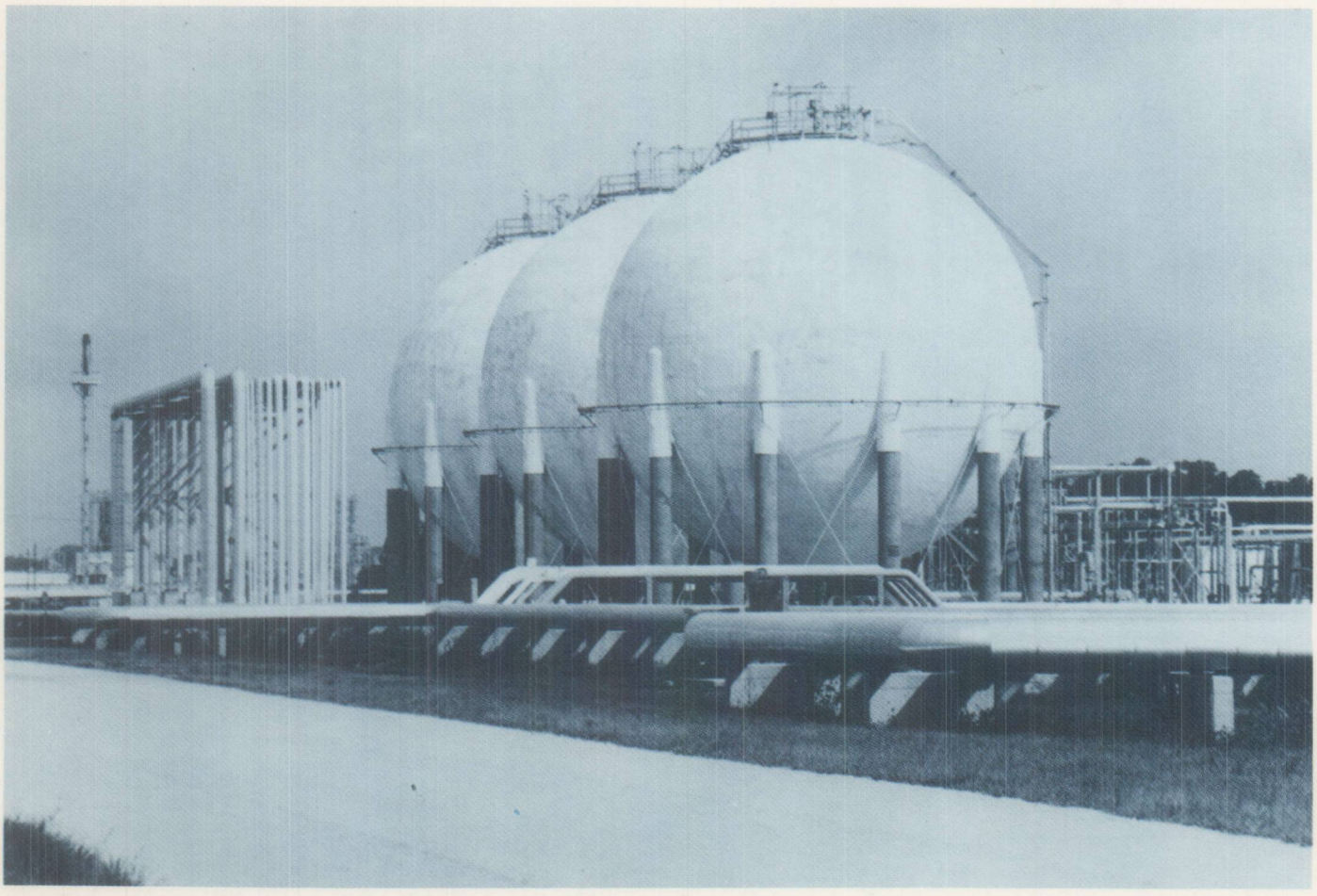
DOE/EIA-0516(85)

Energy Information Administration

Manufacturing Energy Consumption Survey: Changes in Energy Efficiency 1980-1985



This publication is available from the Superintendent of Documents, U. S. Government Printing Office (GPO). Information about purchasing this or other Energy Information Administration (EIA) publications may be obtained from the GPO or the EIA's National Energy Information Center (NEIC). Questions on energy statistics should be directed to the NEIC by mail, telephone or, telecommunications device for the deaf (TDD). Addresses, telephone numbers, and hours appear below:

National Energy Information Center, EI-231
Energy Information Administration
Forrestal Building, Room 1F-048
Washington, DC 20585
(202) 586-8800
Telecommunications Device for the Deaf Only:
(202) 586-1181
Hours: 8 a. m. - 5 p. m., M-F, Eastern Time

Superintendent of Documents
U. S. Government Printing Office
Washington, DC 20402
(202) 783-3238

Cover photo: A series of product storage tanks.

PHOTO CREDIT
Chemical Manufacturers Association

Released for Printing January 17, 1990

Contents

Tables

Illustrations

Executive Summary

In recent years, the consumption of energy by the manufacturing sector in the United States has been declining while production has been increasing. These increases in production and corresponding decreases in energy consumption can result from manufacturers consuming energy in a more efficient manner to produce a given level of output. The less energy consumed to produce a constant level of output, the more the process is energy efficient.

The ratio of offsite-produced energy consumption to constant dollar value of shipments is a measure of energy efficiency for any given year. The percent change in these ratios from one year to another produces a measure of the *change* in energy efficiency. A *decrease* in the ratio from one year to another indicates an *increase* in energy efficiency. The 1985 Manufacturing Energy Consumption Survey (MECS), conducted by the Energy Information Administration (EIA), and the 1980 Annual Survey of Manufactures (ASM), conducted by the Bureau of the Census, provide the basis for estimating changes in energy efficiency for the manufacturing sector between 1980 to 1985. Table ES1 summarizes the changes in energy efficiency between 1980 and 1985 for the industry groups within the manufacturing sector.

Important Changes Between 1980 and 1985

- **Manufacturing Sector Energy Efficiency Improved by 25 Percent.** Between 1980 and 1985, the consumption of purchased energy by the manufacturing sector *declined* from 11,947 trillion British thermal units (Btu) to 9,698 trillion Btu, a decrease of nearly 19 percent. The total amount of that decrease is roughly equal to the annual energy consumption of 21 million households. During the same period, the output of the manufacturing sector *increased* by 8 percent. These changes resulted in an overall improvement in energy efficiency of 25 percent between 1980 and 1985.

- **Energy-Intensive Manufacturing Industry Groups Improved Efficiency by 17 Percent.** The five manufacturing industry groups that historically have consumed the most energy are paper and allied products; chemicals and allied products; petroleum and coal products; stone, clay and glass products; and primary metals. Together, these manufacturing industry groups consumed 8,624 trillion Btu of purchased energy in 1980, or 72 percent of the total consumption by manufacturers. By 1985, the consumption had decreased to 6,842 trillion Btu, or 71 percent of the consumption by manufacturers. Between 1980 and 1985, purchased energy consumption *decreased* by 21 percent. During this same period, the combined output of these industry groups *decreased* by five percent. The combined energy efficiency of these industry groups *increased* by 17 percent over this 5-year period.

The 1985 MECS is the first of a triennial series of national surveys of energy use by manufacturing establishments in the United States. The MECS sample includes establishments from all major manufacturing industry groups in the manufacturing sector. This report is the fourth of a series of reports based on data from the 1985 MECS. Other reports in the series cover energy consumption, fuel-switching capabilities, and the survey methodology.[1]

Table ES1. Energy Efficiency Changes in Manufacturing Industry Groups, 1980 - 1985

SIC Code[a]	Industry Group	Energy Efficiency Ratios[b]		Energy Efficiency Change[c,d] (percent)
		1980	1985	
20	Food and Kindred Products	3.5	2.7	22.9
21	Tobacco Manufactures	Q	Q	Q
22	Textile Mill Products	5.7	4.8	16.3
23	Apparel and Other Textile Products	NA	NA	NA
24	Lumber and Wood Products	Q	Q	Q
25	Furniture and Fixtures	1.9	1.6	17.4
26	Paper and Allied Products	16.0	13.9	13.0
27	Printing and Publishing	1.1	0.9	15.2
28	Chemicals and Allied Products	15.1	12.4	17.6
29	Petroleum and Coal Products	5.4	4.4	19.8
30	Rubber and Misc. Plastics Products	4.3	3.1	27.8
31	Leather and Leather Products	Q	Q	Q
32	Stone, Clay and Glass Products	21.6	16.6	23.0
33	Primary Metal Industries	16.4	14.6	11.0
34	Fabricated Metal Products	2.8	2.3	16.4
35	Machinery, Except Electrical	1.7	0.9	43.6
36	Electrical and Electronic Equipment	1.7	1.2	26.4
37	Transportation Equipment	1.5	1.1	25.0
38	Instruments and Related Products	1.7	1.2	29.3
39	Misc. Manufacturing Industries	1.8	1.4	23.9
--	**All Manufacturing**	5.8	4.4	25.1

[a]See Appendix A for a description of the Standard Industrial Classification Codes.

[b]Thousand British thermal units per constant (1980) dollar of value of shipments.

[c]A decrease in the energy efficiency ratios from 1980 to 1985 indicates an improvement in energy efficiency, and, thus, a positive value for "energy efficiency change."

[d]The estimates of energy efficiency change are calculated from *unrounded* energy efficiency ratios, and may differ from changes calculated from the rounded ratios in columns 1 and 2.

Q=Withheld because relative standard error is greater than or equal to 50 percent.

NA=Not available.

Sources: Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA-0512(85) (Washington, DC, 1988), and unpublished data provided by the U.S. Department of Commerce, Bureau of the Census, Industry Division, from the *Annual Survey of Manufactures*.

[1]Published reports are available from the National Energy Information Center (NEIC) or the U.S. Government Printing Office (GPO). Addresses and telephone numbers are provided on the inside front cover of this report.

Introduction

Joint industry-government efforts to stimulate energy conservation began immediately following the 1973 oil embargo. Early programs concentrated primarily on awareness programs and establishing conservation goals.

In 1975, the enactment of the Energy Policy and Conservation Act (EPCA) required the establishment of an Industrial Energy Conservation Program (Efficiency Program) including mandatory reporting. The Efficiency Program was administered by the Office of Industrial Programs (OIP) of the U.S. Department of Energy.[2]

The OIP, in cooperation with representatives of the manufacturing sector, developed voluntary energy efficiency improvement targets for the 10 most energy-intensive manufacturing industry groups and established a tracking program to monitor progress toward these targets. The tracking program was eventually expanded to cover all 20 of the industry groups in the manufacturing sector, although indicators were actually developed for only 16 of those groups. The remaining four industry groups did not qualify under the minimum size criterion developed for the program.

The tracking program consisted of developing indicators of energy efficiency change for industry groups from data supplied by the largest energy-consuming corporations. For the Efficiency Program, energy efficiency was defined as energy consumption per unit of physical production. The changes in energy efficiency were calculated by comparing the energy efficiency ratios in the current year with the efficiency ratios that existed in an earlier base year (1972 or 1978). The changes were calculated by determining the percent difference between actual current energy consumption and the amount of energy that would have been required to produce current year output at base year efficiency levels. Thus, a decrease in the energy efficiency ratios between the base year and the current year indicated improved energy efficiency.

The U.S. Congress eliminated the Efficiency Program with the passage of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509, as amended.

Section 310(a) of the 1986 Reconciliation Act also mandated the Manufacturing Energy Consumption Survey (MECS). The MECS was first conducted in 1986 to collect 1985 data. This first survey was conducted prior to the passage of Public Law 99-509, and was, therefore, conducted under the authority of the Federal Energy Administration Act of 1974, Public Law 93-275, as amended. Future surveys will be conducted every three years under the authority of Section 310(a) of Public Law 99-509. The MECS is designed and published by the Energy Information Administration. The data are collected and compiled by the Industry Division of the U.S. Bureau of the Census (Census Bureau). All MECS responses submitted to the Census Bureau are confidential under the provisions of Section 9, Title 13 of the U.S. Code.

The primary purposes of the MECS are to provide estimates of energy consumption and fuel-switching capability for the manufacturing sector. However, by supplementing the MECS data with data collected by the Bureau of the Census in the 1980 and 1985 Annual Survey of Manufactures (ASM), it is also possible to develop estimates of changes in energy efficiency from 1980 to 1985.

The purpose of this report is to present the MECS/ASM estimates of the changes in energy efficiency by manufacturing industry groups between 1980 and 1985, and to compare those estimates with those of the Efficiency Program. These comparisons are necessary because the two programs are

[2]See Appendix C for a more complete description of the Energy Efficiency Improvement Program.

incompatible in a number of respects: base years, survey coverage, definitions of energy consumption, and measures of output. The MECS/ASM estimates, for example, define energy efficiency as the ratio of offsite-produced energy consumption to a measure of output defined as the constant dollar value of shipments. The Efficiency Program, on the other hand, based its efficiency ratios on a measure of total energy consumption (including the consumption of onsite-produced byproduct fuels) to physical output.

This report is the fourth of a series based on the results of the 1985 MECS. The data in this report are published to provide objective, accurate energy information for a wide audience including Congress, Federal and State agencies, industry, and the public. The MECS is the first survey conducted by the EIA to collect detailed data on energy use by the manufacturing sector. The MECS does not include energy data for mining, agriculture, construction, fishing, forestry activities, or electric utilities. Other publications in the MECS series include reports on energy consumption and fuel-switching capability, and a methodological report.[3]

The MECS data are included in the Longitudinal Manufacturing Energy Data System (LMEDS) maintained by the Bureau of the Census. The LMEDS file includes yearly data from 1972 to 1986 for individual establishments that responded to the 1985 MECS. The file of approximately 10,000 establishments contains information collected in two Bureau of the Census surveys, the Census of Manufactures and the Annual Survey of Manufactures, as well as the 1985 MECS. The Bureau of the Census surveys provide data on over 70 variables including employment, payroll, value of shipments, capital expenditures, assets, and supplemental labor costs. The file also contains annual data on the consumption of specific types of fuel for 1974 through 1981.[4]

The EIA gratefully acknowledges the cooperation of respondents in supplying information for the 1985 MECS.

[3]See Appendix E, Related EIA Publications on Energy Consumption.

[4]A researcher interested in using LMEDS should send a research proposal to the EIA for consideration. The EIA, in consultation with the Bureau of the Census, will examine the proposal and review with the researcher how the use of the file may benefit the proposed research. If the use of the LMEDS is deemed appropriate, the Bureau of the Census will perform the work on a cost-reimbursable basis.

Surveying the Manufacturing Sector

Manufacturing Sector Consists of Business Establishments that Produce Goods

The manufacturing sector consists of establishments that use mechanical or chemical processes to transform materials or substances into new products. These products may be final products that consumers will purchase, such as an automobile or a chair. Manufacturers also produce goods for use by other manufacturers such as parts for automobile engines or rolls of upholstery fabric.

An establishment is usually at a single physical location and is often called a plant, factory, or mill. It ordinarily uses power-driven machines and equipment for handling materials. A manufacturing establishment may also assemble parts or perform blending operations.

The Office of Management and Budget developed procedures for classifying manufacturing and nonmanufacturing establishments into industry classes. Those procedures are known as the Standard Industrial Classification (SIC) system.[5] Each industry class consists of establishments that produce similar types of goods or services.

The SIC system divides the manufacturing sector into 20 broad groups, and assigns a numerical code to each of those groups. For the manufacturing sector, the codes range from 20 through 39. For example, SIC 26 consists of establishments that manufacture paper and allied products. The SIC system subdivides each of the broad industry groups into several specific industries and assigns each a four-digit code. For example, the paper and allied products industry group (SIC 26) contains 17 specific industries. SIC 2621 includes establishments classified as paper mills, and SIC 2631 includes paperboard mills.

If an establishment produces more than one good or service, it is classified into a four-digit industry based upon its *primary* production (see Glossary). For example, an establishment that primarily engages in manufacturing paper from wood pulp, and also manufactures some paperboard, is classified in the paper mill industry (SIC 2621). It is not classified in the paperboard mill industry (SIC 2631).

MECS Samples Establishments in All the Major Industry Groups

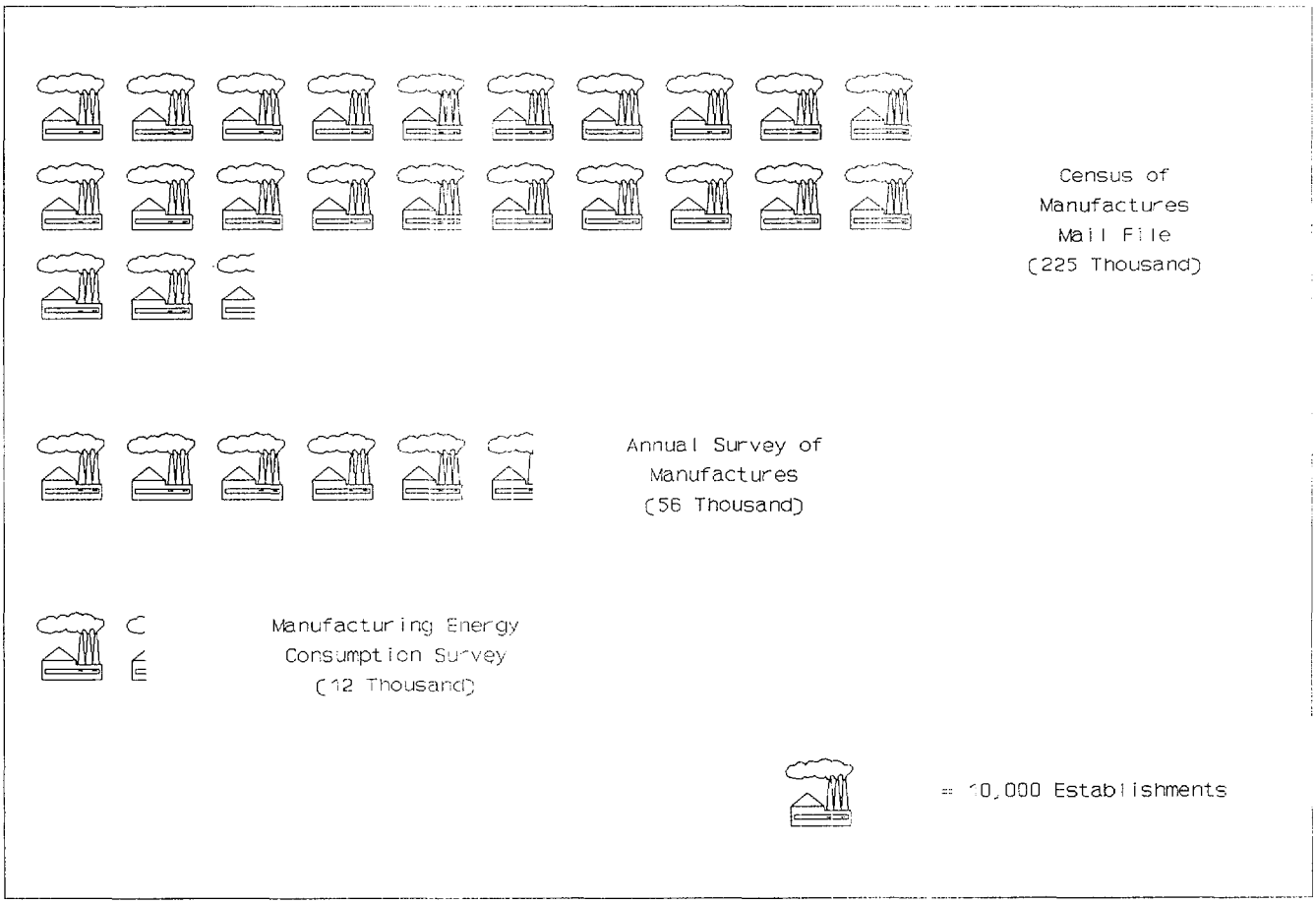
The estimates of energy efficiency change presented in this report are based on 1985 data collected by the MECS, and on 1980 and 1985 data collected by the ASM. The EIA included several important considerations in the criteria for the design of the MECS sample. Specifically, the sampling procedures assure that the MECS sample is representative of the population of establishments from which it was drawn. Also, the size of the sample in each industry class was controlled so error levels of the survey estimates would be similar for each class.

