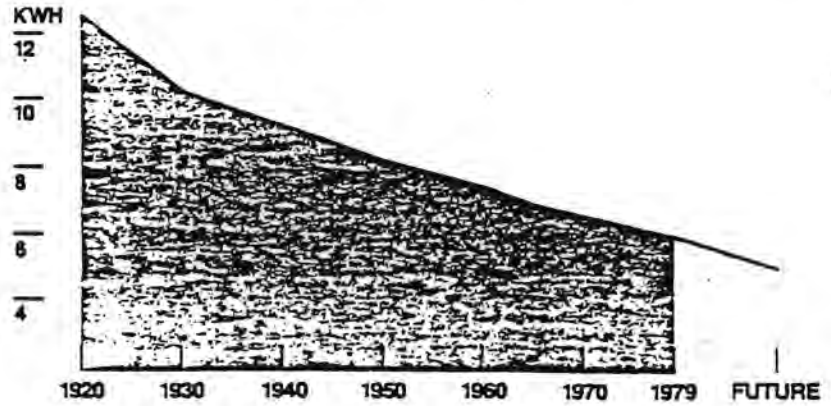


Fig. 2.5-9 ALUMINUM INDUSTRY CONSERVATION PROGRESS IN SMELTING, 1920-1979

Source: The Aluminum Association, Energy and the Aluminum Industry, April 1980.

APPENDIX B

DATA AND NOTES FOR FIGURES

DATA USED FOR FIGURE A.1

YEAR	TOTEN	GNP72	ENGNP	BUSENG	GNPBUS	ENGNPBUS	YEAR
*****	******	*******	*******	******	********	********	*****
1960	44080	737.2	59.793	31285	707.88	60.158	1960
1961	44723	756.6	59.11	31570	726.96	59.72	1961
1962	46798	800.3	58.475	32963	769.31	59.275	1962
1963	48605	832.5	58.385	34341	800.36	59.222	1963
1964	50776	876.4	57.937	35959	842.58	58.77	1964
1965	52989	929.3	57.02	37486	893.87	58.038	1965
1966	55922	984.8	56.785	39542	947.46	57.89	1966
1967	57892	1011.4	57.239	40828	972.7	58.212	1967
1968	61323	1058.1	57.956	43083	1017.3	58.842	1968
1969	64529	1087.1	59.359	44950	1044.1	59.842	1969
1970	66828	1085.6	61.559	46162	1040.7	61.274	1970
1971	68300	1122.4	60.851	46639	1075.8	60.499	1971
1972	71628	1185.9	60.4	48931	1136.7	60.06	1972
1973	74609	1254.3	59.483	51474	1203.3	59.494	1973
1974	72759	1246.3	58.38	50100	1197.7	59.102	1974
1975	70707	1231.6	57.411	47654	1181.2	57.314	1975
1976	74510	1298.2	57.395	50466	1245.6	57.463	1976
1977	76332	1369.7	55.729	51659	1315.1	56.084	1977
1978	78175	1438.6	54.341	52983	1382.4	55.016	1978
1979	78910	1479.4	53.339	54100	1423.8	54.616	1979
1980	75913	1474	51.501	51752	1420.5	53.338	1980
1981	73895	1502.6	49.178	50044	1448.8	51.183	1981

KEY:

(1) TOTEN: Total energy consumption, trillion Btu.
(2) GNP: Gross National Product, billions of 1972 dollars.
(3) ENGNP: Energy/GNP ratio, (1)/(2).
(4) BUSENG: Consumption of Energy by the Business Sector, trillion Btu.
(5) GNPBUS: GNP less personal consumption expenditures (PCE) for energy 1972 dollars).
(6) ENGNPADJ: Adjusted Energy/GNP Ratio.

SOURCES:

TOTEN: EIA Annual Report to Congress, 1982, and Monthly Energy Review, August 1982, DOE/EIA.

GNP: National Income and Product Accounts, Department of Commerce. Survey of Current Business, July 1982.

BUSENG: Derived as the difference between total national energy consumption (TOTEN) and household energy use (TOTHOUS). See notes for Figure A.3 for derivation of TOTHOUS.

GNPBUS: Difference between total GNP and personal consumption expenditures for energy. Personal consumption expenditures for energy through 1981 taken from Table 2.5, Survey of Current Business, July 1982.

ENGNPADJ: Composition-adjusted Energy/GNP ratio, base year is 1973. Computed as 0.959 *(BUSENG/GNPBUS) + 0.041*(TOTEN-BUSENG)/(GNP-GNPBUS); where 0.959 and 0.041 are the 1973 relative shares of GNP less PCE for energy, and PCE for energy respectively (expressed in 1972 dollars)

DATA USED FOR FIGURE A.2

YEAR	TOTEN	POP	TEPC	TOTHOUS	REPC	BUSENG	BEPC	YEAR
1960	44080	179.98	244.92	12794	71.088	31285	173.83	1960
1961	44723	182.29	245.34	13153	72.155	31570	173.18	1961
1962	46798	185.77	251.91	13834	74.471	32963	177.44	1962
1963	48605	188.48	257.88	14265	75.681	34341	182.2	1963
1964	50776	191.14	265.64	14817	77.519	35959	188.13	1964
1965	52989	193.53	273.81	15504	80.111	37486	193.7	1965
1966	55922	195.58	285.94	16380	83.753	39542	202.18	1966
1967	57892	197.46	293.19	17064	86.419	40828	206.77	1967
1968	61323	199.4	307.54	18240	91.475	43083	216.07	1968
1969	64529	201.38	320.43	19579	97.223	44950	223.2	1969
1970	66828	203.98	327.61	20666	101.31	46162	226.3	1970
1971	68300	206.83	330.23	21661	104.73	46639	225.5	1971
1972	71628	209.28	342.25	22697	108.45	48931	233.8	1972
1973	74609	211.36	353	23135	109.46	51474	243.54	1973
1974	72759	213.34	341.04	22659	106.21	50100	234.83	1974
1975	70707	215.46	328.16	23053	106.99	47654	221.17	1975
1976	74510	217.56	342.48	24044	110.52	50466	231.96	1976
1977	76332	219.76	347.34	24673	112.27	51659	235.07	1977
1978	78175	222.09	351.99	25192	113.43	52983	238.56	1978
1979	78910	224.57	351.39	24810	110.48	54100	240.91	1979
1980	75913	227.16	334.19	24161	106.36	51752	227.82	1980
1981	73895	229.3	322.26	23851	104.01	50044	218.24	1981

KEY:

(1) TOTEN: Total energy consumption, trillion Btu.
(2) POP: Population in millions
(3) TEPC: Total energy per capita, million Btu.
(4) TOTHOUS: Total household energy consumption including transportation use, trillion Btu.
(5) REPC: Household energy consumption per capita, (4)/(2)
(6) BUSENG: Business portion of total energy consumption, trillion Btu, (1)-(4).
(7) BEPC: Business energy consumption per capita, million Btu, (6)/(2).

SOURCES:

TOTEN: See source for Figure A.1

TOTHOUS: Residential energy use (TOTRES in Figure A.3) from 1980 State Energy Data Report, July 1982, and Monthly Energy Review, DOE/EIA, August 1982. See Note.
Transportation use (TRANS in Figure A.3) based on worksheets provided by Bureau of Economic Analysis, used in constructing PCE estimates for "Gasoline and Oil."

POP: Figures for 1960-1969 from 1980 Statistical Abstract of the U.S. , updated figures for 1970-1981, based on 1980 Census, Current Population Reports, Census Bulletin Series, P-25, No. 906, December 1981.

Note

To obtain residential energy use for 1981, the residential/commercial figures as shown in the Monthly Energy Review (MER) (August 1982) had to be split. The major fuels were split according to the following procedures:

Electricity - Separate data for residential and commercial sales in Kwh as shown in the Monthly Energy Review's section on Electricity were used to split the residential/commercial consumption figures for electricity purchases (in Btu) and electricity losses (in Btu).

Gas - Separate figures for residential and commercial gas sales as shown in Table 46 of the EIA's 1982 Annual Report to Congress were used to allocate the MER total. The values for 1981 were scaled proportionately so that the sum would agree with the 1981 control total from the August 1982 MER for residential/commercial.

Coal, Petroleum Products - The relative proportions between the residential and commercial sector were maintained at the 1980 values as implied in the State Energy Data Report.

DATA USED FOR FIGURE A.3

YEAR	TOTHOUS	HH	GEHH	TOTRES	TOTRESHH	TRANS	TRANSHH	YEAR
1960	12794	52.8	242.32	8309.1	157.37	4485.2	84.947	1960
1961	13153	53.46	246.04	8618.5	161.21	4534.8	84.826	1961
1962	13834	54.65	253.15	9136.4	167.18	4698.1	85.967	1962
1963	14265	55.19	258.46	9402.9	170.37	4861.7	88.09	1963
1964	14817	56	264.59	9712.2	173.43	5104.9	91.159	1964
1965	15504	57.25	270.81	10161	177.49	5342.3	93.316	1965
1966	16380	58.09	281.98	10703	184.25	5677	97.727	1966
1967	17064	58.85	289.96	11188	190.11	5876.1	99.849	1967
1968	18240	60.44	301.79	11903	196.95	6336.7	104.84	1968
1969	19579	61.81	316.77	12768	206.57	6811.1	110.19	1969
1970	20666	62.96	328.24	13368	212.32	7298.3	115.92	1970
1971	21661	64.6	335.31	13918	215.45	7742.7	119.86	1971
1972	22697	67.05	338.51	14530	216.7	8167.1	121.81	1972
1973	23135	68.77	336.41	14633	212.78	8502.3	123.63	1973
1974	22659	70.54	321.23	14370	203.71	8289.9	117.52	1974
1975	23053	71.89	320.68	14444	200.92	8609.5	119.76	1975
1976	24044	73.87	325.49	14972	202.68	9072.1	122.81	1976
1977	24673	75.29	327.7	15213	202.05	9460.1	125.65	1977
1978	25192	77.42	325.39	15524	200.51	9668.2	124.88	1978
1979	24810	78.9	314.45	15413	195.35	9397.6	119.11	1979
1980	24161	80.78	299.1	15272	189.06	8888.9	110.04	1980
1981	23851	82.34	289.66	14955	181.62	8896	108.04	1981

KEY:

(1) TOTHOUS: Total residential energy consumption including transportation use, trillion Btu.
(2) HH: Number of households, in millions.
(3) GEHH: Total residential energy consumption per household, million Btu
(4) TOTRES: Residential energy consumpton excluding transportaion use.
(5) TOTRESHH: TOTRES per household, million Btu. (4)/(2)
(6) TRANS: Energy used by household for transportation, trillion Btu.
(7) TRANSHH: Transportation use per household, million Btu. (6)/(2)

SOURCES:

TOTHOUS: See notes for Figure A.2
HH: Data for 1960-1969 taken from Statistical Abstract of the U.S. Number of Households for 1971-1979 were estimated using the household size estimate found in Table 62, 1980 Statistical Abstract of the U.S., and 1980 Census based population figures (see source for POP for Figure A.2).
TOTRES: See notes for Figure A.2.
TRANS: Transportation use based on worksheets provided by Bureau of Economic Analysis, U.S. Department of Commerce, used in constructing Personal Consumption Expenditures estimates for "Gasoline and oil" (Table 2.5, Survey of Current Business).

DATA USED FOR FIGURE R.1

YEAR	BTUINDEX	VALINDEX	YEAR	BTUINDEX	VALINDEX
*****	********	********	*****	********	********
1960	.7262	.66851	1971	.99422	.98782
1961	.74393	.68858	1972	1	1
1962	.77146	.71647	1973	.98189	.99567
1963	.7862	.73678	1974	.94003	.9573
1964	.80031	.75519	1975	.92715	.94431
1965	.81904	.77792	1976	.93528	.95192
1966	.85024	.81138	1977	.93239	.96052
1967	.87728	.84208	1978	.92527	.95677
1968	.90882	.88186	1979	.90144	.93379
1969	.95324	.93187	1980	.87243	.91541
1970	.97976	.96782	1981	.83812	.88477

KEY:

(1) BTUINDEX: Index based on actual consumption in Btu per household.
(2) VALINDEX: Laspeyres or value-weighted index of aggregate energy consumption per household.

SOURCES:

For sources of residential consumption and households, see notes for Figure A.3. For the construction of VALINDEX, the following 1972 prices (per million Btu) were used as weights: (1) coal, .37; (2) natural gas, 1.18; (3) distillate fuel oil, 1.42; (4) kerosene, 1.58; (5) LPG, 1.24; (6) Electricity (including losses), 1.95.

DATA USED FOR FIGURE R.2

YEAR	GASPC	GASPCWHR
*****	********	*********
1970	130.72	130.82
1971	124.82	129.45
1972	130.36	131.51
1973	119.09	123.94
1974	122.67	122.41
1975	115.49	120.74
1976	122.12	117.38
1977	120.74	114.35
1978	119.22	114.18
1979	109.21	109.21
1980	105.96	109.49
1981	106.48	107.64

KEY:

(1) GASPC: Gas consumption per consumer (million Btu) as reported by American Gas Association. Year shown is beginning year of July 1 - June 30 period.

(2) GASPCWHR: Gas consumption adjusted for weather variation measured by population-weighted heating degree days.

SOURCES:

Total residential gas consumption and number of customers taken from various issues of Quarterly Report on Gas Utility Industry, American Gas Association, Arlington, Va.

Heating degree days in constructing GASPCWHR from State Regional and National Monthly and Seasonal Heating Degree Days Weighted by Population, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data and Information Service, September 1981.

Note:
Complete data for the last annual period (July 1, 1981--June 30, 1982) were available from AGA for only first three quarters; i.e. through March 31, 1982. Average consumption for second quarter 1982 was assumed to be the same as the corresponding period in 1981, for both series presented. Consumption in the second quarter accounts for less than 20 percent of total annual consumption, and so this treatment should not significantly bias the comparison of the last two annual average consumption figures.

DATA USED FOR FIGURE R.3

YEAR	FOILPC	FOILWHR
*****	******	********
1969	1416	1376.5
1970	1410	1391.6
1971	1339	1371.2
1972	1463	1461
1973	1294	1347
1974	1305	1302.5
1975	1249	1301.5
1976	1371	1300.3
1977	1297	1230.4
1978	1198	1144.5
1979	1081	1081
1980	941	946.09
1981	942	896.22

KEY:

(1) FOILPC: Fuel oil consumption per consumer (gallons) as reported by Fuel Oil and Oil Heat magazine. Year shown is beginning year of September 1 - May 1 heating season.

(2) FOILWHR: Fuel oil consumption adjusted for weather variation measured by population-weighted heating degree days.

SOURCES: Commercial and Residential Fuel Oil Consumption Trends: 1970-1980, Vol. II, Centaur Associates, Inc., March 1982, p. II-44. Prepared for DOE Office of Policy, Planning, and Analysis. Original data taken from Fuel Oil and Oil Heat magazine, (various issues).

DATA USED FOR FIGURE R.4

YEAR	ENERGY	PCECURR	SHARE	ENERGY72	PCE72	SHARE72	YEAR
*****	********	********	*******	********	******	*******	*****
1960	24.129	324.9	7.4266	29.318	452	6.4863	1960
1961	24.542	335	7.326	29.642	461.4	6.4244	1961
1962	25.746	355.22	7.2479	30.987	482	6.4288	1962
1963	26.787	374.58	7.1512	32.143	500.5	6.4222	1963
1964	28.051	400.5	7.004	33.823	528	6.4059	1964
1965	29.984	430.38	6.9669	35.432	557.5	6.3555	1965
1966	32.118	465.12	6.9053	37.341	585.7	6.3754	1966
1967	34.021	490.26	6.9394	38.699	602.7	6.4209	1967
1968	36.394	536.88	6.7788	40.751	634.4	6.4235	1968
1969	39.448	581.78	6.7806	42.972	657.1	6.5396	1969
1970	42.258	621.72	6.7969	44.927	672.1	6.6846	1970
1971	45.424	672.24	6.7571	46.62	696.8	6.6906	1971
1972	49.23	737.05	6.6793	49.23	737.1	6.6789	1972
1973	55.333	811.96	6.8147	51.016	768.5	6.6384	1973
1974	68.356	888.11	7.6968	48.603	763.6	6.365	1974
1975	77.788	976.45	7.9664	50.411	780.2	6.4613	1975
1976	86.71	1084.3	7.9971	52.625	823.7	6.3889	1976
1977	97.244	1204.4	8.0741	54.568	864.3	6.3135	1977
1978	106.04	1346.5	7.8752	56.183	903.2	6.2204	1978
1979	130.52	1507.2	8.6596	55.587	927.6	5.9926	1979
1980	162.52	1667.2	9.7484	53.474	930.5	5.7468	1980
1981	183.3	1843.2	9.9447	53.788	947.6	5.6762	1981

KEY:

(1) ENERGY: Personal consumption expenditures on energy, billions of current dollars.
(2) PCECURR: Total personal consumption expenditures in billions of current dollars.
(3) SHARE: Percentage share of consumption on energy, (1)/(2).
(4) ENERGY72: Personal consumption expenditure on energy, billions of constant 1972 dollars.
(5) PCE72: Total personal consumption expenditures billions of constant 1972 dollars.
(6) SHARE72: Percentage share of consumption on energy, constant 1972 dollars, (4)/(5).

SOURCES:

All expenditure data obtained from National Income and Product Accounts, published by the Department of Commerce in various issues of the Survey of Current Business.

DATA USED IN FIGURE R.5

YEAR	FOIL	NGAS	ELEC	YEAR	FOIL	NGAS	ELEC
1960	1.0782	1.1285	1.1857	1971	1.0285	.98145	.98346
1961	1.1106	1.132	1.1773	1972	1	1	1
1962	1.0995	1.1184	1.1643	1973	1.0859	.9845	.9889
1963	1.1086	1.1061	1.1504	1974	1.5497	.99817	1.0524
1964	1.07	1.0951	1.1298	1975	1.5373	1.0963	1.0917
1965	1.0735	1.0798	1.1051	1976	1.558	1.209	1.0977
1966	1.0713	1.0562	1.0744	1977	1.659	1.3508	1.0991
1967	1.0746	1.0245	1.0538	1978	1.6328	1.3795	1.097
1968	1.0643	.99307	1.0205	1979	2.0603	1.4388	1.0621
1969	1.0316	.95921	.98664	1980	2.5241	1.5106	1.082
1970	1.0099	.95582	.96231	1981	2.7978	1.5605	1.1277

KEY:

(1) FOIL: Index of price of fuel oil relative to the Consumer Price Index.
(2) NGAS: Index of price of natural gas relative to the Consumer Price Index.
(3) ELEC: Index of price of electricity relative to the Consumer Price Index.

SOURCES:

All the relative prices are constructed as ratios of the corresponding Consumer Price Indexes regularly published by the U.S. Department of Labor, Bureau of Labor Statistics. Prices through 1978 obtained in Handbook of Labor Statistics, Table 122. More recent data based on the CPI Detailed Report, issued monthly by the Bureau of Labor Statistics.