The MECS sample is a subset of the mail sample used by the Census Bureau to collect data for the ASM. The ASM sample includes 56,000 manufacturing establishments. The ASM sample is, in turn, a subset of the mail file of 225,000 manufacturing establishments used by the Census Bureau to conduct the Census of Manufactures. The Census of Manufactures is conducted every five years, while the ASM is conducted annually. The Census Bureau selected about 12,000 manufacturing establishments from the ASM sample to serve as the MECS sample. The approximate relationships among these various samples are shown in Figure 1. See Appendix A for a comprehensive discussion of the sampling and estimation procedures for the MECS.

[5]Office of Management and Budget, *Standard Industrial Classification Manual, 1972* (Washington, DC, 1982).

The MECS sample was stratified to provide controlled representation from each of the 20 major manufacturing indsustry groups (two-digit SIC codes) that make up the manufacturing sector. In addition, representation was controlled in the 10 specific industries (four-digit SIC codes) that historically have consumed the most energy. Thus, the MECS sample not only represented all major manufacturing industry groups, it also had a high probability of including the major energy-consuming establishments in the universe of manufacturing establishments. (See Appendix D for descriptions of the 20 major industry groups.)

Figure 1. Sample Sizes for Surveys of the Manufacturing Sector



Source: Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Methodological Report 1985,* DOE/EIA-0514(85) (Washington, DC, 1988), p. 7.

Energy Efficiency in the Manufacturing Sector

Energy Efficiency Is an Input-Output Measure

"Efficiency" is typically defined as the ratio of useful output to the total input in any system. Fuel efficiency in automobiles, for example, is measured as the ratio of miles (output) per gallon of gasoline (input). Such output-input measures are, basically, measures of productivity--that is, they measure the consumption of a fixed amount of input to produce a variable amount of output. The basic concept of fuel-efficiency is to produce as many miles as possible with a given amount of input.

The concept of energy efficiency, however, is to consume the minimum amount of energy while producing a fixed amount of output. In other words, the demand for the output is to be fulfilled as efficiently as possible with respect to energy consumption. Therefore, in this report, energy efficiency is defined as the ratio of energy consumption (input) to production (output). More specifically, energy consumption is defined as the energy that was consumed onsite and produced offsite. Output is defined as the value of shipments expressed in constant dollars. This report presents changes in these energy-efficiency ratios from 1980 to 1985. A *decrease* in the energy efficiency ratios between these two years indicates an *increase* in energy efficiency, and visa versa.

There are several alternative measures of energy consumption and output that could have been used to measure energy efficiency. The following sections describe some of these alternatives and present the reasons for selecting offsite-produced energy and constant dollar value of shipments as the components of the energy-efficiency ratios.

Offsite-Produced Energy Is the Consumption Measure for Computing Efficiency

The primary reason for selecting offsite-produced energy as the measure of energy consumption is that it is the only measure for which comparable estimates are available for both 1980 and 1985. The 1985 estimates of offsite-produced energy consumption by manufactures come directly from the MECS.[6] Comparable consumption estimates for the base year of 1980 were taken from the 1980 ASM.[7]

- **Offsite-produced energy consumption** is the total amount of energy purchased or transferred from offsite sources that is consumed onsite to produce heat and power and to generate electricity.

The use of energy by establishments in the manufacturing sector, however, is much more complex than simply purchasing or transferring energy from offsite sources and consuming it to produce heat and power and to generate electricity. Some manufacturers transform energy into other products (including other fuels), and some produce useful energy as a byproduct of their manufacturing process. The MECS deals with this complexity by using two additional methods for measuring energy consumption.[8]

- **Primary energy consumption** consists of the total energy requirements (including raw material inputs of energy) of manufacturing industries to produce goods.

- **Total inputs of energy** represents the total amount of energy used to produce heat and power and to generate electricity. Total inputs of energy differs from primary consumption in that total inputs does

[6]Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Consumption of Energy 1985,* DOE/EIA-0512(85) (Washington, DC, 1988), Table 7.

[7]U.S. Department of Commerce, Bureau of the Census, *1980 Annual Survey of Manufactures*, "Fuels and Electric Energy Consumed," M80(AS)-4.1 (Washington, DC, August 1982).

[8]Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Consumption of Energy 1985*, Tables 1 and 3.

does not include energy consumed as raw material (feedstock) inputs. Total inputs of energy differs from offsite-produced energy consumption in that it includes fuels that are byproducts of the manufacturing process. Byproduce fuels are excluded from offsite-produced energy consumption. Electricity is measured on a net basis. That is, it is obtained by summing purchases, transfers in, and generation from noncombustible renewable resources minus quantities sold and transferred out.

Using offsite-produced energy in the calculation of energy efficieny ratios does have its limitations because the resulting ratios do not include the effect of switching from offsite-produced energy to byproduct and other energy produced onsite. Such switches are energy-efficient in their own right and should be reflected in the energy efficiency ratios.

The 1985 MECS is the first energy consumption survey to provide these three distinct measures of energy consumption, and future MECS will collect the same three measures. This will allow future reports to present estimates of energy-efficiency change using all three of these measures of energy consumption. The differences among the three measures of energy consumption are discussed in detail in Appendix A.

Manufacturing Output Is Measured by Value of Shipments

The estimates of changes in energy efficiency presented in this report are based on energy-efficiency ratios calculated from constant dollar value of shipments as the measure of output. The value of shipments is collected as a part of the ASM. The Census Bureau defines the value of shipments including the receipts for products manufactured, services rendered, and resales of products bought and resold without further manufacture.[9] Changes in the output of an establishment result in corresponding changes in its value of shipments and receipts. Physical output and the value of shipments are, therefore, correlated.

A change in the value of shipments from one period to another reflects more than just changes in output, however. A change may also reflect an increase (or decrease) in price resulting from inflation (or deflation). Such price changes do not represent a change in output. Therefore, before using estimates of the value of shipments as an output measure, they should be adjusted for the effect of changes in price.

The U.S. Bureau of Labor Statistics (BLS) publishes many "price indices." Government agencies and the private sector use these indices to adjust for inflation and deflation. The best known of these indices is the Consumer Price Index (CPI). The BLS describes the CPI as "... a measure of the average change in prices paid by urban consumers for a fixed market basket of goods and services."[10] The CPI is commonly used to convert average net family income to purchasing power.

The BLS also publishes a series known as the "industry price index." This index, as described by the BLS, is a price series that follows "... the general economic pattern of a particular industry."[11] The industry price index can be used to convert the value of shipments and receipts to a constant dollar measure which excludes the effect of price changes. Changes in the adjusted value of shipments from one period to another closely correspond to changes in physical output.

An alternative measure of output for the manufacturing sector is the physical quantity of the good produced. For example, the output of a broadwoven cotton fabric mill (SIC 2211) might be measured in linear yards of fabric. A major difficulty with that approach, however, is that physical quantities are product-specific. Few establishments and no 4-digit industry produce a single product line. A broadwoven fabric mill may produce woven fabrics measured in linear yards and sheets and pillow cases measured in dozens. Because they have no common basis, physical quantity measures are inappropriate for measuring the total output of a multiproduct establishment.

[9]U.S. Department of Commerce, Bureau of the Census, *1985 Annual Survey of Manufactures*, "Statistics for Industry Groups and Industries," M85(AS)1 (Washington, DC, January 1987), p. A-2.

[10]U.S. Department of Labor, Bureau of Labor Statistics, *BLS Handbook of Methods*,Volume II, Bulletin 2134-2 (Washington, DC, April 1984), p. 3.

[11]U.S. Department of Labor, Bureau of Labor Statistics, *BLS Handbook of Methods*, Volume I, Bulletin 2134-1 (Washington, DC, December 1983), p. 49.

Using product-specific physical quantities for the development of energy-efficiency ratios would not be a serious problem if energy consumption estimates also were available for each product line. However, manufacturing establishments usually monitor total energy consumption only. When necessary, they estimate energy consumption for each product line. In the interest of reducing respondent burden, the MECS did not try to collect energy consumption for specific products.

Value added by manufacture, published by the Census Bureau, was considered as the measure of output for developing the estimates of energy-efficiency change that appear in this report. It was rejected in favor of the value of shipments and receipts. A complete discussion of the reasons for selecting the value of shipments over value added appears in Appendix A of this report.

Measuring Energy-Efficiency Changes from 1980 to 1985

The purpose of this report is to present the percent changes in energy-efficiency ratios from 1980 to 1985 for the two-digit industry groups of the manufacturing sector. The first step in determining these ratios consisted of deriving constant dollar value of shipments for use as an output measure. The Census Bureau provided estimates of the 1980 and 1985 value of shipments and receipts for each of the 20 manufacturing industry groups. The BLS provided industry price indices for the same years and industry groups. The EIA expressed the 1985 value of shipments in constant 1980 dollars to remove the effect of price changes between 1980 and 1985. Energy consumption estimates (offsite-produced energy) for 1985 were available for each of the 20 manufacturing industry groups from the MECS. Comparable energy consumption estimates for 1980 were available from the ASM.

Energy-efficiency ratios (offsite-produced energy consumption per constant dollar of value of shipments) were prepared for each two-digit manufacturing industry group for 1980 and 1985. That calculation consisted of dividing the energy consumption for each two-digit SIC industry group by its corresponding constant dollar value of shipments (output).

Measures of the change in energy efficiency were developed for each of the 20 manufacturing industry groups by calculating the percent change from the 1980 ratio to the 1985 ratio. The results for 16 of the 20 manufacturing industry groups are published in this report. The results for four industry groups were withheld because either their relative standard errors (RSE) exceeded 50 percent, or the estimates of energy consumption for 1980 and 1985 were not comparable. (A complete discussion of RSE's appears in Appendix B of this report.)

Other Measures of Energy Efficiency

The Energy Policy and Conservation Act of 1975, Public Law 94-163, mandated the creation of the Industrial Energy Efficiency Improvement Program (Efficiency Program) at the Department of Energy (DOE). A major responsibility of that program was to monitor the progress of industry toward meeting voluntary energy efficiency improvement targets. Beginning in 1976, DOE monitored this progress by requiring selected manufacturing corporations to submit annual reports of "energy efficiency improvement."

Estimates of energy efficiency improvement were calculated using physical output measures and estimated energy consumption for individual product lines. These measures were then compared with comparable data for a "base year:" 1972 for most respondents, and 1978 for the others. An "improvement index" was calculated for each year through 1985 for most of the major manufacturing industry groups (two-digit SIC). The U.S. Congress eliminated the Efficiency Program with the passage of the Omnibus Budget Reconciliation Act of 1986.

The indices resulting from the Efficiency Program are reproduced in this report (rebased to cover the period from 1980 to 1985) as a basis for comparison with the efficiency changes based on the MECS and ASM. There are several differences between the two programs, however, which can cause them to produce different estimates of energy efficiency change for the same industry. These differences and some of the possible effects are summarized in the box on page 10. See Appendix C for a more complete discussion of the Efficiency Program and the differences between that program and the MECS.

MECS and Industrial Energy Efficiency Improvement Program Differ in Definitions and Coverage

There are five basic differences between the MECS and the Industrial Energy Efficiency Program (Efficiency Program). These differences can result in substantial discrepancies between the measures of changes in energy efficiency from the two data sets.

- **Differences in the base years**--The MECS/ASM measures of energy efficiency change presented in this report use 1980 as a base year. The Efficiency Program used 1972 or 1978 as a base year, depending on the desires of the respondent. To make the two series more comparable, the EIA rebased the Efficiency Program indices to 1980, so that *both* series reflect changes in energy efficiency for the same period--1980 to 1985.

- **Differences in survey coverage**--The samples for the MECS and the ASM include establishments that represent the entire manufacturing sector. The sample for the Efficiency Program, however, was not designed to represent the entire manufacturing sector. Rather, it was designed to monitor the progress of energy conservation activities in those U.S. corporations that consumed at least one trillion Btu per year in any two-digit SIC industry group. Thus, the sample selection procedures for the Efficiency Program tended to exclude smaller energy-consuming establishments. The effect of these differences in coverage varies among industries. Some industries contain mostly larger plants (petroleum and coal products, for example), and were well-represented in the Efficiency Program. The MECS/ASM and the Efficiency Program estimates of changes in energy efficiency for these industry groups should not differ appreciably because of sample coverage. Other industries include a large number of smaller plants (food and kindred products, for example). The sample for the Efficiency Program was not representative for these industries. Differences in the estimates of changes in energy efficiency due to sample coverage can be expected in these industries.

- **Differences in measures of output**--The efficiency measures from the MECS/ASM use constant dollar value of shipments as a measure of output. The Efficiency Program used physical output. In most cases, the effect of this difference is expected to be small because changes in physical output are accompanied by corresponding changes in constant dollar value of shipments. However, energy-efficiency changes based on constant dollar value of shipments do not reflect changes in product mix during the period. The Efficiency Program was designed to reflect changes in product mix. When product mix effects energy consumption, differences between the MECS/ASM and the Efficiency Program estimates are likely.

- **Differences in the definitions of energy consumption**--The energy consumption measure used in the calculation of the MECS/ASM efficiency measures is offsite-produced energy consumption. For all manufacturing industry groups except paper and allied products, the Efficiency Program used an energy consumption measure which included byproduct fuels with purchased fuels, and is similar to the MECS estimate of total inputs of energy. The increased use of byproduct fuels as an energy conservation measure tends to result in decreased use of offsite-produced energy. Shifts from offsite-produced energy to byproduct fuels would be reflected as efficiency gains by the MECS/ASM estimates, but not by the Efficiency Program estimates. For paper and allied products, the Efficiency Program used an energy consumption measure that included offsite-produced energy sources only.

- **Differences in the measurement of the heat content of electricity**--The Efficiency Program used a conversion factor of 3,412 British thermal unit (Btu) per kilowatthour of electricity for all industry groups except chemicals and allied products (SIC 28) and petroleum and coal products (SIC 29). The conversion factor for those two industry groups was 10,000 Btu per kilowatthour. The conversion factor used in the MECS was 3,412 for all industry groups. This discrepancy could result in minor differences in the estimates of change in energy efficiency for these two industry groups.

Energy Efficiency Change In the Manufacturing Industry Groups, 1980 - 1985

The remainder of this report presents estimates of changes in energy efficiency from 1980 to 1985 for 16 of the 20 major manufacturing industry groups (2-digit SIC). Four manufacturing industry groups are excluded. These groups are tobacco manufacturers (SIC 21), apparel and other textile products (SIC 23), lumber and wood products (SIC 24), and leather and leather products (SIC 31). The results for SIC's 21, 24, and 31 are not included because the estimates had relative standard errors (RSE) which exceeded 50 percent. (RSE's for the estimates of change in energy efficiency are included in Appendix B.) The results for SIC 23 are not published because the apparel industry consists of many jobbers, contractors, and manufacturers, making it difficult to produce comparable estimates of energy consumption from one year to another. Such year-to-year fluctuations would distort the measures of energy efficiency included in this report.

Each of the 16 presentations of changes in energy efficiency includes three graphs and a brief discussion. The first graph presents a historical overview of the relationship of energy consumption and output from 1974 through 1985. It provides indices of energy consumption and output. Both indices have a base year of 1974 (that is, 1974 = 100). The output indices were calculated using estimates of the value of shipments as published by the ASM. Those estimates were converted to constant (1980) dollars using the industry price indices provided by the Bureau of Labor Statistics (BLS). The energy consumption indices were calculated from estimates of purchased fuels and electricity from the ASM for 1974 through 1981. The MECS estimate of offsite-produced energy consumption was used for 1985. Estimates of energy consumption for 1982 through 1984 are not available.

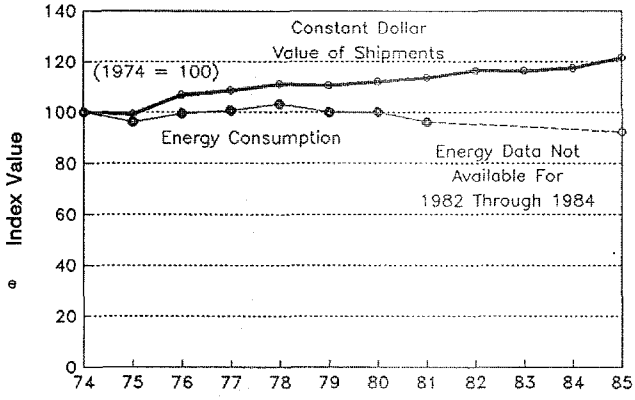
The second graph presents estimates of the percent change in energy efficiency using data from the MECS and the ASM and, where available, the Efficiency Program. The estimates are the percent change in energy consumption per unit of output from 1980 to 1985. To improve comparability between the two series, the Efficiency Program estimates of energy efficiency change were rebased to 1980.

Note that the first graph uses ASM-weighted value of shipments for the calculation of the historic measures of output. (See Appendix A for an explanation of sampling weights.) However, the MECS/ASM estimates of the percent change in energy efficiency presented in the second graph use specially-prepared estimates of the value of shipments using the MECS weights. (It was necessary to use the MECS-weighted estimates of value of shipments so that the resulting values would be fully comparable to the MECS estimates of offsite-produced energy consumption.) The difference between the estimates of value of shipments is small for most industry groups. There are a few industry groups, however, for which the MECS-weighted and ASM-weighted estimates differ substantially. As a result, the reported percent change in energy efficiency may differ substantially from what might be expected by examining the historical trends in the first graph.

The third graph presents three measures of 1985 energy consumption: total inputs of energy and total offsite-produced energy consumption from the MECS, and energy consumption from the Efficiency Program. The *difference* between the two MECS estimates of energy consumption is *approximately* equal to byproduct fuel consumption. This difference is useful in determining whether the use of byproduct fuels could explain a difference between the MECS/ASM and Efficiency Program estimates of changes in energy efficiency. The difference between the MECS estimate of total inputs of energy and the energy consumption estimate from the Efficiency Program is useful in determining whether the coverage of the two samples is similar. (See box on page 8 for details.)

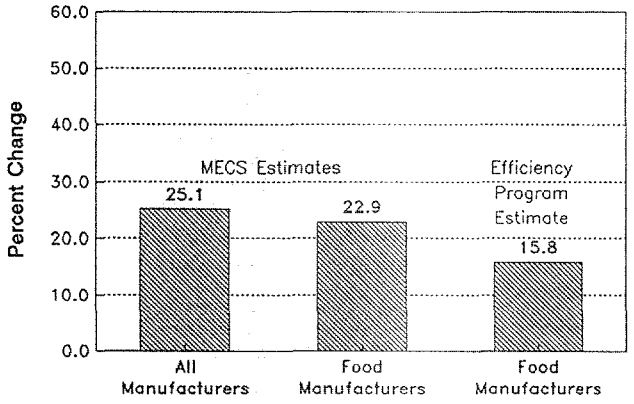
Food and Kindred Products Industry Group, 1980 - 1985

Figure 2. Output and Energy Consumption Indices, SIC 20, 1974 to 1985



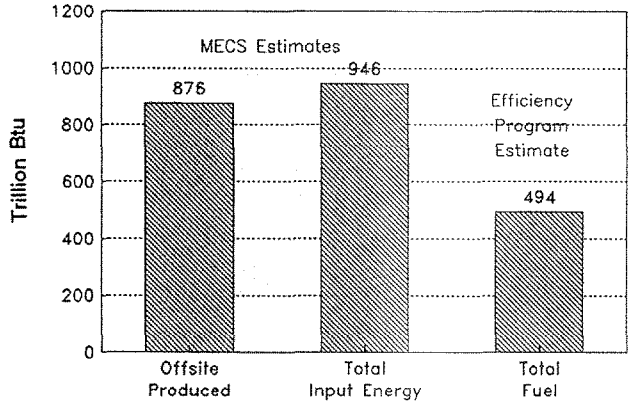
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 3. Percent Change in Energy Efficiency, SIC 20, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 4. Energy Consumption, SIC 20, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the food and kindred products industry group (SIC 20) increased by approximately 22 percent (Figure 2). Output decreased slightly in 1975, 1979, and 1983. Otherwise, the increases were fairly consistent from year to year. During the same period, the consumption of offsite-produced energy decreased by 8 percent. The largest single-year decreases occurred from 1974 to 1975, and from 1978 to 1979. From 1975 through 1978, energy consumption and output moved in the same direction. As output increased, so did energy consumption. Beginning in 1979, however, output continued to increase while energy consumption decreased.

Energy Efficiency, 1980 - 1985

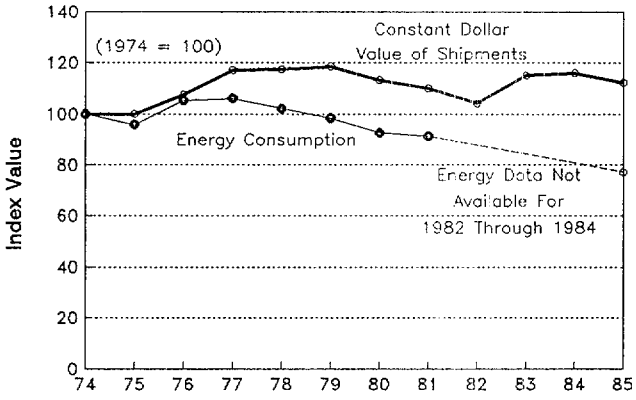
According to the MECS estimates, food manufacturers improved their energy efficiency by 23 percent between 1980 and 1985 (Figure 3). For the same period, the estimate from the Efficiency Program was 16 percent. The difference between the two estimates of efficiency change was within the bounds of sampling error.

While food processing plants use some byproduct fuels (particularly biomass and waste materials), most energy consumption in 1985 was of offsite-produced energy (Figure 4). Therefore, there would be no expected difference between the MECS/ASM and Efficiency Program estimates of energy efficiency change as a result of shifts from offsite-produced to byproduct fuel use.

The MECS reported that food manufacturers consumed 946 trillion Btu of energy for total fuel consumption in 1985. The Efficiency Program estimate for the same year was 494 trillion Btu (Figure 4). The Efficiency Program collected data primarily from the largest establishments. The MECS collected data representing the entire industry group. Therefore, the two estimates of energy efficiency change do not cover the same populations. The difference in coverage, however, caused no statistically discernable effect on the change in energy efficiency as measured by the two systems.

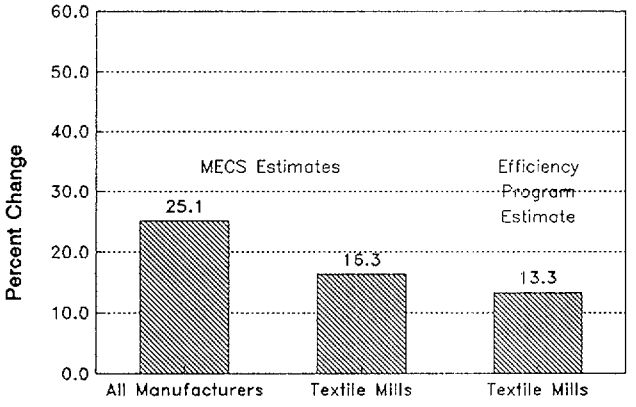
Textile Mill Products Industry Group, 1980 - 1985

Figure 5. Output and Energy Consumption Indices, SIC 22, 1974 to 1985



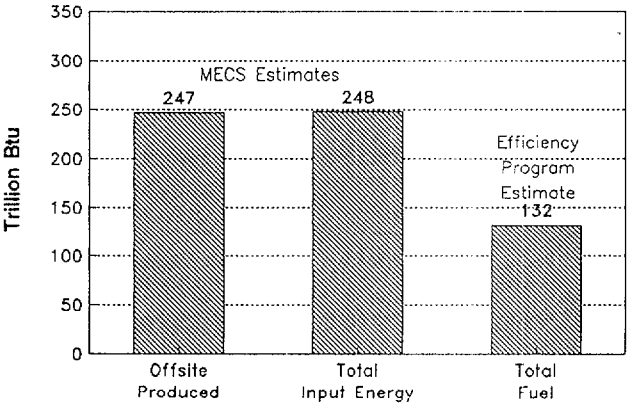
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 6. Percent Change In Energy Efficiency, SIC 22, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 7. Energy Consumption, SIC 22, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the textile mill industry group (SIC 22) increased approximately 12 percent (Figure 5). Major increases in output occurred in 1976, 1977, and 1983. Large decreases occurred in 1980 through 1982, and 1985. The consumption of offsite-produced energy during the period from 1974 to 1985 decreased approximately 23 percent. The only year in which energy consumption increased was 1977. After that, consumption declined steadily. Until 1981, energy consumption generally paralleled the output trend. However, by 1985, consumption showed a continued decline while output had increased.

Energy Efficiency, 1980 - 1985

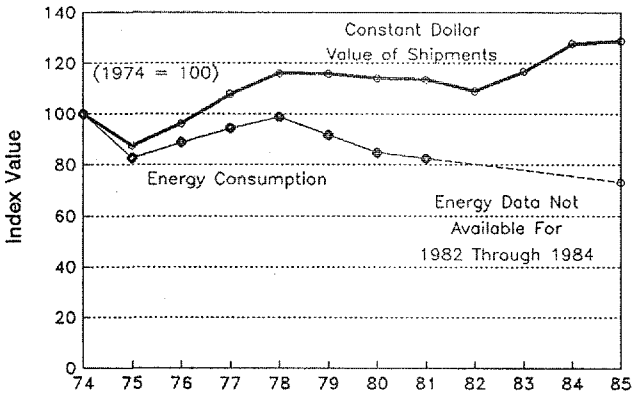
Manufacturers of textile mill products improved their energy efficiency by 16 percent between 1980 and 1985, according to MECS/ASM estimates (Figure 6). For the same period, the estimate from the Efficiency Program was 13 percent. The small difference between the two surveys' efficiency estimates was within the bounds of sampling error.

Most of the energy used in this industry group was produced offsite (Figure 7). Thus, there would be no expected difference between the MECS and the Efficiency Program estimates of energy efficiency change as a result of shifts from offsite-produced to byproduct fuel use.

The MECS reported that the manufacturers of textile mill products consumed 248 trillion Btu in 1985 (Figure 7). During the same year, the Efficiency Program estimate was 132 trillion Btu. The Efficiency Program collected data primarily from the larger establishments which explains why its estimate for consumption is 47 percent less than the MECS estimate. Because of this, the two estimates of energy efficiency change do not cover the same populations. This difference in coverage, however, caused no statistically discernable effect on the change in energy efficiency as measured by the two systems.

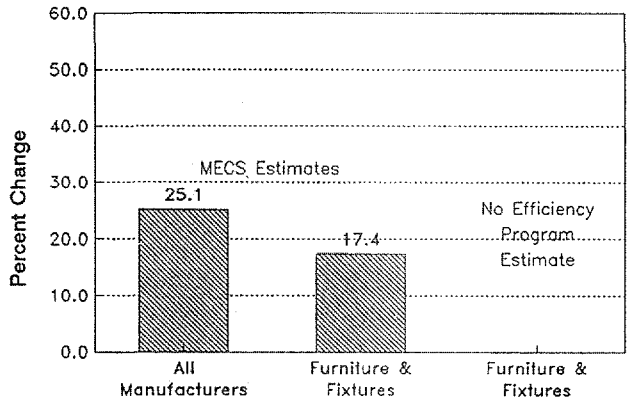
Furniture and Fixtures Industry Group, 1980 - 1985

Figure 8. Output and Energy Consumption Indices, SIC 25, 1974 to 1985



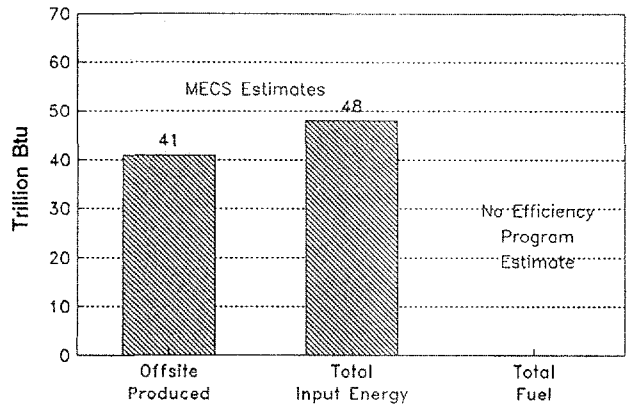
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 9. Percent Change in Energy Efficiency, SIC 25, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 10. Energy Consumption, SIC 25, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the furniture and fixtures industry group (SIC 25) increased by approximately 28 percent (Figure 8). Output decreased in 1975 and again in 1982. Major increases occurred between the years 1975 and 1978 and in 1983 and 1984. During the same period the consumption of offsite-produced energy decreased by 27 percent. Through 1978, energy consumption paralleled output, dropping initially in 1975 then rising steadily. However, in 1979 consumption started a steady decline while output remained constant and then increased in 1983 and 1984.

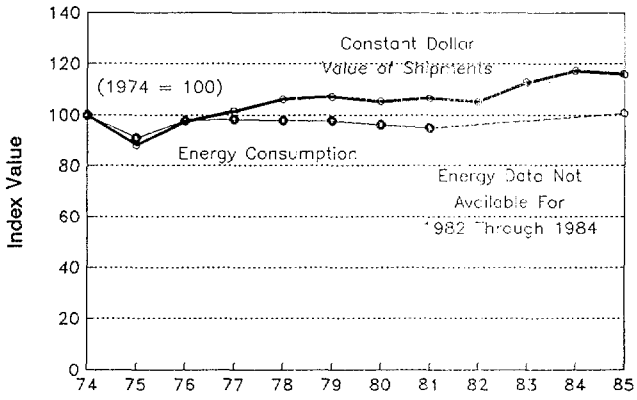
Energy Efficiency, 1980 - 1985

Manufacturers of furniture and fixtures improved their energy efficiency 17 percent, according to the MECS/ASM (Figure 9). The Efficiency Program did not collect data from establishments classified in this industry group because too few corporations were identified as consuming as much as one trillion Btu of energy, the minimum energy consumption criterion for eligibility.

Approximately 85 percent of the total fuel consumption was produced offsite (Figure 10). The major onsite-produced sources of fuel were wood-chips, woodwaste, and other waste materials.

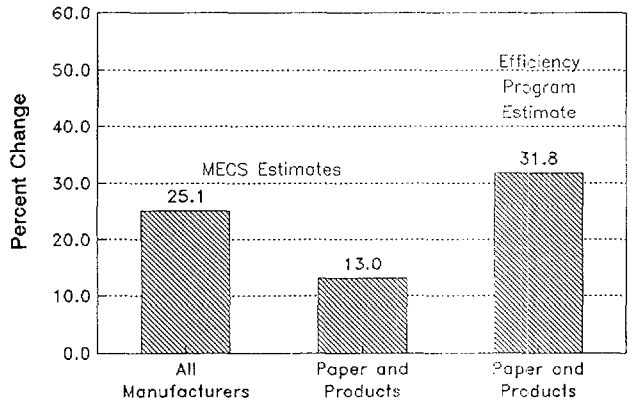
Paper and Allied Products Industry Group, 1980 - 1985

Figure 11. Output and Energy Consumption Indices, SIC 26, 1974 to 1985



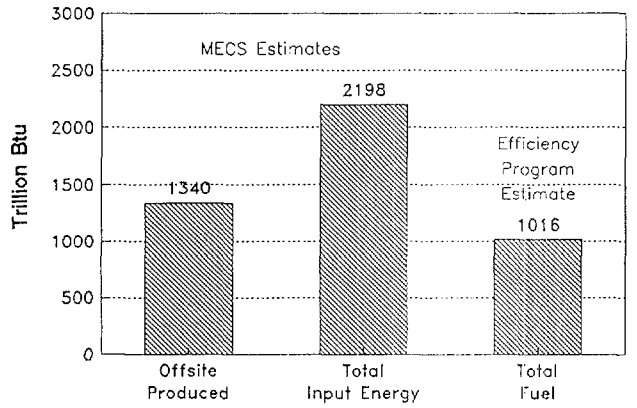
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 12. Percent Change In Energy Efficiency, SIC 26, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 13. Energy Consumption, SIC 26, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the paper and allied product industry group (SIC 26) increased 16 percent (Figure 11). After an initial decrease in 1975 of approximately 12 percent, output showed a generally increasing trend, but with small decreases in 1980, 1982 and 1985. During the same period, consumption of offsite-produced energy increased approximately 1 percent. Consumption was relatively constant throughout the period except for a sharp decrease in 1975, followed by nearly full recovery in 1976.

Energy Efficiency, 1980 - 1985

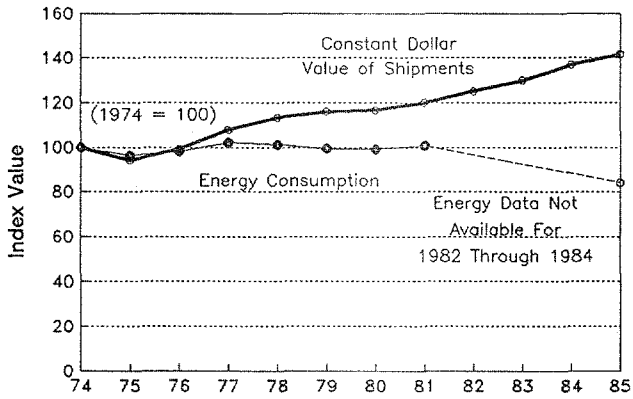
Between 1980 and 1985, establishments in the paper and allied products industry group improved their energy efficiency 13 percent, according to MECS/ASM estimates (Figure 12). For the same period, the Efficiency Program estimated efficiency improvement to be approximately 32 percent, a significantly larger value.

According to MECS estimates, approximately 61 percent of the total fuel consumption was produced offsite (Figure 13). The remaining fuel consumption was from onsite-produced sources such as pulping liquor, woodchips, bark, and other woodwaste. However, these onsite-produced substances were not counted in the Efficiency Program estimate since that program considered these as fuels produced from waste products. Therefore, for this industry group, the consumption estimate from the Efficiency Program is closely comparable to the MECS estimate for offsite-produced consumption.

A possible reason for the difference in efficiency change estimates is the difference in coverage between the two surveys. The MECS estimate for offsite-produced consumption was 1,340 trillion Btu while the consumption estimate from the Efficiency Program was 1,016 trillion Btu. The Efficiency Program collected data primarily from the largest establishments. The data from the MECS, on the other hand, represented the entire industry group. Therefore, the two estimates of efficiency change do not cover the same populations.

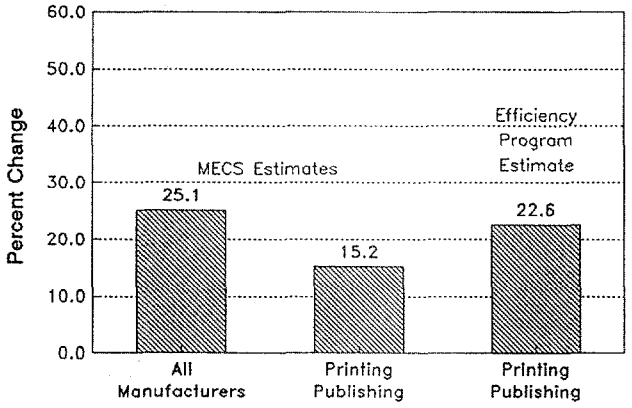
Printing and Publishing Industry Group, 1980 - 1985

Figure 14. Output and Energy Consumption Indices, SIC 27, 1974 to 1985



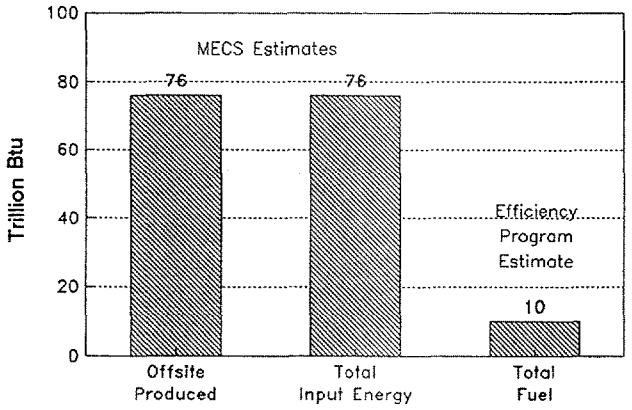
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 15. Percent Change in Energy Efficiency, SIC 27, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 16. Energy Consumption, SIC 27, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the output of the printing, publishing, and allied products industry group (SIC 27) increased approximately 42 percent (Figure 14). After an initial decrease in 1975, output rose steadily to its 1985 level. During the same period, the consumption of offsite-produced energy decreased 16 percent. Energy consumption remained essentially at the same level through 1981. The consumption in 1985 indicates that a sharp decrease occurred between 1981 and 1985 but no energy data were collected in the intervening years to show when this decrease took place.