DATA USED FOR FIGURE R.6

YEAR	TOTBTU	HH	BTUPHH	EFFINDEX	BTUPHHC	YEAR
*****	******	*******	*******	********	*******	*****
1973	14633	68.77	212.78	1	212.78	1973
1974	14370	70.54	203.71	1	203.71	1974
1975	14444	71.89	200.92	1	200.92	1975
1976	14972	73.87	202.68	.99908	202.87	1976
1977	15213	75.29	202.06	.99816	202.43	1977
1978	15524	77.42	200.52	.99724	201.07	1978
1979	15413	78.9	195.35	.99373	196.58	1979
1980	15272	80.776	189.07	.98971	191.03	1980

KEY:

(1) TOTBTU: Total residential energy consumption, trillion Btu.
(2) HH: Number of households, in millions.
(3) BTUPHH: TOTBTU per household, million Btu, (1)/(2).
(4) EFFINDEX: Index of appliance efficiency.
(5) BTUPHHC: Energy use per household assuming constant 1972 appliance efficiencies, (3)/(4).

SOURCES:

For sources of TOTBTU and HH, see notes in Figure A.3. See text accompanying Figure R.4 for derivation of EFFINDEX.

DATA USED FOR FIGURE R.8

YEAR	COALRC	GASRC	PETROLRC	FOSLRC	ELECRC	YEAR
*****	*********	*******	********	********	*******	*****
1960	.052619	.38654	.27106	.71021	.28979	1960
1961	.046228	.39013	.27055	.7069	.2931	1961
1962	.042013	.39406	.26711	.70319	.29681	1962
1963	.03544	.39353	.2617	.69066	.30934	1963
1964	.030038	.40243	.24436	.67683	.32317	1964
1965	.026937	.39638	.24438	.66769	.33231	1965
1966	.024962	.3994	.23154	.6559	.3441	1966
1967	.020587	.39787	.22943	.64788	.35212	1967
1968	.017524	.38546	.22591	.6289	.3711	1968
1969	.015334	.3818	.21495	.61208	.38792	1969
1970	.012664	.3731	.20596	.59172	.40828	1970
1971	.011585	.36828	.19938	.57925	.42075	1971
1972	.0084885	.36231	.19727	.56807	.43193	1972
1973	.0081755	.34012	.1892	.5375	.4625	1973
1974	.0081796	.34107	.17518	.52442	.47558	1974
1975	.0066448	.34773	.16968	.52405	.47595	1975
1976	.0060989	.3438	.17946	.52936	.47064	1976
1977	.005965	.32296	.17402	.50295	.49705	1977
1978	.0060269	.3209	.16569	.49262	.50738	1978
1979	.0052911	.32796	.15028	.48352	.51648	1979
1980	.004253	.31863	.12808	.45096	.54904	1980
1981	.0046138	.31568	.12444	.44473	.55527	1981

KEY:

(1) COALRC: Share of coal to total energy used in the residential sector.
(2) GASRC: Share of natural gas to total energy used in the resdential sector.
(3) PETROLCC: Share of petroleum products to total energy used in the residential sector.
(4) FOSSILCC: Share of total fossil fuel energy to total energy used in the residentialsector.
(5) ELECCC: Share of electricity to total energy used in the residential sector.

SOURCE: For 1960-1980 data, 1980 State Energy Data Report, DOE/EIA, July 1982. For 1981 data, see note for Data Used in Figure A.2.

DATA USED FOR FIGURE R.9

YEAR	ELEC	GAS	OIL	SOLAR	OTHER
*****	*******	*******	********	**********	**********
1968	.22568	.65397	.097121	0	.022238
1969	.25246	.65671	.080011	0	.0098167
1970	.27121	.65287	.069984	0	.004938
1971	.29544	.61994	.072102	0	.011521
1972	.36053	.56045	.071661	0	.0063581
1973	.40915	.4889	.092102	0	.0088437
1974	.48573	.4302	.075327	0	.0077358
1975	.49392	.4077	.078287	0	.019091
1976	.48822	.39948	.094395	0	.016912
1977	.50739	.37879	.091399	0	.021418
1978	.51811	.37509	.07716	.0037277	.024913
1979	.51243	.39154	.064805	.0026831	.027535
1980	.48376	.42653	.03115	.0066419	.050914
1981	.46796	.43923	.018311	.0076314	.065876

KEY:

(1) ELEC: Share of single family houses using electricity for space heating.
(2) GAS: Share of single family houses using gas for space heating.
(3) OIL: Share of single family houses using oil for space heating.
(4) SOLAR: Share of single family houses using solar energy for space heating.
(5) OTHER: Share of single family houses using other forms of energy for space heating.

SOURCE

Figures for the years 1968-1977 from Building Energy Use Data Book, Edition 2, ORNL-5552, December 1979, Table 2.66. For years 1978-1981 figures were updated from unpublished quarterly survey data from Bureau of Census; made available to Energy Information Administration by special arrangement.

DATA USED FOR FIGURE R.10

YEAR	ELEC	GAS	OIL	OTHSOLAR
*****	******	******	*******	********
1976	.6225	.3081	.0652	.00832
1977	.6832	.2615	.04636	.00886
1978	.6936	.2408	.05596	.008654
1979	.6834	.2593	.04703	.009222
1980	.6485	.3105	.02959	.01038
1981	.6438	.3271	.01709	.011002

KEY:

(1) ELEC: Share of multiple family units using electricity for space heating.
(2) GAS: Share of multiple family units using gas for space heating.
(3) OIL: Share of multiple family units using oil for space heating.
(4) OTHSOLAR: Share of multiple family units using solar and other energy sources for space heating.

SOURCE

Data for 1976-1980 based on Characteristics of New Housing, 1980, U.S. Bureau of the Census, Census Report Series C25. Data for 1981 based on unpublished quarterly survey information (averaged over first three quarters) from Bureau of Census, U.S. Department of Commerce; made available to Energy Information Administration by special arrangement.

DATA USED FOR FIGURE R.11

YEAR	INSTALD	NONE
*****	*******	*******
1976	.50118	.49882
1977	.54072	.45928
1978	.5806	.4194
1979	.60582	.39418
1980	.60234	.39766
1981	.61639	.38361

KEY:

(1) INSTALD: Share of new single family housing units with central air conditioning.

(2) NONE: Share of new single family housing units without central air conditioning.

SOURCES:

See notes for Figure R.8

DATA USED FOR FIGURE R.12

YRQR	ELEC	GAS	OIL	SOLAR	OTHER
*****	*******	*******	**********	**********	**********
78.1	.586	.36168	.037417	.0086471	.005251
78.2	.5824	.37161	.037239	.0044009	.003343
78.3	.58218	.36634	.041125	.0037384	.0056076
78.4	.56952	.37568	.039773	.0065395	.0074876
79.1	.58216	.36717	.040694	.0043468	.0046313
79.2	.56151	.38952	.040687	.0036222	.0036676
79.3	.55168	.39929	.036612	.0054423	.0059745
79.4	.56331	.38909	.033464	.0042446	.0088901
80.1	.52262	.44153	.022029	.0063629	.0064679
80.2	.53779	.41806	.020806	.013425	.0089172
80.3	.5239	.43046	.014402	.0053188	.024927
80.4	.53449	.43585	.0124	.0089279	.0073254
81.1	.51657	.45127	.013219	.012192	.0057515
81.2	.53153	.43707	.010147	.011585	.0086716
81.3	.51375	.45216	.0064932	.0058986	.020695

(1) ELEC: Share of new single family housing units with water heaters using electricity.

(2) GAS: Share of new single family housing units with water heaters using gas

(3) OIL: Share of new single family housing units with water heaters using oil.

(4) SOLAR: Share of new single family housing units with water heaters using solar energy.

(5) OTHER: Share of new single family housing units with water heaters using other energy sources.

SOURCE:

Unpublished quarterly survey data from Bureau of Census; made available to Energy Information Administration by special arrangement.

DATA USED FOR FIGURE R.13

YEAR	TOGAS	FRGAS
*****	*******	******
1972	81018	19793
1973	127643	5473
1974	108624	7131
1975	71901	7366
1976	34836	13615
1977	56562	12794
1978	141916	3751
1979	483577	8312
1980	441288	4750
1981	215135	3623

KEY:

(1) TOGAS: Number of customers that switched primary heating fuel from fuel oil to natural gas. Year shown is beginning year of September 1 - May 1 heating season.

(2) FRGAS: Number of customers that swtiched primary heating fuel from natural gas to fuel oil. Heating season is same as define above.

SOURCE: Commercial and Residential Fuel Oil Consumption Trends: 1970-1980, Vol. II, Centaur Associates, Inc., March 1982, p. II-29. Prepared for DOE Office of Policy, Planning, and Analysis. Original data taken from Fuel Oil and Oil Heat magazine, (various issues).

DATA USED FOR FIGURE R.14

YEAR	TOELEC	TOCW	FRELEC	FRCW
*****	******	******	******	******
1972	21266	0	7661	52012
1973	35706	2402	2301	14161
1974	31070	489	7984	15905
1975	20576	191	8164	12202
1976	31054	995	13347	26518
1977	20777	646	13616	13904
1978	31416	1053	7965	11923
1979	53287	8844	5177	3972
1980	30844	17849	4843	784
1981	22535	15176	3653	3769

KEY:

(1) TOELEC: Number of customers that switched primary heating fuel from fuel to electricity. Year shown is beginning year of September 1 - May 1 heating season.
(2) TOCW: Number of customers that switched primary heating fuel from fuel to either coal or wood.
(3) FRRLEC: Number of customers that switched primary heating fuel from electricity to fuel oil.
(4) FRCW: Number of customers that switched primary heating fuel from either coal or wood to electricity.

SOURCES: Commercial and Residential Fuel Oil Consumption Trends: 1970-1980, Vol. II, Centaur Associates, Inc., March 1982, p. II-29. Prepared for DOE Office of Policy, Planning, and Analysis. Original data taken from Fuel Oil and Oil Heat magazine, (various issues).