Energy Efficiency, 1980 - 1985

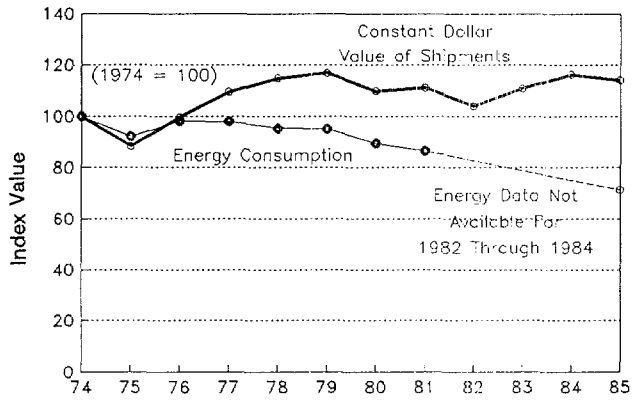
According to the MECS/ASM estimates, printers and publishers improved their energy efficiency by 15 percent between 1980 and 1985 (Figure 15). For the same period, the estimate from the Efficiency Program was 23 percent. The difference between the two surveys' efficiency estimates, while seemingly large, was within the bounds of sampling error.

Almost the entire amount of fuel used in this industry group was from offsite-produced sources (Figure 16). Therefore, there was no difference in coverage of the types of fuels between the MECS and the Efficiency Program.

The MECS estimate for fuel consumption was 76 trillion Btu while the Efficiency Program estimate was 10 trillion Btu (Figure 16). The Efficiency Program collected data primarily from a relatively few establishments in larger companies. The MECS data, on the other hand, represented the entire industry group. Therefore, the two surveys covered very different populations. This difference in coverage, however, caused no statistically discernable effect on the change in energy efficiency as measured by the two systems.

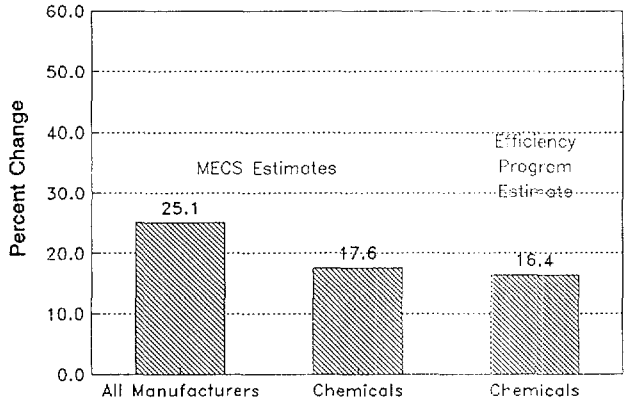
Chemicals and Allied Products Industry Group, 1980 - 1985

Figure 17. Output and Energy Consumption Indices, SIC 28, 1974 to 1985



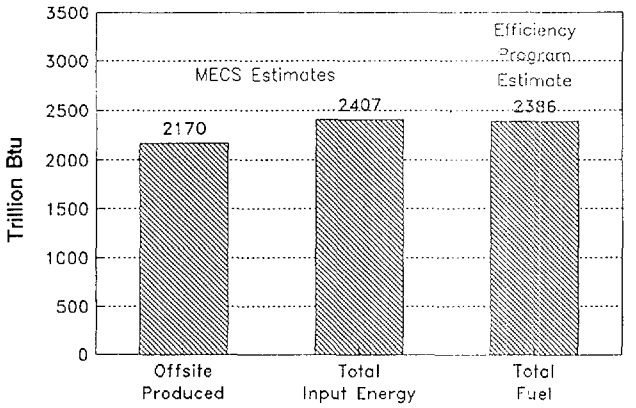
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 18. Percent Change In Energy Efficiency, SIC 28, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 19. Energy Consumption, SIC 28, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the chemicals and allied products industry group (SIC 28) increased by approximately 14 percent (Figure 17). Output consistently increased from 1975 through 1979, declined from 1980 to 1982, then increased again from 1983 to 1985. Consumption of offsite-produced energy between 1974 and 1975 decreased approximately 29 percent. From 1977 to 1985, consumption decreased steadily.

Energy Efficiency, 1980 - 1985

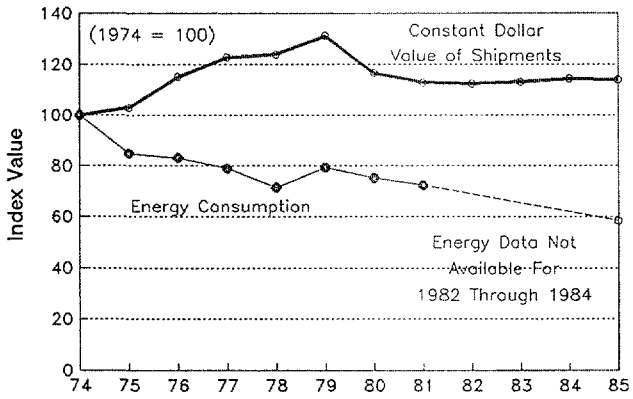
Chemical manufacturers improved their energy efficiency by approximately 18 percent between 1980 and 1985, according to MECS/ASM estimates (Figure 17). For the same period, the estimate from the Efficiency Program was approximately 16 percent. The small difference in the efficiency estimates of the two surveys was within the bounds of sampling error.

In 1985, according to MECS estimates, chemical manufacturers consumed 2,407 trillion Btu of energy which made them the second largest manufacturing industry group in fuel consumption (Figure 19). The industry group was the leading consumer within manufacturing of offsite-produced fuel energy. Approximately 89 percent of the industry group's total fuel consumption came from offsite. Some of the fuels produced onsite that were consumed by this industry group were hydrogen, alcohol, waste gas, and waste oils and tars. There is no evidence to suggest that the improvement in efficiency was due to a shift from offsite-produced fuels to byproduct energy.

The fuel estimate for 1985 from the Efficiency Program was 2,386 trillion Btu. As stated above, the MECS estimate for total fuel consumption in 1985 was 2,407 trillion Btu (Figure 19). The difference in total fuel estimates between the two surveys was within the bounds of MECS sampling error. This difference suggests that the Efficiency Program covered virtually all of SIC 28, so the efficiency change estimates for the two systems would not be expected to differ because of coverage.

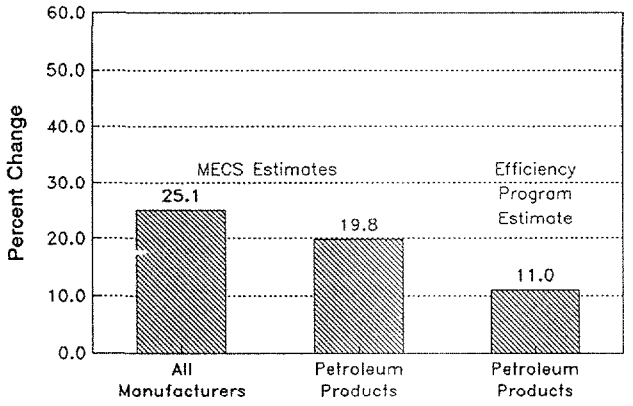
Petroleum and Coal Products Industry Group, 1980 - 1985

Figure 20. Output and Energy Consumption Indices, SIC 29, 1974 to 1985



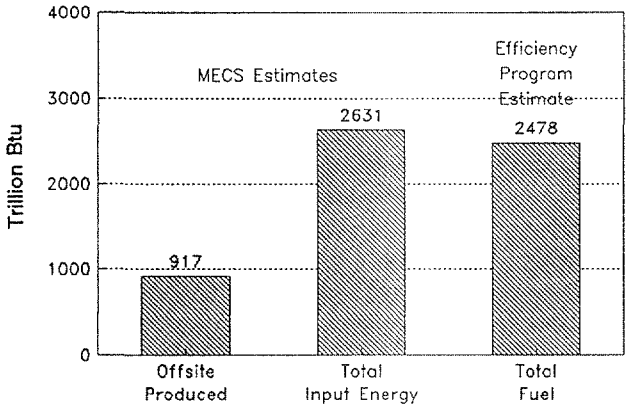
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 21. Percent Change In Energy Efficiency, SIC 29, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 22. Energy Consumption, SIC 29, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the output of the petroleum refining and related industries group (SIC 29) increased 14 percent (Figure 20). Output increased steadily through 1979, decreased in 1980 and 1981, and then maintained that the 1981 level through 1985. During that same period, consumption of offsite-produced energy decreased by approximately 42 percent.

Energy Efficiency, 1980 - 1985

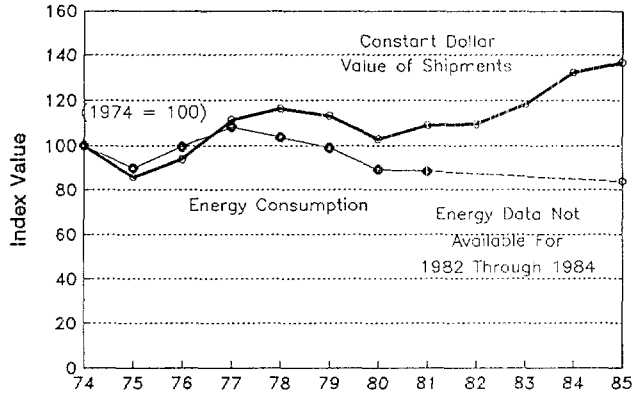
According to MECS/ASM, the petroleum manufacturers and related industries group improved their efficiency 20 percent between 1980 and 1985 (Figure 21). For the same period, the estimate from the Efficiency Program was 11 percent. The large difference between the MECS/ASM estimate and the Efficiency Program estimate cannot be explained by sampling error.

The difference between the MECS and the Efficiency Program estimates does not appear to be attributable to differences in coverage between the two surveys. The MECS estimate for total fuel used was 2,631 trillion Btu. The fuel estimate for 1985 from the Efficiency Program (after recalculating to account for the two surveys employing different electricity-to-Btu conversion factors) was 2,478 trillion Btu (Figure 22). The Efficiency Program collects data primarily from the largest establishments, while the MECS data represents the entire population. However, in this industry group, most of the establishments are large and energy-intensive so the practical effects of the difference in coverage was minimal.

More likely, the difference is due to the extensive use of byproduct energy sources by petroleum refineries to meet their fuel requirements. Approximately 65 percent of the fuel used in this industry group is from byproducts such as still gas and petroleum coke (Figure 22). The MECS efficiency change estimates used offsite-produced fuel as the consumption measure while the Efficiency Program used total fuel. As the MECS showed a greater efficiency change than the Efficiency Program, it is likely that the industry group experienced a decrease in the relative share of offsite-produced fuels between 1980 and 1985 that was made up by using more byproduct fuels.

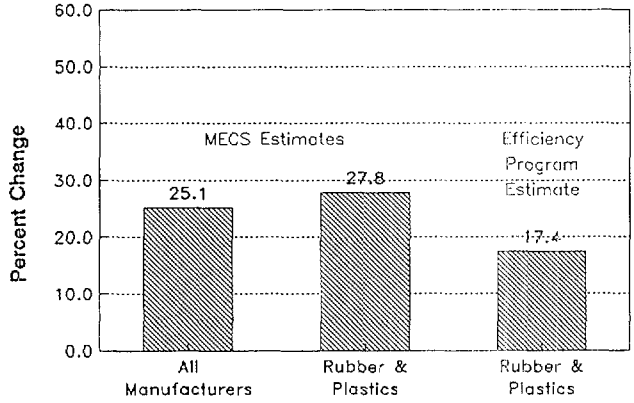
Rubber and Miscellaneous Plastics Products Industry Group, 1980 - 1985

Figure 23. Output and Energy Consumption Indices, SIC 30, 1974 to 1985



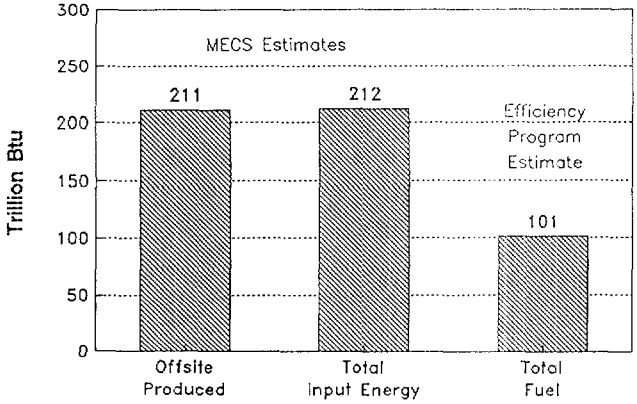
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 24. Percent Change In Energy Efficiency, SIC 30, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 25. Energy Consumption, SIC 30, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the rubber and plastics products industry group (SIC 30) increased approximately 37 percent (Figure 23). Other than the decreases in output that occurred in 1975, 1979, and 1980, output generally increased. During that same period, consumption of offsite-produced energy decreased by approximately 16 percent. Energy consumption generally paralleled the pattern of changes in output until 1981. After that, output markedly increased, while consumption decreased slightly. (The exact pattern is unknown as there was no available energy data for the years 1982 through 1984.)

Energy Efficiency, 1980 - 1985

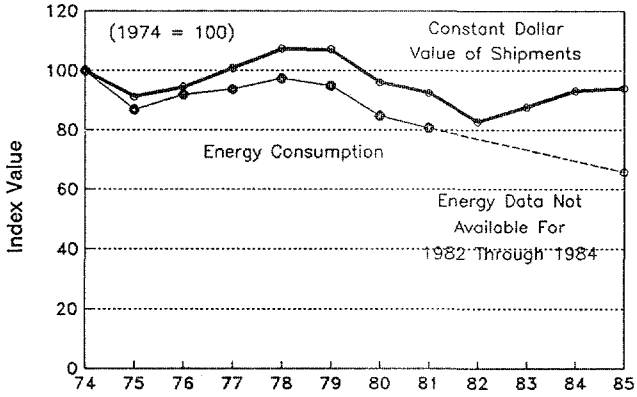
The rubber and plastics products industry improved its energy efficiency by 28 percent between 1980 and 1985, according to the MECS/ASM estimates (Figure 24). For the same period, the Efficiency Program produced an estimate of 17 percent, a significantly lower value.

The difference between the MECS and the Efficiency Program estimates of changes in energy efficiency does not appear to be due to an increased reliance on onsite-produced fuel. Most of the fuel consumed in this industry group was received from offsite (Figure 25), so there would be no difference between the two surveys in the types of fuels covered.

The most likely reason for the difference between the efficiency change estimates is the difference in coverage of the two surveys. The MECS reported that total fuel consumption in 1985 was 212 trillion Btu while the Efficiency Program estimate for the same year was 101 trillion Btu (Figure 25). The Efficiency Program collected data primarily from the largest establishments. The data from the MECS, on the other hand, represented the entire industry group. Therefore, the two estimates of efficiency change do not cover the same populations.

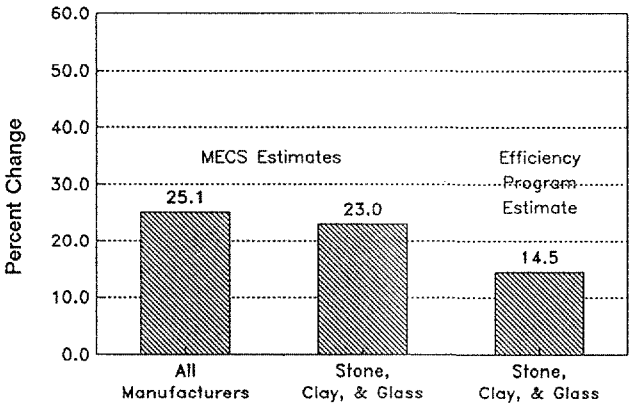
Stone, Clay and Glass Products Industry Group, 1980 - 1985

Figure 26. Output and Energy Consumption Indices, SIC 32, 1974 to 1985



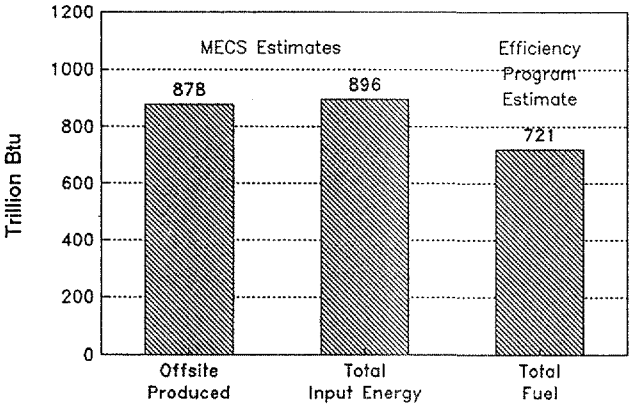
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 27. Percent Change In Energy Efficiency, SIC 32, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 28. Energy Consumption, SIC 32, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the stone, clay, glass, and concrete products industry group (SIC 32) decreased by approximately 6 percent (Figure 26). Within this period, output peaked in 1978 to an increase of approximately 7 percent above its 1974 level. It fell to its lowest level in 1982, approximately 17 percent below its 1974 level. After that, output steadily rose to its 1985 level. During the same period, consumption of offsite-produced energy decreased by approximately 34 percent. The energy consumption trend generally followed the increases and decreases of output. However, the 1985 value for consumption indicates that consumption must have decreased, while output increased after 1981.

Energy Efficiency, 1980 - 1985

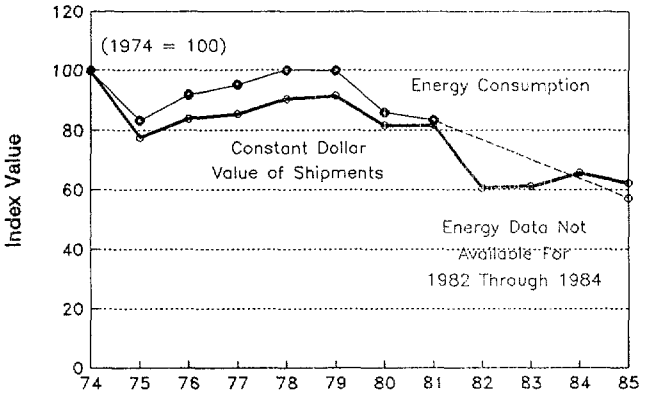
According to MECS/ASM estimates, stone, clay, and glass manufacturers improved their energy efficiency 23 percent between 1980 and 1985 (Figure 27). For the same period, the estimate from the Efficiency Program was 14 percent. The difference between the two surveys' efficiency estimates was within the bounds of sampling error.

The MECS estimate for total fuel consumption was 896 trillion Btu. Approximately 98 percent of that consumption was offsite-produced (Figure 28). The MECS efficiency change estimate used offsite-produced energy for its energy consumption measure while the Efficiency Program used total fuel. Because so much of the fuel used was offsite-produced, there is little difference between the two surveys in the types of fuels covered.

There was possibly a difference between the two surveys in the establishments covered by each. The MECS estimate for total fuel was 896 trillion Btu. The Efficiency Program estimate was 721 trillion Btu, approximately 80 percent of the MECS total (Figure 28). The Efficiency Program collected data primarily from the largest establishments. The MECS data, on the other hand, represented the entire industry. This difference in coverage, however, caused no statistically discernable effect on the change in energy efficiency as measured by the two systems.

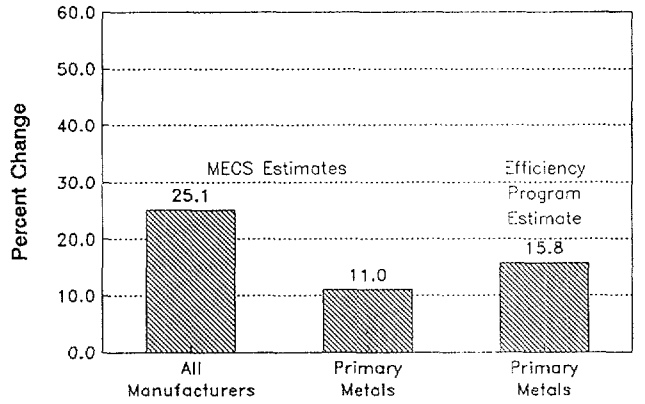
Primary Metals Industry Group, 1980 - 1985

Figure 29. Output and Energy Consumption Indices, SIC 33, 1974 to 1985



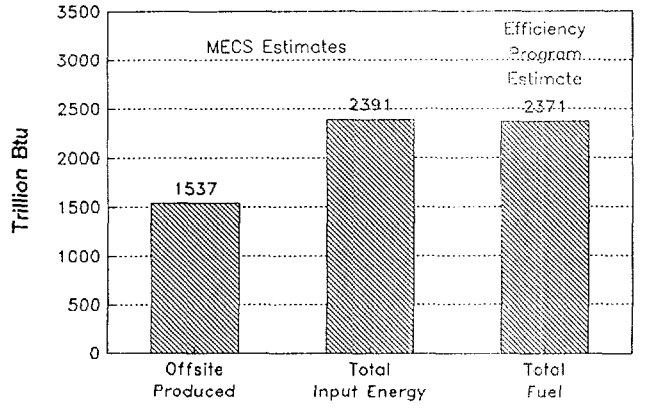
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 30. Percent Change In Energy Efficiency, SIC 33, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 31. Energy Consumption, SIC 33, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between the years 1974 and 1985, the constant dollar value of shipments (output) of the primary metals industry group (SIC 33) decreased by approximately 38 percent (Figure 29). The 1974 level of output was the industry group's highest during that period. Major decreases in output occurred in 1975, 1980, and 1982. Later increases did not fully compensate for the decreases. During that same period, consumption of offsite-produced energy decreased by approximately 43 percent.

Energy Efficiency, 1980 - 1985

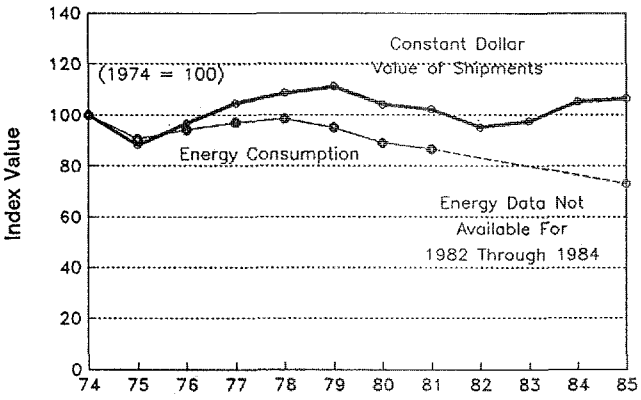
The primary metals industry group, according to MECS/ASM estimates, improved their energy efficiency by 11 percent between 1980 and 1985 (Figure 30). For the same period, the estimate from the Efficiency Program was 16 percent, a significantly higher value than the MECS/ASM estimate.

The difference in efficiency estimates between the two surveys cannot be attributed to a difference in coverage. The MECS estimate for total fuel consumption in 1985 was 2,391 trillion Btu, and the Efficiency Program estimate for the same year was 2,371 trillion Btu (Figure 31). The Efficiency Program primarily surveyed the larger establishments while the MECS data represent the entire industry. However, the primary metals industry group is comprised mainly of large, energy-intensive establishments so the actual difference in coverage was minimal.

A possible reason for the difference is the amount of byproduct and other onsite-produced fuels used by the industry group. Some of these onsite-produced fuels are coal coke, blast furnace gas, coke oven gas, and waste oils and tars. According to MECS estimates, the industry group consumed 1,537 trillion Btu of offsite-produced fuels, approximately 64 percent of total fuel consumption. The MECS efficiency change estimate included only offsite-produced fuels while the Efficiency Program measured the change in total fuel use. It is possible that this industry group has increased the consumption of offsite-produced energy relative to the consumption of byproduct fuels due to decreases in production and/or the emergence of steel "mini-mills" using electric arc furnaces to provide high quality steel from recycled scrap.

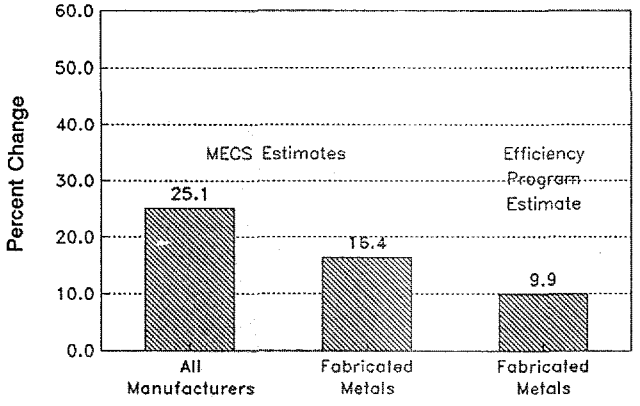
Fabricated Metal Products Industry Group, 1980 - 1985

Figure 32. Output and Energy Consumption Indices, SIC 34, 1974 to 1985



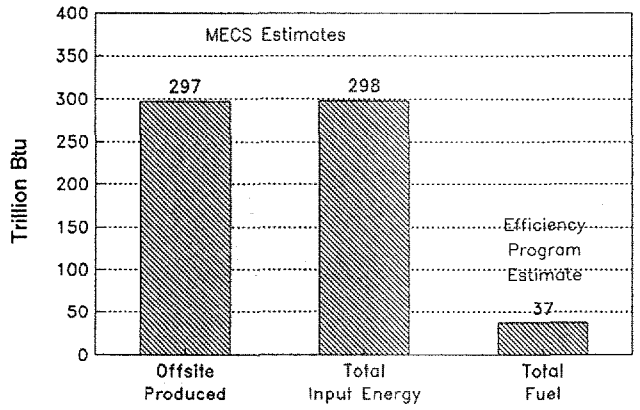
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 33. Percent Change in Energy Efficiency, SIC 34, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 34. Energy Consumption, SIC 34, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the fabricated metal products industry group (SIC 34) increased by approximately 6 percent (Figure 32). Output decreased in 1975 and 1980 through 1982. Otherwise, the trend was generally small annual increases with a peak output in 1979. During the same period, the consumption of offsite-produced energy decreased by approximately 27 percent. Consumption decreased in 1975 and then increased annually until almost reaching the 1974 level in 1978. From 1979 to 1985, consumption decreased steadily.

Energy Efficiency, 1980 - 1985

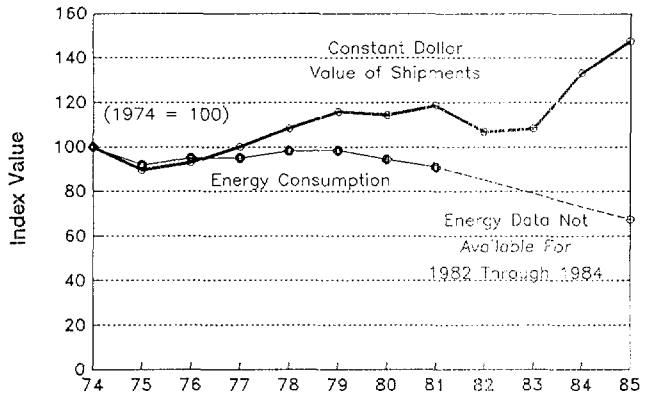
According to MECS/ASM estimates, fabricated metal products manufacturers increased their energy efficiency by 16 percent (Figure 33). For the same period, the estimate from the Efficiency Program was 10 percent.

The difference between the MECS and Efficiency Program estimates cannot be attributed to the increased use of byproduct fuels. According to MECS estimates, almost the entire amount of fuel used came from offsite (Figure 34). Therefore, there would be no real difference in the type of fuels covered by the two surveys.

A possible reason for this difference is the establishment coverage of the two surveys. The MECS reported that total fuel consumption was 298 trillion Btu in 1985. For the same year, the Efficiency Program estimated fuel consumption at 37 trillion Btu (Figure 34). The Efficiency Program collected data primarily from the largest establishments, while the MECS data represented the entire industry group. Therefore, the two estimates of energy efficiency change do not cover the same populations.

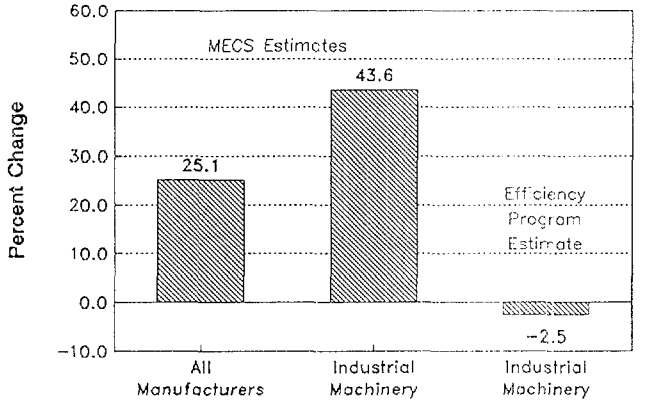
Machinery, Except Electrical Industry Group, 1980 - 1985

Figure 35. Output and Energy Consumption Indices, SIC 35, 1974 to 1985



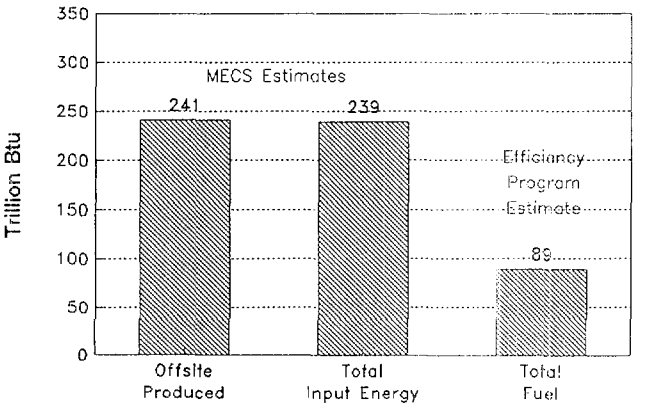
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 36. Percent Change In Energy Efficiency, SIC 35, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 37. Energy Consumption, SIC 35, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the nonelectrical machinery industry group (SIC 35) increased by approximately 47 percent (Figure 35). Decreases in output occurred in 1975, 1980, and 1982. Otherwise, output had steady annual increases, with very sharp rises in 1984 and 1985. During the same period, the consumption of offsite-produced fuels and electric energy decreased by approximately 33 percent. Consumption remained generally at a constant level until 1980, when it started to decrease steadily.

Energy Efficiency, 1980 - 1985

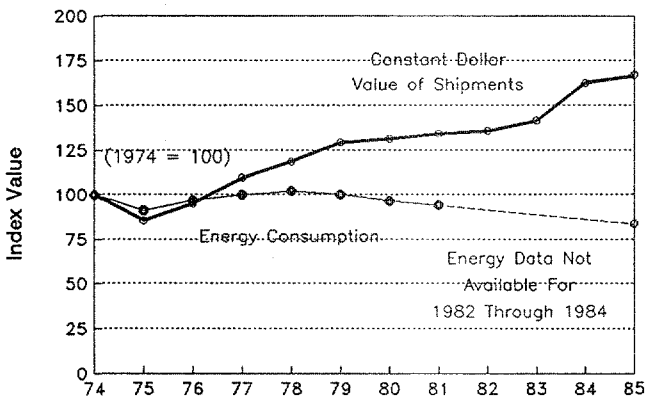
The manufacturers of nonelectrical equipment improved their energy efficiency, according to MECS/ASM estimates, by 44 percent (Figure 36). For the same period, the estimate from the Efficiency Program was a decrease of 2 percent.

The difference between the MECS and Efficiency Program estimates does not appear to be due to an increase in the use of byproduct fuels by the manufacturing group. Virtually the entire amount of fuel used was produced offsite (Figure 37). Due to the electricity and steam sales included in the MECS total fuel estimate, the offsite-produced energy estimate is slightly greater than the total fuel estimate.

A possible reason for the difference in efficiency estimates is the coverage of the two surveys. The MECS reported that fuel consumption of this industry group in 1985 was 239 trillion Btu (Figure 37). The Efficiency Program estimate for the same year was 89 trillion Btu. The Efficiency Program collected data primarily from the larger, energy-intensive, establishments. The MECS collected data that represents the entire industry group. Between 1980 and 1985, ASM output data reveals that computer manufacturing significantly increased its share of output relative to the rest of the industry group. Moreover, this type of manufacturing was more energy efficient than the rest of the industry group, according to 1980 and 1981 ASM data. If these establishments were excluded from the Efficiency Program due to their size, it is reasonable that the two surveys could yield different efficiency change estimates.

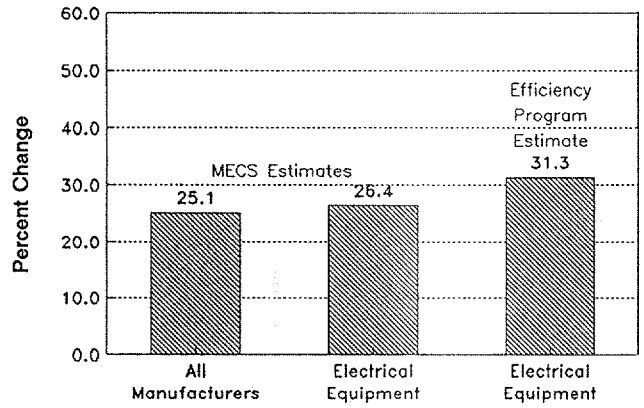
Electrical and Electronic Equipment Industry Group, 1980 - 1985

Figure 38. Output and Energy Consumption Indices, SIC 36, 1974 to 1985



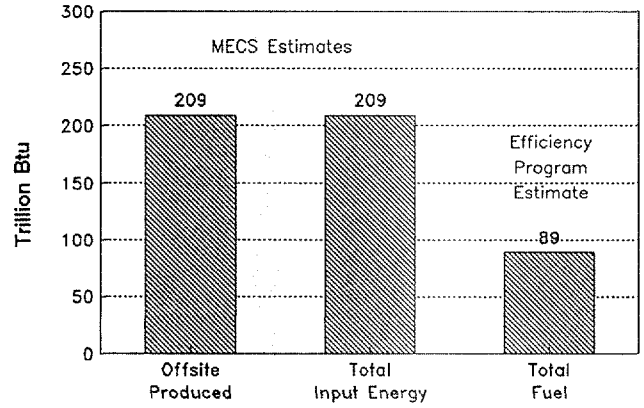
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 39. Percent Change In Energy Efficiency, SIC 36, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 40. Energy Consumption, SIC 36, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, constant dollar value of shipments (output) increased in the electrical equipment industry group (SIC 36) by approximately 67 percent (Figure 38). The only decrease occurred in 1975. After that year, output increased steadily. Particularly rapid growth occurred in the years 1976 through 1979 and in 1984. During the same period, the consumption of offsite-produced energy decreased approximately 16 percent. The largest single-year decline in consumption occurred in 1975 and was entirely compensated for by increases in 1976 and 1977. After 1978, energy consumption decreased steadily.

Energy Efficiency, 1980 - 1985

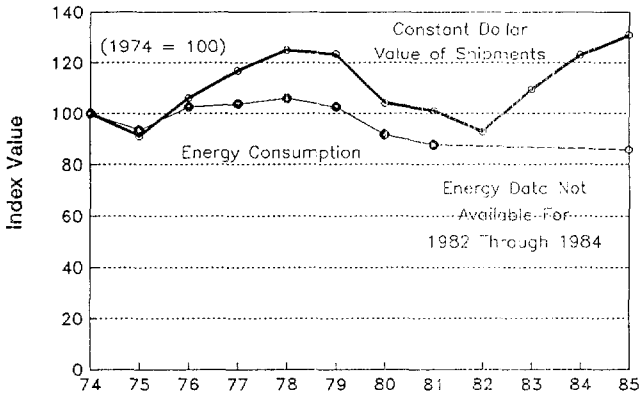
According to MECS/ASM estimates, electronic equipment manufacturers improved their energy efficiency by 26 percent (Figure 39). For the same period, the estimate from the Efficiency Program was 31 percent. The difference between the two surveys' efficiency estimates was within the bounds of sampling error.

Virtually the entire amount of fuel used was produced offsite (Figure 40). Therefore, the fuels included in the efficiency change estimates of both the MECS and the Efficiency Program should be the same.

There was a substantial difference, in the establishment coverage of the two surveys, however. The MECS estimate for fuel consumed by this industry group in 1985 was 209 trillion Btu. The fuel estimate from the Efficiency Program for the same year was 89 trillion Btu (Figure 40). The Efficiency Program collected data primarily from the largest establishments. The MECS data represented the entire industry group. Because of this, the two estimates do not cover the same populatlions. This difference in coverage, however, caused no statistically discernable effect on the changes in energy efficiency as measured by the two systems.