DATA USED FOR FIGURE C.1

YEAR	SQFTOT	TECCBUS	TOTSPF	ELECBUS	ELCSPF	FOSLBUS	FOSPSF
1960	17191	4906.9	285.43	1900.8	110.57	3006.1	174.87
1961	17358	5004.8	288.33	1970.1	113.5	3034.6	174.83
1962	17948	5289.2	294.7	2115.1	117.85	3174.1	176.85
1963	18581	5457.9	293.73	2334.7	125.65	3123.2	168.08
1964	19221	5641.6	293.51	2497	129.91	3144.6	163.6
1965	19956	6026.7	302	2683.3	134.46	3343.4	167.54
1966	20721	6432.2	310.42	2926.5	141.23	3505.7	169.19
1967	21448	6984.8	325.66	3143.7	146.57	3841.1	179.09
1968	22250	7398.2	332.5	3446.3	154.89	3951.9	177.61
1969	23138	7898.2	341.35	3775.4	163.17	4122.7	178.18
1970	23896	8397.7	351.43	4127.9	172.75	4269.8	178.68
1971	24732	8751.1	353.84	4433.1	179.24	4318	174.59
1972	25615	9200.4	359.18	4814.2	187.94	4386.2	171.23
1973	26603	9574	359.88	5201.5	195.52	4372.5	164.36
1974	27502	9410.4	342.17	5204.5	189.24	4205.9	152.93
1975	28139	9483.5	337.02	5473.3	194.51	4010.2	142.51
1976	28748	10039	349.22	5712.5	198.71	4327	150.51
1977	29474	10207	346.31	6023.9	204.38	4183.1	141.93
1978	30347	10488	345.59	6209.6	204.62	4278.1	140.97
1979	31268	10670	341.25	6334.5	202.59	4335.6	138.66
1980	32186	10622	330.01	6529.3	202.86	4092.4	127.15
1981	33000	10789	326.94	6744	204.36	4045	122.58

KEY:

(1) SQFTOT: Total floor space in the commercial sector, millions of square feet.
(2) TECCBUS: Total energy consumption in commercial sector, trillion Btu.
(3) TOTPSF: Total energy per square foot, including electricity losses, thousand Btu/sq. ft.
(4) ELECBUS: Electricity consumption (including generation and transmission losses) in the commercial sector, trillion Btu.
(5) ELCPSF: Electricity use (including losses) per square foot, thousand Btu/sq. ft.
(6) FOSLBUS: Fossil fuel consumption (coal, gas, and oil) in the commercial sector, trillion Btu.
(4) FOSPSF: Fossil fuel energy per square foot, thousand Btu/sq. ft.

SOURCES:

Square footage data from ORNL Commercial Energy Use Model data base for 1970-1977. Retirement rates were computed for 1970 and 1977 on the basis of ORNL data on gross and net additions to stock. These retirement rates for each of seven major building categories together with additions data from F.W Dodge, were used by PNL to extend the series back to 1960 and forward to 1980. Gross additions for 1960-1969 (from F.W. Dodge survey) were provided by ORNL. Additions for 1978 and 1979 taken from table 1388 in 1980 Statistical Abstract of the U.S. 1980 data based on extrapolation of 1979 data with construction information from the National Income and Product Accounts.
Energy data for commercial sector for 1960-1980 from 1980 State Energy Data Report, DOE/EIA, July 1982. 1981 data estimated by PNL; see notes for Figure A.2.

DATA USED FOR FIGURE C.2

YEAR	COALCC	GASCC	PETROLCC	FOSLCC	ELECCC	YEAR
*****	*********	*******	********	*******	*******	*****
1960	.12834	.21519	.2691	.61263	.38737	1960
1961	.11463	.2227	.26903	.60635	.39365	1961
1962	.10756	.23612	.25643	.60011	.39989	1962
1963	.088703	.23949	.24404	.57223	.42777	1963
1964	.073197	.25147	.23272	.55739	.44261	1964
1965	.065532	.24721	.24203	.55477	.44523	1965
1966	.062313	.26061	.2221	.54503	.45497	1966
1967	.049269	.28944	.21121	.54992	.45008	1967
1968	.041767	.28927	.20314	.53418	.46582	1968
1969	.037269	.29413	.19059	.52199	.47801	1969
1970	.029515	.29447	.18446	.50845	.49155	1970
1971	.026941	.29559	.17089	.49343	.50657	1971
1972	.019606	.29112	.16601	.47674	.52326	1972
1973	.017909	.27668	.16211	.4567	.5433	1973
1974	.01855	.27809	.15029	.44693	.55306	1974
1975	.015005	.26978	.13807	.42285	.57714	1975
1976	.013472	.27077	.14674	.43099	.56901	1976
1977	.013128	.24966	.14703	.40982	.59018	1977
1978	.01383	.25198	.1421	.40792	.59208	1978
1979	.012074	.2658	.12845	.40633	.59367	1979
1980	.0089173	.25171	.12466	.38528	.61472	1980
1981	.0092687	.24868	.11697	.37492	.62508	1981

KEY:

(1) COALCC: Share of coal to total energy used in the commercial sector.
(2) GASCC: Share of natural gas to total energy used in the commercial sector.
(3) PETROLCC: Share of petroleum products to total energy used in the commercial sector.
(4) FOSSILCC: Share of total fossil fuel energy to total energy used in the industrial sector.
(5) ELECCC: Share of electricity to total energy used in the commercial sector.

SOURCES: For 1960-1980 data, 1980 State Energy Data Report, DOE/EIA, July 1981. For 1981 data, see note for Data Used in Figure A.2.

DATA USED FOR FIGURE I.1

YEAR	EOVMM	EOEMM	EOEADJ
*****	******	******	******
1960	11764	11182	10884
1961	11826	11118	10707
1962	11385	10909	10663
1963	11272	10740	10579
1964	11262	10694	10621
1965	10706	10392	10472
1966	10434	10443	10588
1967	10396	10511	10487
1968	10289	10422	10402
1969	10341	10333	10280
1970	10959	10714	10380
1971	10788	10495	10113
1972	10311	10181	10004
1973	10000	10000	10000
1974	9796	9842	9709
1975	10033	10135	9575
1976	9624	9753	9459
1977	9264	9536	9331
1978	8795	9147	9014
1979	8632	9065	8989
1980	8430	9036	8726

KEY:

(1) EOVMM: Value-added weighted energy intensity index.
(2) EOEMM: Energy-weighted (Marlay) energy intensity index
(3) EOEADJ: Marlay Index adjusted for changes in capacity utilization, reference year, 1972.

SOURCES:

The value-added and Marlay indexes were provided by Robert Marlay of DOE's Office of Policy and Evaluation. Capacity utilization adjustment was carried out by Pacific National Laboratory.

DATA USED FOR FIGURE I.2

YEAR	COALIC	GASIC	PETROLIC	FOSLIC	ELECIC	YEAR
*****	*******	*******	********	*******	*******	*****
1960	.24099	.30461	.29224	.83784	.1979	1960
1961	.22993	.31345	.29178	.83516	.20172	1961
1962	.22356	.31572	.2933	.83258	.20527	1962
1963	.22464	.31614	.29156	.83234	.20507	1963
1964	.22637	.31398	.28941	.82977	.20634	1964
1965	.22753	.31126	.2875	.82629	.2109	1965
1966	.22056	.31379	.28622	.82056	.21682	1966
1967	.20711	.32072	.28405	.81188	.2239	1967
1968	.19544	.32913	.28222	.80679	.23009	1968
1969	.18225	.33712	.28066	.80004	.23693	1969
1970	.17913	.34161	.27974	.80048	.23925	1970
1971	.15446	.35522	.28212	.7918	.24803	1971
1972	.14845	.33964	.29422	.78231	.25651	1972
1973	.14205	.33935	.29729	.7787	.26172	1973
1974	.13595	.33598	.2924	.76433	.27172	1974
1975	.13763	.30923	.29697	.74383	.29124	1975
1976	.12863	.29765	.30898	.73526	.29752	1976
1977	.11612	.28666	.325	.72779	.30569	1977
1978	.1109	.28087	.33035	.72213	.31068	1978
1979	.11641	.27372	.32953	.71966	.31405	1979
1980	.10818	.28548	.31538	.70905	.32381	1980
1981	.1119	.28368	.29223	.68782	.34118	1981

KEY:

(1) COALIC: Share of coal to total energy used in the industrial sector.
(2) GASIC: Share of natural gas to total energy used in the industrial sector.
(3) PETROLIC: Share of petroleum products to total energy used in the industrial sector.
(4) FOSSILIC: Share of total fossil fuel energy to total energy used in the industrial sector.
(5) ELECIC: Share of electricity to total energy used in the industrial sector.

NOTE: As of the March 1982 issue of the Monthly Energy Review , asphalt and road oil consumption were included as part of the industrial energy consumption. Total here excludes asphalt and road oil.