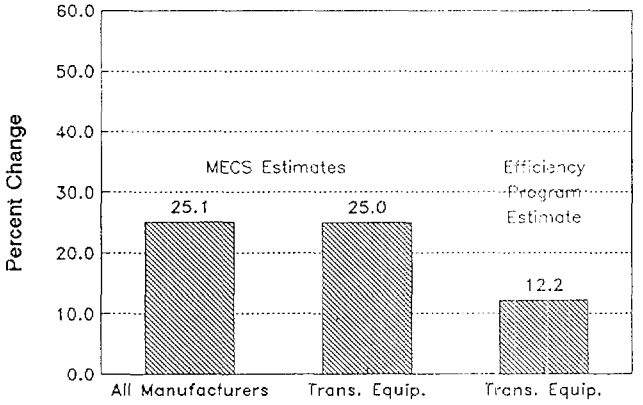
Transportation Equipment Industry Group, 1980 - 1985

Figure 41. Output and Energy Consumption Indices, SIC 37, 1974 to 1985



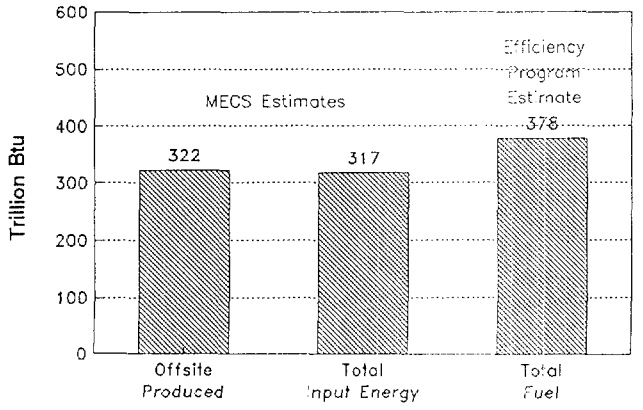
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 42. Percent Change In Energy Efficiency, SIC 37, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 43. Energy Consumption, SIC 37, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the transportation equipment industry group (SIC 37) increased by approximately 31 percent (Figure 41). Decreases in output occurred in 1975, and 1979 through 1982. Increases occurred in all other years during this period. Consumption of offsite-produced energy decreased approximately 14 percent between 1974 and 1985. Consumption increased in the years 1976 through 1978 and decreased in all other years. During this period, consumption and output changed in the same direction until consumption data collection in the ASM was discontinued after 1981. By 1985, output had risen substantially while consumption had decreased slightly.

Energy Efficiency, 1980 - 1985

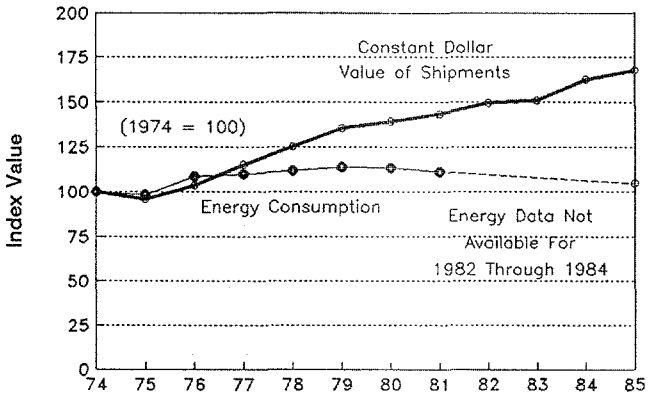
According to MECS/ASM estimates, transportation equipment manufacturers improved their energy efficiency by 25 percent (Figure 42). For the same period, the estimate from the Efficiency Program was 12 percent.

Virtually the entire amount of fuel used by this industry group was produced offsite (Figure 43). (The higher value for offsite-produced fuel compared to total fuel is due to electricity and steam that left the establishment in the form of sales or transfers, quantities removed from total input energy, but not from offsite-produced energy.) Therefore, there was no difference in coverage of the types of fuels between the MECS and Efficiency Program.

The difference between the Efficiency Program and the MECS estimates for efficiency change cannot be explained by differences in coverage. The Efficiency Program covers primarily the largest establishments. The MECS data, on the other hand, represent the entire industry group. Yet, the MECS estimate for total input energy in 1985 was 317 trillion Btu while the Efficiency Program's estimate for the same year was 378 trillion Btu. Under normal circumstances, the MECS estimate for total input energy should be at least as large as the estimate from the Efficiency Program. Since the MECS estimate is significantly smaller than the Efficiency Program estimate, it is probable that one of the estimates is in error.

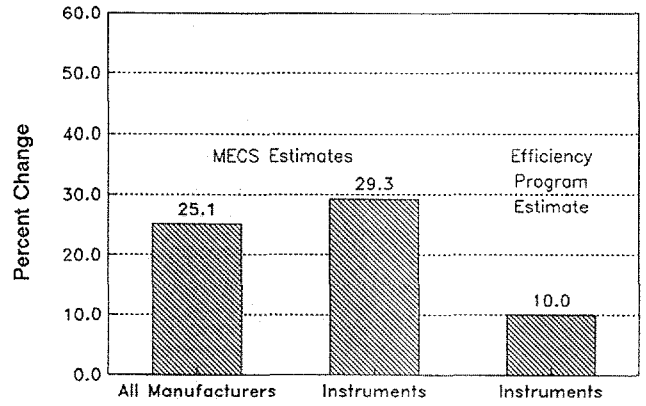
Instruments and Related Products Industry Group, 1980 - 1985

Figure 44. Output and Energy Consumption Indices, SIC 38, 1974 to 1985



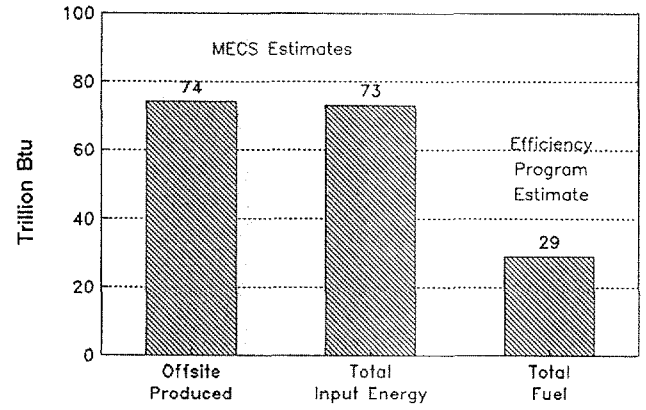
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 45. Percent Change in Energy Efficiency, SIC 38, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 46. Energy Consumption, SIC 38, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the measuring instruments and related products industry group (SIC 38) increased approximately 68 percent (Figure 44). After a small decrease in 1975, output increased steadily every year. During that same period, consumption of offsite-produced fuels and electric energy increased 5 percent. The largest increase in consumption occurred in 1976. After that, consumption slowly rose to a peak in 1979, then started to decrease annually. None of the annual increases or decreases were sizable.

Energy Efficiency, 1980 - 1985

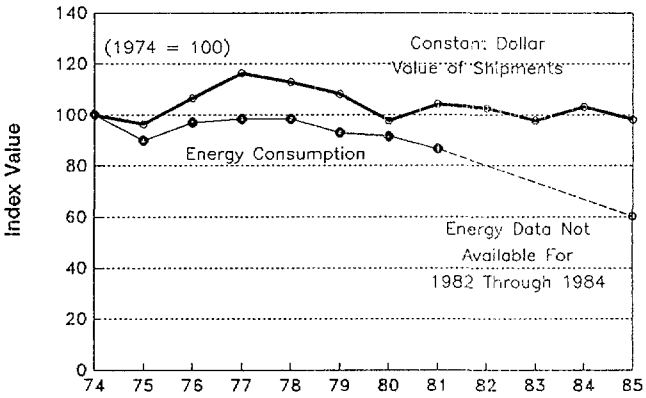
According to MECS/ASM estimates, manufacturers of measuring instruments and related products improved their energy efficiency by 29 percent (Figure 45). For the same period, the estimate from the Efficiency Program was 10 percent. The difference between the two surveys' efficiency estimates, while seemingly large, was within the bounds of sampling error.

Virtually the entire amount of fuel used by the industry group was produced offsite (Figure 46). Therefore, there would have been no difference in the coverage of fuels between the two surveys.

There was a major difference in the coverage of the establishments of the two surveys. The MECS estimate for total fuel consumption was 73 trillion Btu. The Efficiency Program estimate for the same year was 29 trillion Btu. The Efficiency Program collected data primarily from the largest establishments. The MECS data represented the entire industry. Because of this, the two estimates do not cover the same populatlions. This difference in coverage, however, caused no statistically discernable effect on the changes in energy efficiency as measured by the two systems.

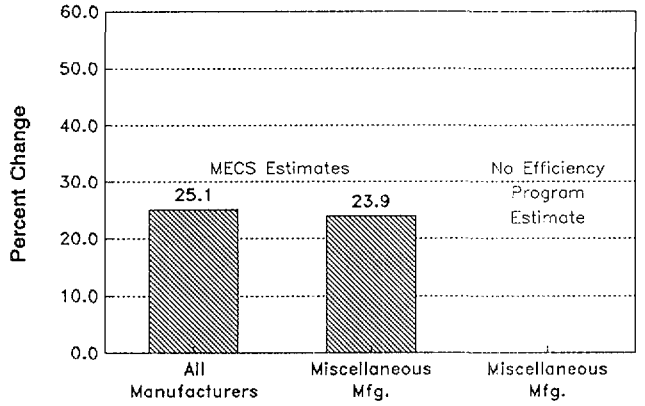
Miscellaneous Manufacturing Industry Group, 1980 - 1985

Figure 47. Output and Energy Consumption Indices, SIC 39, 1974 to 1985



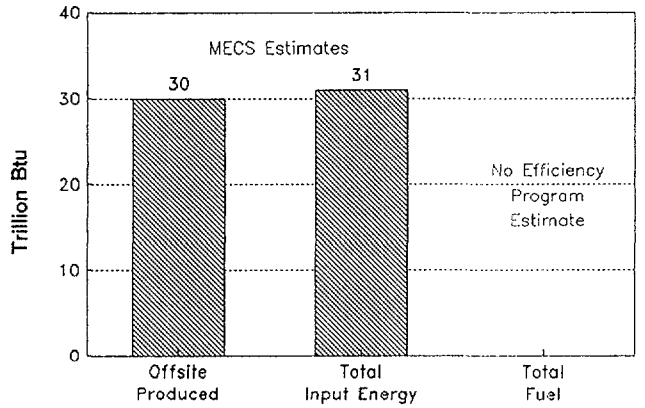
Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and Bureau of the Census, Annual Survey of Manufactures.

Figure 48. Percent Change In Energy Efficiency, SIC 39, 1980 to 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Figure 49. Energy Consumption, SIC 39, 1985



Sources: EIA, 1985 Manufacturing Energy Consumption Survey, and DOE, 1985 Industrial Energy Efficiency Program.

Historical Trends

Between 1974 and 1985, the constant dollar value of shipments (output) of the miscellaneous manufacturing industries group (SIC 39) decreased by approximately 2 percent (Figure 47). After declining in 1975, output grew to a peak in 1977, then fell to its 1974 level by 1980. After that time, there have been minor fluctuations with no discernable trend in output. During that same period, consumption of offsite-produced energy decreased by 40 percent. Consumption increased in 1976 and 1977 and did not change in 1978. In all other years it decreased with the major decreases occurring sometime during the period 1982 to 1985.

Energy Efficiency, 1980 - 1985

Between 1980 and 1985, the miscellaneous manufacturing industries group improved their energy efficiency 24 percent, according to MECS/ASM estimates (Figure 48). The Efficiency Program did not survey this industry group because no corporations were identified that consumed as much as one trillion Btu of energy, the minimum criterion for eligibility.

The MECS estimate for total fuel consumption in 1985 was 31 trillion Btu. Virtually the entire amount was produced offsite (Figure 49).

Appendix A

Survey Design, Implementation, and Estimates

Appendix A

Survey Design, Implementation, and Estimates

Introduction

The 1985 Manufacturing Energy Consumption Survey (MECS) has been designed by the Energy Information Administration (EIA) to provide information related to energy consumption in the manufacturing sector. The MECS data collection consisted of two parts. Part I collected data on energy consumption and related matters. Part II collected information on the capability of manufacturers to substitute alternate fuels for those actually consumed in 1985. The energy consumption and fuel-switching capability estimates were published separately by the EIA.[12] The results of Part I of the survey (the 1985 consumption data), along with data provided by the Census Bureau from the Annual Survey of Manufactures (ASM), were used to prepare the estimates in this report on energy efficiency in the manufacturing sector.

The basic unit of data collection for the 1985 MECS was the manufacturing establishment. A nationally representative sample of these establishments supplied the information through mailed questionnaires. The questionnaires for Part I of the survey were mailed on July 14, 1986; those for Part II were mailed on November 26, 1986. The Industry Division of the Census Bureau selected the MECS sample according to EIA's design specifications; conducted the fieldwork; and handled data processing, again with EIA input.

This appendix presents a summary of the design and implementation procedures for Part I of the survey, and describes the energy efficiency estimates included in this report. Complete details on the survey are available in a methodological report on the MECS published by EIA.[13]

Description of the Manufacturing Sector

The manufacturing sector consists of all manufacturing establishments in the 50 States and the District of Columbia. The working definition of a manufacturing establishment is the definition stated in the Office of Management and Budget's Standard Industrial Classification (SIC) Manual.[14] A manufacturing establishment is an economic unit "... at a single physical location that is engaged in the mechanical or chemical transformation of materials or substances into new products. These establishments are usually described as plants, factories, or mills and typically use power-driven machines and materials-handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement. Also included is the blending of materials such as lubricating oil, plastics, resins, or liquors."

The SIC Manual contains a hierarchial classification system that groups establishments according to their primary economic activities. This system divides the manufacturing sector into 20 major industrial groups that are relatively homogeneous with respect to primary output. Each of these major industrial groups is assigned a two-digit code. The two-digit codes for the manufacturing division range from SIC 20, Food and Kindred Products, through SIC 39, Miscellaneous Manufacturing Industries. Each major group is subdivided into three-digit groups which are further

[12]See Appendix E for related EIA publications on energy consumption.

[13]Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Methodological Report, 1985,* DOE/EIA-0514(85) (Washington, DC, November 1988).

[14]Office of Management and Budget, *Standard Industrial Classification Manual, 1972* (Washington, DC, 1972), p. 57.

divided into four-digit industries. For example, SIC 20 includes SIC 201, Meat Products, which, in turn, is subdivided into SIC 2011, Meat Packing Plants; SIC 2012, Sausages and Other Prepared Meat Products; SIC 2016, Poultry Dressing Plants; and SIC 2017, Poultry and Egg Processing.

The SIC category is the single most important classification variable in the MECS data system, both for selecting the MECS sample and analyzing the MECS data. The categories of primary interest for the MECS are the 20 major industrial groups (SIC 20 through 39) and the 10 four-digit industries within these industry groups that consume the largest quantities of energy. A description of these 20 major industrial groups and 10 industries appears in Appendix D.

The Sampling Frame and Its Relationship to the Manufacturing Sector

As mentioned in the Introduction to this appendix, the Census Bureau serves as the collecting and compiling agent for the MECS. A major benefit of selecting the Census Bureau to provide this service was that the EIA was able to have access to an intact list of manufacturing establishments to serve as the frame for the MECS sample. Therefore, before discussing the MECS sample, the frame from which it was selected will be described in some detail.

A major responsibility of the Industry Division of the Census Bureau is to conduct the Census of Manufactures (CM) and the ASM. The CM is conducted in those years ending in "2" or "7" (for example, 1982), and provides economic data for the complete universe of approximately 350,000 manufacturing establishments in the United States. For the purposes of data collection, the CM universe is divided into two major subsets as follows.

1. **Small Single-Establishment Companies Not Sent a Report Form:** These companies are excused from filing a CM report. Generally, those with less than 5 employees are excused while all with more than 20 are mailed report forms. Those with 5 through 20 employees are excused or sent a report form based on the magnitude of their annual payroll and shipments data. Approximately 125,000 establishments are excused due to this criterion.

2. **Establishments Sent a Report Form:** The remaining manufacturing establishments in the universe are sent a report form.

The ASM is conducted during non-CM years to provide estimates of economic characteristics for the universe of manufacturing establishments. The ASM contains two components. The mail portion is a probability sample of manufacturing establishments selected from the list of establishments that are sent the CM report form (see above). Those establishments are weighted so they represent the mail portion of the CM universe. There are approximately 56,000 manufacturing establishments in the ASM mail sample. Before mailing the ASM materials, the sample is updated by adding new manufacturing establishments and removing those that went out of business or out of scope.

The second component of the ASM is the nonmail portion of the CM. These small establishments are not sent an ASM questionnaire, but their contribution is estimated based on selected information obtained annually from other Federal agencies.

The mail portion of the 1985 ASM, in turn, serves as the frame for the MECS sample. Thus, the universe covered by the MECS is the same universe covered by the ASM mail sample (that is, active CM establishments that are sent a report form, plus establishments that began operations since the last CM).

Sample Design

The overall size of the MECS sample was set at approximately 12,000 establishments based upon available resources and preliminary estimates of sampling error. The desired sample was allocated among 30 industry-based strata consisting of the 10 most energy-consumptive four-digit SIC industries and the remaining portions of the 20 two-digit SIC industry groups. Because of random variability in the sample selection process, the actual sample contained

12,065 establishments. For the 10 most energy-intensive industries, all 1,907 establishments in the 1984 ASM sample were included in the 1985 MECS sample with certainty. The remaining 10,158 establishments were sampled from the 20 two-digit groups in a pattern designed to keep sampling errors within pre-established bounds for estimates of total consumption and consumption of four types of energy: electricity, natural gas, residual oil, and coal.

The procedure for subselecting ASM sample establishments into the MECS sample was such that their overall probabilities of selection for the MECS were proportional to an estimated energy measure of size. The overall probabilities for selection of the MECS sample establishments ranged from 0.002 to 1.000.

The selection of the MECS sample is, therefore, a two-stage selection process. The first stage is the selection of the ASM mail sample, and the second, the subselection of the MECS sample from the ASM sample. Thus, a MECS sample establishment is selected conditional upon it having been selected into the ASM mail sample. The probability of selection of a MECS sample establishment from the ASM sample is a conditional probability so that the overall probability of selection into the MECS sample is represented by the product of this conditional probability and its ASM selection probability.

Of the initial sample of 12,065 establishments, 381 were determined to be out of business or out of scope based on updating procedures used by the Census Bureau. Thus, a final sample of 11,684 establishments were mailed the consumption portion of the MECS. Usable responses were received from 10,499, or 90 percent, of those establishments. However, those respondents represented 97 percent of the total unweighted value of shipments and receipts of the final sample.

Fieldwork, Editing, and Quality Control

Questionnaires were mailed to the in-scope MECS sample establishments on July 14, 1986. Returned questionnaires were subjected to initial screening procedures for completeness, and incomplete forms or responses with obvious inconsistencies were set aside for review by industry specialists. Valid returned questionnaires were forwarded directly to check-in and then to data entry.

All forms that were incomplete or failed the initial screening procedures were carefully reviewed by industry specialists. The specialists retrieved missing data and verified questionable items by telephone contact with the individual who completed the questionnaire. Once forms were completed and verified, they were forwarded to check-in and data entry.