SOURCES:

1980 State Energy Data Report and Monthly Energy Review ,DOE/EIA.

DATA USED FOR FIGURE I.4

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	*******	*******	*******	*******	********	*******
1958	11249	280962	157344	123618	24.977	13.987	10.989
1959	12617	286558	153345	133213	22.712	12.154	10.558
1960	12276	283175	150051	133124	23.067	12.223	10.844
1961	12650	275031	142796	132235	21.742	11.288	10.453
1962	13568	281475	144444	137031	20.745	10.646	10.1
1963	13812	294889	150907	143982	21.35	10.926	10.424
1964	14605	316629	161924	154705	21.679	11.087	10.593
1965	15322	327922	164910	163012	21.402	10.763	10.639
1966	16329	344640	168690	175950	21.106	10.331	10.775
1967	16252	372920	180751	192169	22.946	11.122	11.824
1968	16787	375893	172365	203528	22.392	10.268	12.124
1969	16476	385265	172009	213256	23.383	10.44	12.943
1970	16329	382365	166316	216049	23.416	10.185	13.231
1971	16783	398619	176403	222216	23.751	10.511	13.241
1972	17684	408125	168177	239948	23.079	9.5101	13.569
1973	16962	406615	154450	252165	23.972	9.1056	14.866
1974	16276	376201	141257	234944	23.114	8.6789	14.435
1975	15927	366067	135114	230953	22.984	8.4833	14.501
1976	18218	392795	146099	246696	21.561	8.0195	13.541
1977	19701	391390	147102	244288	19.867	7.4667	12.4
1978	20583	373725	139013	234712	18.157	6.7538	11.403
1979	21359	364872	131823	233049	17.083	6.1718	10.911

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Textile Mill Products, SIC 221, 222, 224, 225, and 228.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.5

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	********	********	*******	*******	*******	*******
1958	10872	876012	734165	141847	80.575	67.528	13.047
1959	12052	912489	755705	156784	75.713	62.704	13.009
1960	12118	938313	773884	164429	77.431	63.862	13.569
1961	12426	948321	779862	168459	76.318	62.761	13.557
1962	13142	1014901	834790	180111	77.226	63.521	13.705
1963	13885	1047832	851262	196570	75.465	61.308	14.157
1964	14407	1099389	884537	214852	76.309	61.396	14.913
1965	15390	1184325	956938	227387	76.954	62.179	14.775
1966	16507	1258183	1001664	256519	76.221	60.681	15.54
1967	16572	1299960	1025495	274465	78.443	61.881	16.562
1968	17493	1367956	1059887	308069	78.2	60.589	17.611
1969	18802	1426134	1093132	333002	75.85	58.139	17.711
1970	18232	1409969	1059058	350911	77.335	58.088	19.247
1971	18529	1512224	1140291	371933	81.614	61.541	20.073
1972	19853	1563090	1173336	389754	78.733	59.101	19.632
1973	21720	1508464	1103256	405208	69.45	50.794	18.656
1974	23205	1590971	1149844	441127	68.562	49.552	19.01
1975	19819	1457202	1033274	423928	73.526	52.136	21.39
1976	21946	1577512	1106200	471312	71.882	50.406	21.476
1977	22301	1593801	1106903	486898	71.468	49.635	21.833
1978	23262	1589522	1094669	494853	68.331	47.058	21.273
1979	24370	1595162	1092581	502581	65.456	44.833	20.623

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Paper Products, SIC 26, excluding SIC 265.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.6

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
1958	7009	1749544	858930	890614	249.61	122.55	127.07
1959	8077	1877431	981249	896182	232.44	121.49	110.95
1960	8166	1910570	1022270	888300	233.97	125.19	108.78
1961	8402	1925794	1028411	897383	229.21	122.4	106.81
1962	9160	1971706	1106166	865540	215.25	120.76	94.491
1963	9926	2079018	1191006	888012	209.45	119.99	89.463
1964	10836	2034357	1249050	785307	187.74	115.27	72.472
1965	11676	2190074	1339902	850172	187.57	114.76	72.814
1966	12426	2265334	1439166	826168	182.31	115.82	66.487
1967	12327	2308997	1470850	838147	187.31	119.32	67.993
1968	13088	2330432	1518911	811521	178.06	116.05	62.005
1969	14313	2353661	1542201	811460	164.44	107.75	56.694
1970	14437	2296709	1577744	718965	159.08	109.28	49.8
1971	14635	2447839	1627853	819986	167.26	111.23	56.029
1972	16102	2493453	1550122	943331	154.85	96.269	58.585
1973	17838	2541101	1524009	1017092	142.45	85.436	57.018
1974	18071	2686161	1666357	1019804	148.64	92.212	56.433
1975	14942	2483416	1433918	1049498	166.2	95.966	70.238
1976	17228	2782540	1577579	1204961	161.51	91.571	69.942
1977	18675	2786475	1554922	1231553	149.21	83.262	65.947
1978	19773	2655931	1474927	1181004	134.32	74.593	59.728
1979	20751	2629781	1487586	1142195	126.73	71.687	55.043

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Industrial Chemicals, SIC 281, 2865, and 2869.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.7

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
1958	18745	2149367	2031884	117483	114.66	108.4	6.2674
1959	19893	2260742	2134156	126586	113.65	107.28	6.3634
1960	20443	2347564	2214632	132932	114.83	108.33	6.5026
1961	20415	2360644	2218886	141758	115.63	108.69	6.9438
1962	21143	2424520	2277172	147348	114.67	107.7	6.9691
1963	22408	2437641	2275496	162145	108.78	101.55	7.236
1964	23769	2510538	2340308	170230	105.62	98.461	7.1619
1965	23967	2549552	2373314	176238	106.38	99.024	7.3534
1966	24804	2585000	2401894	183106	104.22	96.835	7.3821
1967	26375	2650261	2439642	210619	100.48	92.498	7.9856
1968	28154	2818576	2585387	233189	100.11	91.83	8.2826
1969	29246	2924351	2672958	251393	99.991	91.396	8.5958
1970	29593	2963203	2705991	257212	100.13	91.44	8.6916
1971	30397	2984602	2708080	276522	98.187	89.09	9.097
1972	31441	3127947	2838793	289154	99.486	90.29	9.1967
1973	30461	3311892	3008088	303804	108.73	98.752	9.9735
1974	33761	3290919	2968992	321927	97.477	87.941	9.5355
1975	33736	3128516	2816895	311621	92.735	83.498	9.237
1976	37526	3224532	2899207	325325	85.928	77.259	8.6693
1977	40049	3349832	2992932	356900	83.643	74.732	8.9116
1978	40779	2896719	2541437	355282	71.035	62.322	8.7124
1979	40330	3205012	2834373	370639	79.47	70.28	9.1902

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Petroleum Refining, SIC 29.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.8

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	*******	*******	*******	********	********	********
1958	8037	174594	111666	62928	21.724	13.894	7.8298
1959	9429	183275	113403	69872	19.437	12.027	7.4103
1960	9513	186548	114466	72082	19.61	12.033	7.5772
1961	9801	184383	110530	73853	18.813	11.277	7.5352
1962	11091	201705	119715	81990	18.186	10.794	7.3925
1963	11629	204226	118359	85867	17.562	10.178	7.3839
1964	12534	215671	122463	93208	17.207	9.7705	7.4364
1965	13729	243067	136821	106246	17.705	9.9658	7.7388
1966	14487	267581	136827	130754	18.47	9.4448	9.0256
1967	14841	270464	146662	123802	18.224	9.8822	8.3419
1968	16378	293503	146616	146887	17.921	8.952	8.9685
1969	17611	316130	154203	161927	17.951	8.7561	9.1946
1970	16838	334226	160204	174022	19.85	9.5144	10.335
1971	17663	365621	176474	189147	20.7	9.9912	10.709
1972	20654	421669	210894	210775	20.416	10.211	10.205
1973	22326	433198	199587	233611	19.403	8.9397	10.464
1974	21506	407395	183157	224238	18.943	8.5166	10.427
1975	18365	384248	162411	221837	20.923	8.8435	12.079
1976	19504	401450	169602	231848	20.583	8.6958	11.887
1977	22727	462490	195498	266992	20.35	8.602	11.748
1978	24682	452460	182785	269675	18.332	7.4056	10.926
1979	26150	439500	171374	268127	16.807	6.5535	10.253

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Rubber and Miscellaneous Plastics, SIC 30.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.9

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	*******	*******	*******	*******	*******	*******
1958	2913	199763	167124	32639	68.576	57.372	11.205
1959	3496	225893	187457	38436	64.615	53.62	10.994
1960	3500	233648	194246	39402	66.757	55.499	11.258
1961	3413	228189	188808	39381	66.859	55.32	11.539
1962	3599	236989	194328	42661	65.849	53.995	11.854
1963	3872	242569	198503	44066	62.647	51.266	11.381
1964	4083	252957	206008	46949	61.954	50.455	11.499
1965	4418	263979	212412	51567	59.751	48.079	11.672
1966	4733	285490	229450	56040	60.319	48.479	11.84
1967	4687	282898	226499	56399	60.358	48.325	12.033
1968	4807	290413	234039	56374	60.415	48.687	11.727
1969	5041	312080	244109	67971	61.908	48.425	13.484
1970	4854	322158	248740	73418	66.37	51.244	15.125
1971	5104	337836	261361	76475	66.19	51.207	14.983
1972	5583	354823	271496	83327	63.554	48.629	14.925
1973	6038	360069	269655	90414	59.634	44.66	14.974
1974	5675	355801	263405	92396	62.696	46.415	16.281
1975	5348	336896	243276	93620	62.995	45.489	17.506
1976	5890	357182	256401	100781	60.642	43.532	17.111
1977	6055	363321	257598	105723	60.003	42.543	17.46
1978	6578	372535	261113	111422	56.634	39.695	16.939
1979	6702	359717	247856	111860	53.673	36.982	16.691

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Glass Products, SIC 311 and 322.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.10

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	********	********	*******	********	*******	*******
1958	21023	2309880	2035755	274125	109.87	96.835	13.039
1959	24022	2493359	2188494	304865	103.79	91.104	12.691
1960	24428	2682884	2359838	323046	109.83	96.604	13.224
1961	23405	2567450	2230366	337084	109.7	95.294	14.402
1962	24117	2617445	2275684	341761	108.53	94.36	14.171
1963	25551	2714733	2351099	363634	106.25	92.016	14.232
1964	29023	3080395	2662506	417889	106.14	91.738	14.399
1965	31848	3242212	2793401	448811	101.8	87.71	14.092
1966	32619	3314331	2827266	487065	101.61	86.675	14.932
1967	30398	3160460	2643949	516511	103.97	86.978	16.992
1968	31331	3267681	2722928	544753	104.3	86.908	17.387
1969	32317	3532413	2938597	593816	109.31	90.93	18.375
1970	28934	3370549	2791827	578722	116.49	96.489	20.001
1971	26919	3146398	2561088	585310	116.88	95.141	21.743
1972	28863	3282473	2682863	599610	113.73	92.952	20.774
1973	34759	3667030	2970916	696114	105.5	85.472	20.027
1974	37570	3592564	2865368	727196	95.623	76.267	19.356
1975	27489	3023726	2419449	604277	110	88.015	21.982
1976	28748	3117464	2475993	641471	108.44	86.127	22.314
1977	27968	3086858	2393097	693761	110.37	85.566	24.806
1978	31060	3355517	2628423	727094	108.03	84.624	23.409
1979	31388	3280696	2526326	754370	104.52	80.487	24.034