The resulting MECS data file was then subjected to a series of computer edits. These edits included consistency checks against data items from other parts of the MECS and the 1985 ASM as well. The edits also included checks for outliers in the distribution of individual variables. Records with failed edits were reviewed and followed up by industry specialists.

The Estimation Process

The 1985 consumption estimates, developed from the MECS, represent the entire population of manufacturers in the CM universe that were covered in the 1985 ASM mailing. Full representation is accomplished by weighting the data received from the establishments. Weighting is the process of multiplying the reported values by a case-specific constant designed to inflate the data from each sample case to that portion of the population which it represents. The first, basic factor in the MECS weights was the sampling weight, which accounted for the MECS sampling process. The sampling weight for a MECS sample case was the reciprocal of its overall probability of selection; that is, its probability of selection into the ASM and subsequent selection for the MECS.

Before producing the estimates, the MECS sampling weights were adjusted to account for nonresponse and noncoverage. Noncoverage resulted from the exclusion of two groups of establishments from the frame. One group was those establishments that began operations in 1984 and continued through 1985. The other group was those establishments that ceased operations during 1985, but should have reported for the time that they were still in business.

Adjustment factors to account for nonresponse and noncoverage were calculated using the estimated 1984 consumption of purchased fuels and electricity. The 1984 estimates were prepared by the Census Bureau using historical Census data. Basically, those factors are ratios of the estimated energy consumption of the population covered by the original MECS sample plus exclusions to the estimated energy consumption of the population covered by MECS respondents.

Because the nonresponding establishments and exclusions were not evenly distributed by SIC or by size of establishment (with respect to fuel consumption), a separate adjustment factor was calculated for large, medium, and small establishments within each of the 30 sampling strata. Within each of the 90 adjustment cells, the appropriate adjustment factor was then multiplied by the sampling weight for all responding MECS establishments. The product of the sampling weight and the adjustment factor is the final adjusted MECS weight, which is used to produce all MECS population estimates in this report. The adjustment factors, in effect, ratio adjust the weighted data from the MECS respondents to estimated totals for the universe that was initially targeted by the MECS frame and sample design, that is, manufacturers represented by the 1985 ASM mail sample.

The Concept of Energy Efficiency

Energy efficiency is one specialized concept that can be measured using the MECS data base and estimation process. Energy efficiency is the ratio of energy consumption to output for any given year. In this report, energy consumption is defined as the consumption of offsite-produced energy, and output is defined as the value of shipments and receipts expressed in constant (1980) dollars. Thus, the energy-efficiency ratio for any given industry group is expressed as:

$$R_j = \frac{E_j}{S_j} , \qquad (1)$$

where, R denotes the energy-efficiency ratio indexed to year j (j = 1980, 1985), E is offsite-produced energy consumption, and S is the constant dollar value of shipments and receipts.

The 1985 estimates of offsite-produced energy consumption were provided by the MECS. The 1980 estimates of offsite-produced energy consumption and the 1980 and 1985 estimates of value of shipments and receipts were provided by the Census Bureau. All four of these estimates represent the same population of manufacturing establishments that are represented by the MECS sample.

The average price of manufactured goods increased by 11 percent between 1980 and 1985. To remove the effect of these price changes, the 1985 value of shipments were converted to constant 1980 dollars using the industry price indices provided by the Bureau of Labor Statistics[15] That adjustment results in a more realistic measure of output than would have been obtained using the unadjusted value of shipments.

Changes in energy efficiency for a given industry group are the percent changes in the efficiency ratios from one period to another. In this report, the changes in energy efficiency reflect the change from the base year of 1980 to the MECS survey year of 1985. The energy efficiency changes are simply,

[15]An explanation of the industry price indices appears in U.S. Department of Labor, Bureau of Labor Statistics, *BLS Handbook of Methods*, Volume I, Bulletin 2134-1 (Washington, DC, December 1983), p. 49.

$$C_{80,85} = 100\left(\frac{R_{80} - R_{85}}{R_{80}}\right), \quad (2)$$

$$= 100\left(1 - \frac{R_{85}}{R_{80}}\right), \quad (3)$$

where $C_{80,85}$ is the percent change[16] in energy efficiency from 1980 to 1985.

There are alternative measures of energy consumption and output which could be used in place of constant dollar value of shipments and the consumption of offsite-produced energy. The reasons for selecting value of shipments and receipts and offsite-produced energy are presented in the two following sections.

Measures of Energy Consumption

The MECS was conducted for the first time in 1986 to collect 1985 data. Before the MECS, the Census Bureau collected energy consumption data for 1974 through 1981 as a part of the Annual Survey or Census of Manufacturers. The 1985 MECS produced three separate estimates of energy consumption. These are the consumption of offsite-produced energy, total inputs of energy, and primary energy consumption.[17]

Offsite-produced energy consumption is defined as the total amount of energy purchased or transferred from offsite sources that is consumed onsite to produce heat and power and to generate electricity. The definition of energy used in the Census Bureau's survey is compatible with the definition of the consumption of offsite-produced energy used in the MECS.

The estimates of offsite-produced energy consumption were used to develop the energy-efficiency ratios because two years' of data are required to examine changes in energy efficiency. The estimate of offsite-produced energy consumption is the only one of the three energy consumption measures resulting from the MECS for which definitionally comparable estimates are available for earlier years. The 1980 Census estimates of energy consumption were used for the base year in constructing the estimates of energy efficiency change. The 1985 estimates of offsite-produced energy were taken from the MECS.

The second MECS energy consumption measure, **total energy inputs**, represents estimates of total input energy for the production of heat, power, and the generation of electricity, regardless of where the input energy originated. The MECS estimates of total energy inputs include the following components:

- Energy consumed onsite as a fuel and produced offsite (offsite-produced energy)
- Energy consumed onsite as a fuel and produced onsite from nonenergy inputs
- Energy consumed onsite as a fuel and produced onsite from energy products.

The basic difference between the estimate of the consumption of offsite-produced energy and total energy inputs is that the latter includes the consumption of byproduct fuels in addition to the consumption of offsite-produced energy.

[16]It should be noted that the numerator in Equation (2) is reversed from what would be normally expected in calculatinmg a percent change. This reversal is to account for the fact that a *derease* in the energy efficiency ratios from 1980 to 1985 results in an *increase* in energy efficiency, while an *increase* in the ratios results in a *decrease* in efficiency.

[17]Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA-0512(85) (Washington, DC, 1988). Tables 1, 3 and 7 present estimates of primary energy consumption, total energy inputs, and the consumption of offsite-produced energy, respectively.

Replacing the consumption of offsite-produced energy with onsite-produced byproduct and other energy is an efficient use of energy, and such shifts should be reflected in measures of energy efficiency change. The estimates of energy efficiency change presented in this report reflect such shifts, because they have been calculated using only the consumption of offsite-produced energy. Thus, it would be expected that a shift away from offsite-produced energy to byproduct energy with no compensating decrease in output would be reflected as an increase in the energy efficiency ratio. However, an increase in energy efficiency could be due to other factors as well. Therefore, in assessing the impact of a shift from offsite-produced energy to byproduct energy, it would be useful to have available estimates of efficiency change based upon total input energy. If there was a shift from purchased to byproduct energy, then the two measures of energy efficiency change would be approximately equal. If, on the other hand, there had been a tendency to replace offsite-produced with byproduct energy, then it would be expected that a measure of efficiency change using total input energy would be smaller than a measure based on offsite-produced energy.

Future reports in the MECS series on energy efficiency will provide measures of efficiency change based on offsite-produced energy consumption and total input energy. The estimates will use the 1985 and the 1988 MECS energy consumption estimates to calculate changes in energy efficiency for 1985 to 1988.

To provide a basis for examining shifts from offsite-produced to byproduct fuels, this report includes the 1985 "energy efficiency indices" produced as a part of the Industrial Energy Efficiency Improvement Program (Efficiency Program). The Efficiency Program was conducted by the Department of Energy for 1976 through 1985. The program used a measure of energy consumption that is approximately equivalent to total energy inputs in the MECS. The efficiency indices from the Efficiency Program can be compared to the measures of changes in energy efficiency using offsite-produced energy to approximate the impact of a switch from offsite-produced to byproduct energy consumption. However, there are several other differences between the MECS and the Efficiency Program which could account for differences in the measures of efficiency. A brief description of the Efficiency Program and its differences from the MECS are presented in Appendix C of this report.

The 1985 MECS also provided estimates of **primary energy consumption** by industry groups in the manufacturing sector. The estimates of primary energy consumption consist of four components:

1. Energy consumed onsite as a fuel and produced offsite (offsite-produced energy)

2. Energy consumed onsite for nonfuel purposes and produced offsite

3. Energy consumed onsite as a fuel and produced onsite from nonenergy inputs

4. Energy consumed onsite for nonfuel purposes and produced onsite from nonenergy inputs.

Primary consumption excludes the quantities of energy that were produced onsite from other energy sources and, therefore, avoids double-counting. It represents the quantities of energy that are "used up" for the production of heat, power, and the generation of electricity, and consumed as raw material inputs to the manufacturing process.

The major differences between primary consumption and the consumption of offsite-produced energy are that primary consumption includes (1) the energy consumed as a feedstock or raw material input to the manufacturing process, and (2) the byproduct fuels that were consumed onsite and produced from nonenergy inputs. Primary consumption excludes those byproduct energy sources that were produced from other energy inputs. Therefore, primary consumption *excludes*, for example, coke oven gas (produced as a byproduct of the destructive distillation of coal to produce coke), petroleum coke (produced in refineries as a result of high temperature treatment of petroleum fractions), and still gas (produced in refineries as a result of distillation cracking, reforming and other processes).

However, primary consumption *includes* such byproduct energy sources as woodchips and woodwaste, pulping liquor, and other waste. These energy sources resulted from materials that were *not originally purchased as an energy source.*[18] Efficiency changes using energy efficiency ratios based upon primary consumption are more difficult to interpret than those based on offsite-produced energy consumption or total energy inputs. An increase in primary consumption-based ratios could reflect a shift from offsite-produced energy consumption to byproduct energy sources resulting from nonenergy source inputs (but not byproduct energy sources resulting from energy source inputs). However, such an increase in efficiency could also reflect increased efficiencies in the consumption of energy sources as a feedstock or raw material input. For completeness, however, future energy efficiency reports will include estimates of energy efficiency change based upon efficiency ratios using primary energy consumption.

Measures of Output

Ideally, the output measure used to calculate the change in energy efficiency would be a measure of physical output. Physical output measures were not collected by the MECS, however, and it was necessary to use a surrogate measure of output. Two economic measures of manufacturing activity were considered for this purpose: value of shipments and value added by manufacture. Both of these economic measures were available from the Bureau of the Census for the establishments in the MECS sample.

Value of shipments consists of the total receipts for products manufactured, services rendered, and the resales of products bought and sold without further manufacture. Value added, on the other hand, represents the unique contribution of a manufacturer to the production of finished goods. It is derived by subtracting the cost of all materials from the value of shipments and adding the net change in finished goods and work in progress inventory. Basically, value added consists of wages and employee supplements, net interest, indirect business taxes and adjustments, and income or corporate profits.[19]

The value of shipments for any given industry group contains a large amount of duplication because the product outputs of some industries are used as raw material inputs by others. For example, a manufacturer of copper wire may sell wire to another manufacturer that builds electric motors. The electric motor manufacturer may, in turn, sell electric motors to a manufacturer that assembles refrigerators. Thus, the cost of the copper wire, which originated with the first manufacturer, appears in the value of shipments for all three manufacturers. If the values of shipments are summed for these three manufacturers, the result will contain duplication of the cost of the copper wire. Because of this duplication, the value of shipments of the individual industry groups should never be summed to calculate the total output of the manufacturing sector. Enormous duplication would result. Value added by manufacture is the output measure appropriate for that purpose because it includes only the unique contribution of each industry group toward the production of final products.

The duplication inherent in the value of shipments is not an important consideration in the estimation of energy efficiency changes, because the purpose is not to compare the efficiency ratios between industries. Rather, the purpose is to compare energy consumption per unit of output at two different points in time within an industry group. In most cases, whatever duplication existed in the base year will also be present in the comparison year (that is, value added as a percent of the value of shipments is approximately equal for the base and comparison years). Accordingly, for industry groups with perfectly stable proportions of value added to value of shipments, the same estimate of energy efficiency change will result regardless of whether the base is the value of shipments or value added.

For a few industry groups, however, value added as a percent of the value of shipments is not stable from year to year. This was especially true in SIC 29, petroleum and coal products between 1980 and 1985. During this period, constant dollar value added as a percent of constant dollar value of shipments declined from 12.5 to 4.3 percent.

[18]The phrase "not originally purchased as an energy source," is a critical distinction in the definition of byproduct energy used in the MECS. For example, the wood purchased for use in manufacturing wood pulp for use in making paper was not purchased as an energy source, but as a nonenergy source raw material input. Accordingly, wood for pulping would not have been reported as an energy source by a MECS respondent. However, the pulping liquor (that is, the spent liquor removed from the digesters) is used as an energy source and originated as a byproduct of the wood for pulping.

[19]For more details on the value of shipments and value added, see U.S. Department of Commerce, Bureau of the Census, *1985 Annual survey of manufactures*, "Statistics for Industry Groups and Industries," M85(AS)1 (Washington, DC, January 1987), Appendix A.

The energy efficiency change calculated using the value of shipments as a base was 19.8 percent. Energy efficiency change calculated using value added as a base was -131.9 percent. The basic question is, then, which economic measure, value added or value of shipments, best mirrors physical output when value added is variable relative to the value of shipments?

The petroleum and coal products industry group is the one group for which some physical output measures are available. In 1980 and 1985, petroleum refineries supplied 6,225.4 and 5,740.0 million barrels respectively of refined petroleum products.[20] (Note that these values represent the output of the petroleum refineries only, and not the entire industry group. Since petroleum refineries account for most of the output of the entire sector, however, the values are a reasonable proxy.) The estimated consumption of offsite-produced energy for these two years was 1,180.5 and 917.0 trillion Btu. Using physical output as the base yields an estimated energy efficiency change of 15.7 percent.

Clearly, for the petroleum and coal products industry group, an estimate of energy efficiency change between 1980 and 1985 based on the value of shipments more closely corresponds to the estimate based on physical products than does the estimate based on value added. Thus, when value added as a proportion of value of shipments differs between the base and comparison years, it would appear that constant dollar value of shipments more closely approximates physical production than does constant dollar value added. Therefore, constant dollar value of shipments were used as the surrogate measure of output for calculating the energy efficiency ratios used in this report.

Finally, it should be noted that using constant dollar value of shipments as a surrogate for physical output is fully consistent with the procedures adopted by other Federal agencies for estimating output. The Bureau of Labor Statistics (BLS), for example, publishes a productivity measure known as "output per employee hour." Basically, this index is produced by dividing an output index by an index of aggregate employee hours for a given industry. According to the BLS,

> ... industry output indexes are based on quantifiable units of products or services of the industry .... Whenever possible, physical quantities are used as the unit of measurement. For those industries lacking quantity data, constant-dollar value of shipments, sales, or revenue data are used to develop the output series.[21]

[20]Energy Information Administration, *Monthly Energy Review*, November 1988 (February 1989), Table 3.1a. Published values converted to annual production.

[21]U.S. Department of Labor, Bureau of Labor Statistics, *BLS Handbook of Methods*, Volume I, Bulletin 2134-1 (Washington DC, December 1983), p. 103.

Appendix B

Quality of the Data

Appendix B

Quality of the Data

Introduction

All data collection activities and the estimates produced from them are subject to a variety of errors. These errors may be broadly classified under two general types, sampling error and nonsampling error.

Sampling error is defined as the variability in a survey estimator that arises because data are collected from a sample of units rather than the entire population. Each possible sample produces different estimates of population parameters, depending on the set of respondents that are selected. Nonsampling errors, on the other hand, occur in any data collection activity, whether a sample survey or a complete census. Nonsampling errors are attributable to all aspects of the total survey design other than the sampling process, and can include both random and systematic (biasing) errors. Commonly recognized sources of nonsampling error include undercoverage, random and systematic response errors, nonresponse, data processing errors, and tabulation errors. This appendix describes the effect of both sampling and nonsampling errors on estimates of energy efficiency change using data from the MECS and the ASM.

Sampling Error

The estimates of energy efficiency change appearing in this report were developed from one of a very large number of samples of manufacturing establishments that could have been selected under the same sampling specifications. As a result, survey estimates differ from true population values that would be obtained from a complete enumeration of all manufacturing establishments. Each possible sample yields its own estimates of the true population values, with the differences attributable to the particular set of establishments selected into each sample.

One measure of variability due to sampling is the average squared differences between the estimates that would be produced by all possible samples and the mean value of these estimates. This type of measure is commonly known as sampling error. Estimates of the magnitude of these sampling errors based on data from a single sample are provided by a statistic known as the standard error of an estimate.

Estimates of standard errors have been computed for the estimated energy efficiency changes appearing in this report. They are presented in the form of relative standard errors (RSE), that is, 100 times the standard error divided by the estimated value to which it refers. The RSE's are given in Table B1 of this appendix.

Computation of Relative Standard Errors

The RSE's for the estimates of efficiency change were computed using a specially-derived formula that yields an approximate RSE. The primary inputs for the computation are the relative variances and covariances of energy consumption, the constant dollar value of shipments, and the estimated change in energy efficiency. The following paragraphs describe the derivation of the formula.

In equation (3) of Appendix A, the change in energy efficiency for a particular industry group is given as:

$$C_{80,85} = \left(1 - \frac{R_{85}}{R_{80}}\right), \tag{4}$$

where $R_{85} = E_{85} / S_{85}$, and $R_{80} = E_{80} / S_{80}$, and the multiplier of 100 in equation (3) is ignored.

The object is to derive an approximate RSE for the change in energy efficiency. The derivation proceeds as follows:

$$RSE\left(C_{80,85}\right) = RSE\left(1 - \frac{R_{85}}{R_{80}}\right), \tag{5}$$

$$= \sqrt{RSE^2\left(1 - R_{85}/R_{80}\right)} \quad , \tag{6}$$

where RSE^2 is the relative variance, or rel-variance. By definition of the rel-variance,

$$RSE\left(C_{80,85}\right) = \sqrt{VAR\left(1 - R_{85}/R_{80}\right) \div C_{80,85}^2} \cdot 100 \quad . \tag{7}$$

equation (7) can be restated as:

$$RSE\left(C_{80,85}\right) = \tag{8}$$

$$\sqrt{\left\{VAR(1) + VAR\left(R_{85}/R_{80}\right) - 2\,COV\left(1, R_{85}/R_{80}\right)\right\} \div C_{80,85}^2} \cdot 100 \quad .$$

Since the variance of a constant and the covariance of a constant and a variable are equal to zero, equation (8) reduces to:

$$RSE\left(C_{80,85}\right) = \sqrt{VAR\left(R_{85}/R_{80}\right) \div C_{80,85}^2} \cdot 100 \quad . \tag{9}$$

Expressing equation (9) in terms of the rel-variance,

$$RSE\left(C_{80,85}\right) = \sqrt{\left\{RSE^2\left(R_{85}/R_{80}\right)\right\} \cdot \left(R_{85}/R_{80}\right)^2 \div C_{80,85}^2} \cdot 100 \quad . \tag{10}$$

By Hansen, Hurwitz, and Madow,[22] the rel-variance of a ratio can be approximated using the rel-variances and the rel-covariance of the components. Applying the approximation of Hansen et al., equation (10) becomes:

$$RSE\left(C_{80,85}\right) \doteq \tag{11}$$

$$\sqrt{\left\{RSE^2\left(R_{85}\right) + RSE^2\left(R_{80}\right) - 2\,RELCOV\left(R_{85}, R_{80}\right)\right\} \cdot \left(R_{85}/R_{80}\right)^2 \div C_{80,85}^2} \cdot 100 \quad .$$

[22]M. Hansen, W. Hurwitz, and W. Madow, *Sample and Survey Methods and Theory*, Volume I (New York: John Wiley & Sons, Inc., 1953), p. 166.