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Iron and Steel, SIC 331.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.11

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	********	*******	********	*******	*******	*******
1958	12886	751985	362430	389555	58.357	28.126	30.231
1959	14234	851840	377062	474778	59.845	26.49	33.355
1960	14250	874596	390239	484357	61.375	27.385	33.99
1961	15179	852185	387120	465065	56.142	25.504	30.639
1962	16311	952615	443464	509151	58.403	27.188	31.215
1963	17316	978343	446809	531534	56.499	25.803	30.696
1964	18188	1023238	464935	558303	56.259	25.563	30.696
1965	20074	1112896	479748	633148	55.44	23.899	31.541
1966	23221	1197507	509609	687898	51.57	21.946	29.624
1967	20832	1215927	494624	721303	58.368	23.743	34.625
1968	21886	1247820	521821	725999	57.015	23.843	33.172
1969	23316	1358968	546009	812959	58.285	23.418	34.867
1970	21319	1362176	532186	829990	63.895	24.963	38.932
1971	20951	1287533	523533	764000	61.454	24.988	36.466
1972	23986	1363086	537452	825634	56.828	22.407	34.422
1973	27208	1542631	555591	987040	56.698	20.42	36.278
1974	26010	1678612	542507	1136105	64.537	20.858	43.68
1975	21064	1377117	423622	953495	65.378	20.111	45.267
1976	23531	1462426	435021	1027405	62.149	18.487	43.662
1977	24988	1548636	449682	1098954	61.975	17.996	43.979
1978	26966	1562699	443724	1118975	57.951	16.455	41.496
1979	28219	1579056	428959	1150097	55.957	15.201	40.756

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Nonferrous Metals, SIC 333 through 338.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.12

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	******	******	******	********	*******	*******
1958	4462	37271	22052	15219	8.353	4.9422	3.4108
1959	5118	38929	21742	17187	7.6063	4.2481	3.3581
1960	5381	41338	23415	17923	7.6823	4.3514	3.3309
1961	5069	41855	24055	17800	8.257	4.7455	3.5115
1962	5866	48611	28729	19882	8.2868	4.8975	3.3893
1963	5943	47520	26526	20994	7.996	4.4634	3.5326
1964	6749	48757	26015	22742	7.2243	3.8546	3.3697
1965	7629	54522	28638	25884	7.1467	3.7538	3.3928
1966	8683	58560	29668	28892	6.7442	3.4168	3.3274
1967	8751	64568	32582	31986	7.3783	3.7232	3.6551
1968	8275	74038	35119	38919	8.9472	4.244	4.7032
1969	8602	75349	36842	38507	8.7595	4.283	4.4766
1970	7620	78079	40603	37476	10.247	5.3285	4.9181
1971	6408	77793	39238	38555	12.14	6.1233	6.0167
1972	7155	75401	35312	40089	10.538	4.9353	5.603
1973	8842	78106	35592	42514	8.8335	4.0253	4.8082
1974	9186	73970	31732	42238	8.0524	3.4544	4.598
1975	7518	67793	25591	42202	9.0174	3.404	5.6134
1976	7483	69103	26302	42801	9.2347	3.5149	5.7198
1977	7916	70321	26100	44221	8.8833	3.2971	5.5862
1978	8413	69448	26502	42947	8.2549	3.1501	5.1048
1979	9253	68870	24996	43874	7.443	2.7014	4.7416

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Metalworking Machinery, SIC 354.
(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)
(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.
(4) ELEC: Electricity consumption, including losses, billion Btu.
(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.
(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.
(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE I.13

YEAR	OUTPUT	TOTENG	FOSSIL	ELEC	EOQTOT	EOQFOS	EOQELC
*****	******	*******	*******	*******	*******	*******	*******
1958	25864	225206	138346	86860	8.7073	5.349	3.3583
1959	32900	246743	144696	102047	7.4998	4.3981	3.1017
1960	37148	263069	152333	110736	7.0816	4.1007	2.9809
1961	32051	244964	142198	102766	7.643	4.4366	3.2063
1962	40562	277482	158749	118733	6.8409	3.9137	2.9272
1963	44866	290003	161705	128298	6.4638	3.6042	2.8596
1964	46037	317013	181599	135414	6.886	3.9446	2.9414
1965	56302	344327	186095	158232	6.1157	3.3053	2.8104
1966	55708	327414	188224	139190	5.8773	3.3788	2.4986
1967	49076	337041	188791	148250	6.8677	3.8469	3.0208
1968	58272	387102	202094	185008	6.643	3.4681	3.1749
1969	58796	370237	191472	178765	6.297	3.2565	3.0404
1970	47766	348192	182666	165526	7.2895	3.8242	3.4654
1971	61051	382591	194825	187766	6.2668	3.1912	3.0756
1972	65218	405389	205216	200173	6.2159	3.1466	3.0693
1973	75593	413299	188392	224907	5.4674	2.4922	2.9752
1974	63472	377602	188605	188997	5.9491	2.9715	2.9776
1975	56959	355984	170599	185385	6.2498	2.9951	3.2547
1976	73948	405008	196699	208309	5.4769	2.66	2.817
1977	84286	426826	198598	228228	5.064	2.3562	2.7078
1978	88890	431729	201698	230031	4.8569	2.2691	2.5878
1979	83710	410644	188398	222246	4.9056	2.2506	2.655

Key:

(1) OUTPUT: Total gross output in millions of 1972 dollars, Motor Vehicles, SIC 371.

(2) TOTENG: Total energy consumption, billion Btu, including electricity losses. (Losses imputed on basis of EIA data on direct electricity sales and associated generation and transmission losses for the industrial sector.)

(3) FOSSIL: Total energy consumption from fossil fuels, billion Btu.

(4) ELEC: Electricity consumption, including losses, billion Btu.

(5) EOQTOT: Energy/Output ratio, total energy, thousand Btu per 1972 dollar of output.

(6) EOQFOS: Energy/Output ratio, fossil fuels, thousand Btu per 1972 dollar of output.

(7) EOQELC: Energy/Output ratio, electricity, thousand Btu per 1972 dollar of output.

Sources: Output data from Bureau of Labor Statistics, Office of Economic Growth. Energy data from National Energy Accounts updated to 1979 with Annual Survey of Manufactures information (Fuels and Electric Energy Consumed). Ratio of generation and transmission losses to direct sales of electricity taken from 1980 State Energy Data Report, DOE/EIA -0214(80), p. 17; and Monthly Energy Review.

DATA USED FOR FIGURE T.1

YEAR	NEW	EEA	FHWA
1970	0	0	13.57
1971	0	0	13.57
1972	0	0	13.49
1973	0	0	13.1
1974	0	0	13.43
1975	13.89	13.31	13.53
1976	14.89	13.49	13.72
1977	15.67	13.76	13.94
1978	16.68	14.12	14.06
1979	17.41	14.53	14.29
1980	19.57	15.11	15.15
1981	21.72	15.88	15.54

KEY:

(1) NEW: Average on-road new passenger car fuel economy (MPG), EEA model.
(2) EEA: Average on-road fleet passenger car fuel economy (MPG), EEA model.
(3) FHWA: Average on-road fleet passenger car fuel economy (MPG), Federal Highway Administration

SOURCES:

Variables NEW and EEA:

Data for 1975-1979 taken from The Highway Fuel Consumption Model-Fourth Quarterly Report prepared by Energy and Environmental Analysis Inc. for Office of Vehicle and Engine R&D., DOE, July 2, 1981. Data for 1980 annd 1981 from The Highway Fuel Consumption Model-Seventh Quarterly Report, April 15, 1982. Data values were from Appendix B of these reports for line items corresponding to total passenger automobiles.

Variable FHWA:

FHWA data from August 1982 issue of Monthly Energy Review, p. 17; original source is Table VM-1, in Highway Statistics, Federal Highway Administration (FHWA), U.S. Department of Transportation. 1981 data directly from FHWA.

DATA USED FOR FIGURE T.2

	1980	1981
Total Change	2.50	2.40
Technology	1.33	1.20
Add/Drop Models	0.30	0.53
Shifts within classes	0.53	0.50
Shifts among classes	0.35	0.10

SOURCES:

Data from tables 10 and 11 in Motor Vehicle Quarterly MPG and Market Share Newsletter, Oak Ridge National Laboratory, October 1981.

DATA USED FOR FIGURE T.3

YEAR	TOTSAVE	LOADF	MIX	TOEFF	SEATCAP	YEAR
*****	*******	*****	*****	*****	*******	*****
1967	0	0	0	0	0	1967
1968	-.15	-.55	.38	-.03	.05	1968
1969	.09	-.72	.6	.1	.06	1969
1970	.05	-.98	.8	.24	-.1	1970
1971	.27	-1.24	1.31	.38	-.12	1971
1972	1.16	-.56	1.48	.28	-.2	1972
1973	1.37	-.73	2.2	.25	-.08	1973
1974	2.45	-.24	1.54	.39	.14	1974
1975	2.43	-.41	1.6	.46	.2	1975
1976	3.2	-.16	1.71	.56	.35	1976
1977	3.75	-.08	1.9	.59	.46	1977
1978	5.61	.9	2.21	.57	.67	1978
1979	6.86	1.23	2.56	.78	.87	1979
1980	6.4	.51	2.92	1.08	.94	1980

KEY:

(1) TOTSAVE: Total savings of commercial airline industry relative to 1967 baseline, billions of gallons. Figures calculated as "baseline" fuel use (fuel use per passenger-mile assumed constant at its 1967 value) minus actual fuel use.
(2) LOADF: Contribution to total savings from average load factor.
(3) MIX: Contribution to total savings from changing composition of aircraft (e.g. increased use of wide-body planes)
(4) TOEFF: Contribution to total savings from technical and operating efficiency.
(5) SEATCAP: Contribution to total savings from increased average number of seats per plane.

SOURCE: "Fuel Demand and Fuel Efficiency in the U.S. Commercial Airline Industry: An Analysis of Trends and Implications," Energy and Environmental Analysis, Inc., prepared for DOE Office of Policy, Planning, and Analysis, May 1982.

DATA USED FOR FIGURE T.4

YEAR	RAIL	WATER	AIR	TRUCK	YEAR
*****	********	********	********	*******	*****
1970	.98485	.93103	1.0813	1.2481	1970
1971	1.0606	.86207	1.0813	1.1945	1971
1972	1.0758	.89655	1.0581	1.0417	1972
1973	1	1	1	1	1973
1974	1.0303	.82759	.90548	1.1502	1974
1975	1.0303	.94828	.94189	1.3602	1975
1976	1.0303	.81034	.88819	1.214	1976
1977	1.0152	.7931	.98786	1.1859	1977
1978	.9697	.65517	.93417	1.1713	1978
1979	.93939	.75862	.86797	1.1346	1979
1980				1.1182	1980

KEY:

(1) RAIL: Index of Btu/ton-mile traveled, Class I railroad freight
(2) WATER: Index of Btu/ton-mile traveled, Domestic waterborne commerce
(3) AIR: Index of Btu/ton-mile traveled, Air cargo (all-cargo carriers only)
(4) TRUCK: Index of Btu/ton-mile traveled, commercial trucking.

SOURCES: For rail, water, and air: Table 4.19, Transportation Energy Conservation Data Book: Edition 5 , Oak Ridge National Laboratory, November 1981. For trucks: "Fuel Demand and Fuel Efficiency in the U.S. Commercial Airline Industry and the Trucking Industry: An Analysis of Trends and Implications." Energy and Environmental Analysis, Inc., prepared for DOE Office of Policy, Planning, and Analysis, May 1982, p. 3-11. (Trucking index was computed by dividing Actual fuel consumption by "Base" fuel consiumption and normalizing the resulting series to 1973 = 1.0.

DATA USED FOR FIGURE U.1

YEAR	ST	PT	PF	YEAR	ST	PT	PF
1951	330	371	271	1967	1099	1214	984
1952	356	399	293	1968	1203	1329	1093
1953	396	443	337	1969	1314	1442	1177
1954	424	472	365	1970	1392	1532	1261
1955	497	547	433	1971	1470	1613	1307
1956	546	601	479	1972	1595	1750	1421
1957	576	632	500	1973	1713	1861	1503
1958	588	645	504	1974	1706	1867	1449
1959	647	710	572	1975	1747	1918	1442
1960	689	753	606	1976	1855	2038	1559
1961	723	792	638	1977	1948	2124	1649
1962	778	852	681	1978	2018	2206	1646
1963	833	917	748	1979	2071	2247	1708
1964	896	984	803	1980	2094	2286	1754
1965	954	1055	858	1981	2111	2293	1753
1966	1035	1144	943				

Key:

(1) ST: Total sales of electricity in the United States, billions of kWH/year.
(2) PT: Total electricity generated in the United States, billions of kWH/year.
(3) PF: Total electricity generated from fossil fuels in the United States, billions of kWH/year.

Source: 1981 Annual Report to Congress, DOE/EIA. ST from T. 67, (p. 155); PT from T. 66, p. 153; PF from Table 65, p. 151.

DATA USED FOR FIGURE U.2

YEAR	TEFF	ST	PT	YEAR	TEFF	ST	PT
*****	*******	*****	*****	*****	*******	*****	*****
1951	88.949	330	371	1967	90.527	1099	1214
1952	89.223	356	399	1968	90.519	1203	1329
1953	89.391	396	443	1969	91.123	1314	1442
1954	89.831	424	472	1970	90.862	1392	1532
1955	90.859	497	547	1971	91.135	1470	1613
1956	90.849	546	601	1972	91.143	1595	1750
1957	91.139	576	632	1973	92.047	1713	1861
1958	91.163	588	645	1974	91.377	1706	1867
1959	91.127	647	710	1975	91.084	1747	1918
1960	91.501	689	753	1976	91.021	1855	2038
1961	91.288	723	792	1977	91.714	1948	2124
1962	91.315	778	852	1978	91.478	2018	2206
1963	90.84	833	917	1979	92.167	2071	2247
1964	91.057	896	984	1980	91.601	2094	2286
1965	90.427	954	1055	1981	92.063	2111	2293
1966	90.472	1035	1144				

KEY:

(1) TEFF: Transmission efficiency in percent, TEFF=(ST/PT)*100.
(2) ST: Total sales of electricity in the United States, billions of kWH/year.
(3) PT: Total electricity generated in the United States, billions of kWH/year.

Source: 1981 Annual Report to Congress, DOE/EIA. ST from T. 67, (p. 155); PT from T. 66, p. 153; PF from Table 65, p. 151.

DATA USED FOR FIGURE U.3

YEAR	PC	PP	PNG	YEAR	PC	PP	PNG
*****	*****	****	****	*****	*****	****	****
1951	185	29	57	1967	630	89	265
1952	195	30	68	1968	685	104	304
1953	219	38	80	1969	706	138	333
1954	239	32	94	1970	704	184	373
1955	301	37	95	1971	713	220	374
1956	339	36	104	1972	771	274	376
1957	346	40	114	1973	848	314	341
1958	344	40	120	1974	828	301	320
1959	378	47	147	1975	853	289	300
1960	402	46	158	1976	944	320	295
1961	422	47	169	1977	985	358	306
1962	450	47	184	1978	976	365	305
1963	494	52	202	1979	1075	304	329
1964	526	57	220	1980	1162	246	346
1965	571	65	222	1981	1202	206	345
1966	613	79	251				

Key:

(1) PC: The quantity of coal generated electricity in billions of kWH/year.
(2) PP: The quantity of petroleum generated electricity in billions of kWH/year.
(3) PNG: The quantity of natural gas generated electricity in billions of kWH/year.

Source: 1981 Annual Report to Congress, DOE/IEA, Table 65 (p. 151).

DATA USED FOR FIGURE U.4

YEAR	CSHARE	PSHARE	NGSHARE	PC	PP	PNG	PF
*****	*******	********	*******	*****	****	****	*****
1951	.68266	.10701	.21033	185	29	57	271
1952	.66553	.10239	.23208	195	30	68	293
1953	.64985	.11276	.23739	219	38	80	337
1954	.65479	.087671	.25753	239	32	94	365
1955	.69515	.08545	.2194	301	37	95	433
1956	.70772	.075157	.21712	339	36	104	479
1957	.692	.08	.228	346	40	114	500
1958	.68254	.079365	.2381	344	40	120	504
1959	.66084	.082168	.25699	378	47	147	572
1960	.66337	.075908	.26073	402	46	158	606
1961	.66144	.073668	.26489	422	47	169	638
1962	.66079	.069016	.27019	450	47	184	681
1963	.66043	.069519	.27005	494	52	202	748
1964	.65504	.070984	.27397	526	57	220	803
1965	.6655	.075758	.25874	571	65	222	858
1966	.65005	.083775	.26617	613	79	251	943
1967	.64024	.090447	.26931	630	89	265	984
1968	.62672	.095151	.27813	685	104	304	1093
1969	.59983	.11725	.28292	706	138	333	1177
1970	.55829	.14592	.2958	704	184	373	1261
1971	.54552	.16832	.28615	713	220	374	1307
1972	.54258	.19282	.2646	771	274	376	1421
1973	.5642	.20892	.22688	848	314	341	1503
1974	.57143	.20773	.22084	828	301	320	1449
1975	.59154	.20042	.20804	853	289	300	1442
1976	.60552	.20526	.18922	944	320	295	1559
1977	.59733	.2171	.18557	985	358	306	1649
1978	.59295	.22175	.1853	976	365	305	1646
1979	.62939	.17799	.19262	1075	304	329	1708
1980	.66249	.14025	.19726	1162	246	346	1754
1981	.68568	.11751	.19681	1202	206	345	1753

Key:

(1) CSHARE: The fraction of coal generated electricity in total fossil generation. CSHARE=(PC/PF)

(2) PSHARE: The fraction of petroleum generated electricity in total fossil generation. PSHARE=(PP/PF)

(3) NGSHARE: The percentage of natural gas generated electricity in total fossil generation. NGSHARE=(PNG/PF)*100.

(4) PC: The quantity of coal-generated electricity in billions of kWH/year. Data are given in Figure U.5.

(5) PP: The quantity of petroleum-generated electricity in billions of kWH/year. Data are given in Figure U.5.

(6) PNG: The quantity of natural gas-generated electricity in billions of kWH/year. Data are given in Figure U.5.

(7) PF: Total electricity generated from fossil fuels in the United States, billions of kWH/year. Data are given in Figure U.1.

DATA USED FOR FIGURE U.5

YEAR	PTHC	PTHP	PTNG	PTHF	HC	HP	HNG	HF
*****	*******	*******	*******	*******	********	********	********	********
1951	22.823	24.847	24.595	23.381	810.59	116.71	231.75	1159.1
1952	23.765	24.418	24.634	24.027	820.55	122.86	276.04	1219.4
1953	24.658	25.225	25.506	24.918	888.16	150.64	313.65	1352.5
1954	26.333	26.187	26.599	26.388	907.62	122.2	353.39	1383.2
1955	27.69	26.808	27.162	27.495	1087.1	138.02	349.75	1574.8
1956	28.424	27.007	27.671	28.147	1192.7	133.3	375.84	1701.8
1957	28.585	27.368	28.13	28.379	1210.4	146.16	405.26	1761.8
1958	29.539	28.073	28.812	29.242	1164.5	142.49	416.49	1723.5
1959	30.081	29.007	29.748	29.904	1256.6	162.03	494.14	1912.8
1960	32.3	29.384	30.195	31.49	1244.6	156.55	523.26	1924.4
1961	32.94	29.863	30.528	32.026	1281.1	157.38	553.6	1992.1
1962	33.124	29.828	30.853	32.237	1358.5	157.57	596.37	2112.5
1963	33.294	30.344	31.18	32.48	1483.7	171.37	647.85	2303
1964	33.274	30.686	31.311	32.521	1580.8	185.75	702.62	2469.2
1965	33.382	30.69	31.623	32.694	1710.5	211.8	702.01	2624.3
1966	33.114	30.472	31.764	32.51	1851.2	259.25	790.19	2900.6
1967	33.292	29.983	31.906	32.585	1892.4	296.84	830.56	3019.8
1968	33.359	30.022	31.959	32.617	2053.4	346.41	951.23	3351
1969	33.32	29.943	31.595	32.391	2118.9	460.88	1054	3633.7
1970	33.19	29.935	31.394	32.136	2121.1	614.66	1188.1	3923.9
1971	33.295	30.315	31.13	32.124	2141.5	725.72	1201.4	4068.6
1972	33.647	30.438	31.41	32.379	2291.4	900.19	1197.1	4388.7
1973	33.42	30.732	31.044	32.27	2537.4	1021.7	1098.4	4657.5
1974	33.103	30.812	31.029	32.133	2501.3	976.88	1031.3	4509.4
1975	33.122	31.279	31.592	32.412	2575.3	923.94	949.62	4448.9
1976	33.143	31.501	31.935	32.562	2848.2	1015.8	923.76	4787.8
1977	32.814	31.431	31.797	32.313	3001.8	1139	962.35	5103.2
1978	32.529	31.456	31.57	32.105	3000.4	1160.4	966.12	5126.9
1979	32.565	31.75	31.098	32.126	3301.1	957.49	1057.9	5316.5
1980	32.706	31.965	31.009	32.253	3552.9	769.59	1115.8	5438.3
1981	32.307	32.08	31.25	32.067	3720.6	642.15	1104	5466.8

continued

DATA USED FOR FIGURE U.5

YEAR	ECA	ECB	EP	ENG	QCA	QCB	QP	QNG
*****	******	******	******	*****	****	******	******	*****
1951	24.6	26.2	6.232	1035	3.9	101.9	63.9	764
1952	24.54	26.2	6.238	1035	3.8	103.3	67.2	910
1953	24.48	26.2	6.253	1035	3.6	112.3	82.2	1034
1954	24.55	26.2	6.251	1035	3.2	115.2	66.7	1165
1955	24.53	25.84	6.254	1035	3.2	140.5	75.3	1153
1956	24.13	25.74	6.256	1035	3.3	155	72.7	1239
1957	24.01	25.72	6.257	1035	3.4	157.4	79.7	1336
1958	24.42	25.54	6.257	1035	2.8	152.9	77.7	1373
1959	24.24	25.48	6.261	1035	2.6	165.8	88.3	1629
1960	24.2	24.03	6.262	1035	2.8	173.9	85.3	1725
1961	24.33	24	6.266	1035	2.5	179.6	85.7	1825
1962	24.2	23.99	6.266	1035	2.3	190.9	85.8	1966
1963	23.86	23.96	6.267	1031	2.1	209.2	93.3	2144
1964	23.89	23.93	6.269	1032	2.2	223.2	101.1	2323
1965	23.95	23.84	6.273	1032	2.2	242.6	115.2	2321
1966	23.75	23.7	6.278	1033	2.2	264.3	140.9	2610
1967	23.25	23.55	6.279	1032	2.2	272	161.3	2746
1968	23.06	23.53	6.267	1031	2.2	295.6	188.6	3148
1969	23.04	23.27	6.265	1031	1.9	308.8	251	3488
1970	23.04	22.6	6.251	1031	1.9	318.3	335.5	3932
1971	23.16	22.32	6.245	1031	1.6	325.7	396.5	3976
1972	23.02	22.22	6.22	1027	1.6	350.2	493.8	3977
1973	17.92	22.26	6.223	1024	1.4	387.8	560.2	3660
1974	17.2	21.8	6.215	1022	1.5	390.3	536.3	3443
1975	17.06	21.66	6.229	1026	1.5	404.5	506.1	3158
1976	17.53	21.69	6.235	1023	1.3	447	555.9	3081
1977	17.24	21.48	6.231	1029	1.4	475.7	623.7	3191
1978	17.1	21.28	6.227	1034	1.1	480.2	635.8	3188
1979	17.45	21.38	6.243	1034	1	526	523.3	3491
1980	17.65	21.3	6.249	1034	1	568.3	420.2	3682
1981	17.65	21.3	6.244	1034	1.2	595	350.9	3643

continued

DATA USED FOR FIGURE U.5

Key:

(1) PTHC: Efficiency of coal generation in percent, PTHC=(PC/HC)*100.
(2) PTHP: Efficiency of petroleum generation in percent, PTHP=(PP/HP)*100.
(3) PTNG: Efficiency of natural gas generation in percent, PTNG=(PNG/HNG)*100.
(4) PTHF: Overall efficiency of fossil generation in percent, PTHF=(PF/HF)*100.
(5) HC: Heat content of coal used in generation in millions of kWH at 100% conversion efficiency, HC=(ECA*QCA+ECB*QCB)/3412.
(6) HP: Heat content of petroleum used in generation in millions of kWH at 100% conversion efficiency, HP=(EP*QP)/3412.
(7) HNG: Heat content of natural gas used in generation in millions of kWH at 100% conversion efficiency, HNG=(ENG*QNG)/3.412×10^6.
(8) HF: Total heat content of fossil fuels used in generation in millions of kWH at 100% conversion efficincy, HF=HC+HP+HNG.
(9) ECA: Energy content of anthracite coal sold to utilities in millions of Btu per short ton.
(10) ECB: Energy content of bituminous coal sold to utilities in millions of Btu per short ton.
(11) EP: Energy content of petroleum sold to utilities in millions of Btu per barrel.
(12) ENG: Energy content of natural gas sold to utilities in Btu per cubic foot.
(13) QCA: Quantity of anthracite coal sold to utilities in millions of short tons.
(14) QCB: Quantity of bituminous coal sold to utilities in millions of short tons.
(15) QP: Quantity of petroleum products sold to utilities in millions of barrels.
(16) QNG: Quantity of natural gas sold to utilities in billions of cubic feet.

Note: For PC, PP, PNG, and PF--see Key for Data Used for Figure U.4.

Source: 1981 Annual Report to Congress. QCA, QCB, QP and QNG from T. 68, p. 156; ECA, ECB, EP and ENG from pp. 218, 220, 221; PC, PP, PNG, PF are from T.65, p. 151.

DATA USED FOR FIGURE U.6

YEAR	KTTOPT	KFTOPF	KT	KF	PT	PF
1951	.85946	.87904	75.8	56.9	371	271
1952	.86662	.88305	82.2	61.8	399	293
1953	.86886	.86217	91.5	69.4	443	337
1954	.9144	.91074	102.6	79.4	472	365
1955	.88054	.86537	114.5	89.5	547	433
1956	.84482	.83121	120.7	95.1	601	479
1957	.85929	.85324	129.1	101.9	632	500
1958	.93002	.9395	142.6	113.1	645	504
1959	.92901	.92003	156.8	125.7	710	572
1960	.93852	.93197	168	134.9	753	606
1961	.95976	.95019	180.7	144.8	792	638
1962	.94352	.94061	191.1	153	852	681
1963	.96564	.94871	210.5	169.5	917	748
1964	.95033	.9343	222.3	179.2	984	803
1965	.9414	.93394	236.1	191.4	1055	858
1966	.91118	.89193	247.8	200.9	1144	943
1967	.93314	.92838	269.3	218.2	1214	984
1968	.9214	.90781	291.1	237	1329	1093
1969	.91396	.91238	313.3	256.5	1442	1177
1970	.93797	.92929	341.6	279.9	1532	1261
1971	.96207	.97442	368.9	304.2	1613	1307
1972	.95814	.96225	398.6	326.6	1750	1421
1973	1	1	442.4	359	1861	1503
1974	1.0761	1.1034	477.6	381.9	1867	1449
1975	1.1148	1.1674	508.3	402.1	1918	1442
1976	1.096	1.1274	531	419.8	2038	1559
1977	1.1095	1.1197	560.2	441	2124	1649
1978	1.1045	1.1548	579.2	454	2206	1646
1979	1.1201	1.1464	598.3	467.7	2247	1708
1980	1.1289	1.1448	613.5	479.6	2286	1754
1981	1.164	1.1836	634.5	495.6	2293	1753

Key:

(1) KTTOPT: The ratio of U.S. total rated generation capacity in kW to total generation of electricity in kWH, each computed as a ratio to their 1973 values. KTTOPT(I)=(KT(I)/KT(1973))/(PT(I)/PT(1973)); I=1951,1952,...1981.

(2) KFTOPF: The ratio U.S. fossil rated generation capacity in kW to the U.S. fossil generation of electricity in kWH, each computed as ratio to their 1973 values. KFTOPF(I)=(KF(I)/KF(1973))/PF(I)/PF(1973)); I=1951,1952,...1981.

(3) KT: The rated generation capacity of all U.S. plants in millions of kW.

(4) KF: The rated generation capacity of U.S. fossil-fueled plants in millions of kW.

(5) PT: Total electricity generated in the United States, billions of kWH/year. Data are given in Figure U.1.

(6) PF: Total electricity generated from fossil fuels in the United States, billions of kWH/year. Data are given in Figure U.1.

Source: 1981 Annual Report to Congress, DOE/EIA. KT and KF from T. 70, p. 159.

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