The relative covariance between the two ratios can be assumed to be zero because sample selection for the 1985 MECS (which provided the values for R_{85}) is independent of sample selection for the 1980 ASM (which provided the values for R_{80}). Thus, equation (11) reduces to:

$$RSE(C_{80,85}) \doteq \sqrt{\left\{RSE^2(R_{85}) + RSE^2(R_{80})\right\} \cdot (R_{85}/R_{80})^2 \div C_{80,85}^2} \cdot 100 \quad . \tag{12}$$

Since the two rel-variances in equation (12) are the rel-variances of the energy efficiency ratios for the industry group in 1980 and 1985, the approximation of Hansen et al. may be used again. Thus, the rel-variances in equation (12) may be approximated as:

$$RSE^2(R_{85}) \doteq RSE^2(E_{85}) + RSE^2(S_{85}) - 2\,RELCOV(E_{85}, S_{85}) \ , \tag{13}$$

and,

$$RSE^2(R_{80}) \doteq RSE^2(E_{80}) + RSE^2(S_{80}) - 2\,RELCOV(E_{80}, S_{80}) \ . \tag{14}$$

The components of these rel-variances were available from the MECS and the ASM, and in information provided by the Census Bureau. The rel-variances of the energy efficiency ratios were estimated and substituted into equation (12) to derive the RSE's of estimated changes in energy efficiency.

Table B1. Relative Standard Errors and Confidence Intervals for Estimates of Energy Efficiency Change, 1980 - 1985

SIC Code[a]	Industry Group	Energy Efficiency Change (percent)	Relative Standard Error (percent)	95 Percent Confidence Interval[b]
20	Food and Kindred Products	22.9	23.2	12.3 - 33.5
21	Tobacco Manufactures	Q	Q	Q
22	Textile Mill Products	16.3	14.1	11.7 - 21.0
23	Apparel and Other Textile Products	NA	NA	NA
24	Lumber and Wood Products	Q	Q	Q
25	Furniture and Fixtures	17.4	26.1	8.3 - 26.5
26	Paper and Allied Products	13.0	28.5	5.6 - 20.4
27	Printing and Publishing	15.2	46.0	1.2 - 29.2
28	Chemicals and Allied Products	17.6	21.3	10.1 - 25.1
29	Petroleum and Coal Products	19.8	10.4	15.7 - 23.8
30	Rubber and Misc. Plastics Products	27.8	9.8	22.8 - 32.8
31	Leather and Leather Products	Q	Q	Q
32	Stone, Clay and Glass Products	23.0	19.8	13.9 - 32.1
33	Primary Metal Industries	11.0	17.6	7.2 - 14.9
34	Fabricated Metal Products	16.4	19.6	10.0 - 22.8
35	Machinery, Except Electrical	43.6	6.2	38.2 - 49.0
36	Electrical and Electronic Equipment	26.4	10.6	20.8 - 31.9
37	Transportation Equipment	25.0	7.8	21.1 - 29.0
38	Instruments and Related Products	29.3	36.4	8.0 - 50.6
39	Misc. Manufacturing Industries	23.9	26.7	11.1 - 36.6
--	**All Manufacturing**	25.1	7.1	21.5 - 28.7

[a]See Appendix A for a description of the Standard Industrial Classification Codes.

[b]These confidence intervals include a range of values which has an approximate 95-percent probability of containing the true, but unknown population parameter with repeated sampling.

Q=Withheld because relative standard error is greater than or equal to 50 percent. Data are included in higher-level totals.

NA=Not available. Data are included in higher-level totals.

Sources: Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA-0512(85) (Washington, DC, 1988), and unpublished data provided by the U.S. Department of Commerce, Bureau of the Census, Industry Division, from the *Annual Survey of Manufactures*.

Nonsampling Errors and Bias

Nonsampling errors that affect estimates of energy efficiency change can be divided into three major categories:

1. **Operational errors**, including editing, coding, and tabulation errors
2. **Errors of measurement**, including a lack of precision by the respondent, failure of the respondent to understand instructions, etc.
3. **Errors of nonobservation**, including nonresponse and noncoverage.

These errors are collectively referred to as nonsampling errors because they are not related to the sampling process, and, thus, would be equally likely to occur in a complete census or a sample survey.

It is felt that operational errors are not a major concern for the estimates included in this report. The quality control procedures that were employed for check-in, editing, coding and keying the returned MECS questionnaires (see Appendix A) are standard procedures that are in place at the Census Bureau and have withstood the test of time. Data tabulations were verified by comparing marginal totals in tables generated from files supplied to EIA with corresponding totals generated directly from microdata files held at the Census Bureau.

Errors of measurement are a concern in any data collection activity. The survey results for the MECS were subjected to extensive editing procedures which were specifically designed to detect errors of measurement. Responses that failed these tests for reasonableness and consistency were recalled by analysts familiar with manufacturing processes and energy use. Major errors, including omissions and misreporting by orders of magnitude, were corrected. No editing procedure is capable of identifying all measurement errors, however, and some small errors will remain. To the extent that these errors are due to random, rather than systematic misjudgments, they are compensating in the aggregate totals presented in this report, and it is believed that there are few large systematic biases that result from them.

Finally, several potential sources of nonsampling error and bias result from errors of nonobservation. One source of noncoverage error results from the MECS target universe not being identical to the total manufacturing universe. As previously described, the population of interest for the MECS is the same universe covered by the ASM mail sample (Appendix A). That target universe excludes very small establishments, and thus, noncoverage represents a source of bias with respect to estimated energy consumption by the universe of manufacturing establishments. The effect of this noncoverage is generally not large (estimated only to be a few percent for most industry groups) because energy consumption is highly concentrated among the larger manufacturing establishments, and the MECS sample was specifically designed to capture those establishments with substantial energy consumption. Nevertheless, users should be aware of this noncoverage bias when attempting to relate the MECS estimates to the universe of all manufacturing establishments.

In addition, Appendix A describes the adjustments that were made to the MECS sampling weights to account for nonresponse and noncoverage of specific portions of the MECS target universe. Basically, the procedure was to ratio adjust the weighted data from the MECS respondents to the estimated totals for the universe that was initially targeted by the MECS frame and sample design. Clearly, had these adjustments not been performed, the estimates produced from only the responding establishments would not have been representative of the target universe for the MECS. Such estimates would potentially have been biased. Adjusting the sampling weights to reflect the target universe is an attempt to mitigate the potential effects of such a bias.

As described in Appendix A, separate adjustment factors were developed by size of establishment within sampling strata, resulting in 90 separate adjustment factors. Adjustment factors were calculated for each of the 90 cells using estimated 1984 fuel consumption for heat and power. Each cell represents a relatively homogeneous subgrouping of establishments with respect to primary output and level of fuel consumption. Implicit in that procedure is the assumption that primary output and level of fuel consumption are highly correlated with energy consumption patterns, so the establishments within a cell would also be homogeneous with respect to the quantities, types, and shares of energy consumed as fuels and for nonfuel purposes.

To the extent that the nonresponding establishments within the adjustment cells share the energy consumption patterns of the responding establishments within those cells, the resulting adjustments to the MECS estimates will tend to be minimally biased. If, on the other hand, the energy consumption patterns of the responding and nonresponding establishments differ substantially, the resulting adjustments are potentially biased, and may not represent the originally targeted MECS universe.

More detailed information on sources of nonsampling error in the MECS can be found in the methodological report.[23]

[23]Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Methodological Report, 1985*, DOE/EIA-0514(85) (Washington, DC, November 1988), pp. 7 - 11.

Appendix C

Energy Efficiency Improvement Program

Appendix C

Industrial Energy Efficiency Improvement Program

History of the Program

The Industrial Energy Efficiency Improvement Program (Efficiency Program) began as a joint industry-government effort to stimulate energy conservation immediately following the 1973 oil embargo.[24] In 1974, the Department of Commerce developed a four-point program aimed at voluntary adoption by the manufacturing sector. Under that program manufacturers were encouraged to:

- obtain the commitment of top management to energy conservation
- undertake a thorough company energy audit
- develop voluntary conservation goals and programs designed to meet them, and
- conduct energy awareness campaigns aimed at employees, suppliers, customers, and the community at large.

The voluntary reporting program was designed to measure progress towards achieving these goals. Trade associations played a major role in communicating the program objectives to their members. The number of voluntary participants grew significantly, with the trade associations assisting by compiling energy improvement data and establishing technology development and transfer programs.

In 1975, the enactment of the Energy Policy and Conservation Act (EPCA) required the establishment of an Industrial Energy Conservation Program including mandatory reporting. This program developed energy efficiency improvement targets for the 10 most energy-intensive manufacturing industry groups and identified the 50 most energy-consumptive corporations among those consuming at least one trillion British thermal units (Btu) of energy within those 10 industry groups.

The program was extensively altered as a result of the National Energy Conservation Policy Act (NECPA) amendments to EPCA. The 1979 calendar year was the first reporting period for which NECPA-mandated changes to the reporting program were implemented.

The legislative changes increased the reporting population to include all corporations consuming more than one trillion Btu per year in any one of the 20 manufacturing industry groups. NECPA also required that each reporting corporation base its report on plant data; and required the Department of Energy (DOE) to establish voluntary 1987 targets on the collection of information regarding the increased utilization of recovered materials from corporations in several industry groups.

In 1979, DOE identified over 1,000 corporations that consumed more that one trillion Btu of energy in manufacturing operations within any 2-digit manufacturing industry group. These corporations were the basis of energy efficiency improvement data collection for the calendar year 1979. In later years, through 1985, the list of eligible corporations was updated based upon the minimum threshold criterion of the consumption of one trillion Btu of energy in any one of the 20 manufacturing industry groups.

[24]Information on program history was extracted from Department of Energy, Assistant Secretary for Conservation and Renewable Resources, Office of Industrial Programs, *Annual Report to Congress and the President on the Industrial Energy Efficiency Improvement Program*, DOE/CE-0015 and DOE/CE-0015/3 (Washington, DC, December 1980 and no date).

Reporting Requirements

All manufacturing corporations identified as eligible under the minimum threshold criterion of one trillion Btu consumption of energy in any one of the 20 manufacturing industry groups were required to collect energy consumption and efficiency data from the plants owned by that corporation which contributed to that eligibility.[25] The individual plant reports were submitted to the corporate headquarters and aggregated to the corporate level. Corporations were permitted to submit the corporate-level reports directly to the DOE Office of Industrial Programs (OIP) or to submit the report through a sponsor, usually a trade association. Sponsors, in turn, aggregated the corporate reports by industry group and submitted the aggregated values to OIP.

Each eligible plant was required to submit energy consumption data for the reference year and the current reporting year. The reference year was either 1972 or 1978, and the choice was left to the eligible corporation. In reporting energy consumption, the eligible plants were required to report all energy used or included in:

- direct manufacturing activities
- thermal self-generation of electricity
- heating, ventilating and air conditioning of manufacturing buildings and plant offices as well as manufacturing services such as shop, cafeteria, other plant personnel services, and plant chemical and analytical laboratories
- in-plant transportation and transportation on a manufacturer's property between mining operations and manufacturing facilities
- raw material storage
- services for finished product warehouses within a plant fence if directly related to manufacturing activities.

The respondents were directed to exclude, among others, all uses of electricity self-generated by thermal means; byproduct fuels sold and shipped or stored for sale; waste used as fuel; and feedstocks. Energy consumption was reported in physical units and Btu. Btu conversion factors were provided by the OIP. For electricity, the Btu conversion factor for the chemicals and allied products and petroleum and coal products industry groups (SIC's 28 and 29, respectively), was 10,000 Btu per kilowatthour. For all other industry groups, the conversion factor was 3,412 Btu per kilowatthour.

Energy efficiency data were provided on a product-specific basis by the eligible plants. For each product, individual plants were required to report the production measure (physical output measure), the reference year energy efficiency measure (consumption per unit of physical output), the current reporting year production (in physical units), the calculated energy consumption (reference year efficiencies multiplied by reporting year physical units), and the actual current consumption. The two items, calculated consumption and actual current consumption, are the basis of calculating energy efficiency change. Calculated consumption represents the quantity of energy in reference year efficiencies that would have been required to produce the output of the current reporting year.

The corporation was required to report aggregate energy consumption by energy source, total calculated consumption, and total current consumption covering all eligible plants. These data were submitted directly to the OIP by a few corporations, but most submitted them to a sponsor where the corporate data were further aggregated and then submitted to OIP.

[25]Information on reporting requirements was extracted from the reporting forms of the Industrial Energy Efficiency Improvement Program: the plant reporting form (CE-189-P), the corporate reporting form (CE-189-C), and the sponsor reporting form (CE-189-S).

Upon receipt of these data, OIP aggregated all corporate and sponsor reports by industry group and calculated "energy efficiency improvement" for each group as follows:

$$C'_{r,c} = 100\left(\frac{E_r^* - E_c}{E_r^*}\right), \tag{15}$$

where C' is the change in energy efficiency from the reference year (r) to the reporting year (c), E_r^* is the aggregate calculated current energy consumption using reference year efficiencies, and E_c is actual energy consumption for the current year.

Differences Between the Efficiency Program and the Manufacturing Energy Consumption Survey

There are numerous definitional and procedural differences between the MECS and the Efficiency Program. These differences may result in large discrepancies between the estimates of energy consumption and energy efficiency change resulting from the two programs.

Measures of Output

The MECS/ASM estimates of energy efficiency change are based on efficiency ratios of energy consumption per constant dollar of the value of shipments and receipts for a given industry group. The Efficiency Program estimates, on the other hand, are based on energy efficiency ratios of energy consumption per physical unit of output.

For the Efficiency Program, the estimates of change in energy efficiency in equation (15) for any given industry group can be expressed as:

$$C'_{r,c} = 100\left(1 - \sum_{j=1}^{n} \frac{w_j R'_{jc}}{R'_{jr}}\right) = 100\left(1 - \frac{R'_c}{R'_r}\right), \tag{16}$$

where C' is the change in energy efficiency from the reference year (r) to the reporting year (c), R' is the energy efficiency ratio for product j, w_j is a product-specific weight representing the relative contribution of product j to the efficiency change for all products within a given industry group, and n is the number of products.

For the MECS/ASM estimates, it was shown in equation (3) of Appendix A that, for any given industry group,

$$C_{80,85} = 100\left(1 - \frac{R_{85}}{R_{80}}\right), \tag{17}$$

where R is the energy efficiency ratio using constant dollar value of shipments as the measure of output.

It is clear from a comparison of equations (16) and (17) that the estimates of efficiency from the Efficiency Program reflect the changes in the product mix within an industry group, and that such changes are not reflected in the MECS/ASM estimates of efficiency change. When product mix effects energy consumption, differences between the MECS/ASM and Efficiency Program estimates are likely.

Survey Coverage

The MECS was specifically designed to represent the energy consumption and related data of the population of manufacturers with five or more employees. (See Appendix A for more details on the representativeness of the

MECS sample.) The Efficiency Program, however, was not designed to produce reliable estimates of energy consumption for the entire manufacturing sector. Rather, its intent was to track energy efficiency change for the *largest* energy-consuming corporations in the U.S. For those industry groups that are dominated by large energy-consuming corporations (petroleum and coal products, for example), it would be expected that the MECS and Efficiency Program estimates of energy consumption would be reasonably close. For other sectors which are dominated by a large number of fairly small companies (printing and publishing, for example), it would be expected that the MECS estimates of energy consumption would be substantially larger than the estimate resulting from the Efficiency Program. Table C1 presents the estimates of energy consumption for 1985 from the MECS and the Efficiency Program, the total number of establishments, and the difference between the estimates.

Table C1: Energy Consumption in the Manufacturing Sector, 1985
(Estimates in Trillions of Btu)

SIC Code[a]	Industry Group	Manufacturing Energy Consumption Survey[b]	Energy Efficiency Improvement Program	Difference (Col. 1 - Col. 2)
20	Food and Kindred Products	946	494	[d]452
21	Tobacco Manufactures	19	17	[e]2
22	Textile Mill Products	248	132	[d]116
23	Apparel and Other Textile Products	30	NA	NA
24	Lumber and Wood Products	333	41	[d]292
25	Furniture and Fixtures	48	NA	NA
26	Paper and Allied Products	2,198	1,016	[f]1,182
27	Printing and Publishing	76	10	[d]66
28	Chemicals and Allied Products	2,407	[c]2,386	[e]21
29	Petroleum and Coal Products	2,631	[c]2,478	[e]153
30	Rubber and Misc. Plastics Products	212	101	[d]111
31	Leather and Leather Products	13	NA	NA
32	Stone, Clay and Glass Products	896	721	[d]175
33	Primary Metal Industries	2,391	2,371	[e]20
34	Fabricated Metal Products	298	37	[d]261
35	Machinery, Except Electrical	239	89	[d]150
36	Electrical and Electronic Equipment	209	89	[d]120
37	Transportation Equipment	317	378	[g]-61
38	Instruments and Related Products	73	29	[d]44
39	Misc. Manufacturing Industries	31	NA	NA
--	**All Manufacturing**	13,615	NA	NA

[a]See Appendix A for a description of the Standard Industrial Classification Codes.
[b]Total input energy -- see Appendix A, "Measures of Energy Consumption."
[c]Estimate adjusted to reflect a conversion factor of 3,412 Btu per kilowatthour rather than 10,000 as used in the Efficiency Program.
[d]Difference attributable to population differences between the MECS and the Efficiency Program.
[e]Difference not significant at p less than 0.05.
[f]Difference attributable to different definitions of energy consumption between the MECS and the Efficiency Program.
[g]Reason(s) for difference unknown.
NA=Not available.
Sources: Energy Information Administration, Office of Energy Markets and End Use, *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA-0512(85) (Washington, DC, 1988), and Department of Energy, Assistant Secretary for Conservation and Renewable Resources, Office of Industrial Programs, *Annual Report to Congress and the President on the Industrial Energy Efficiency Improvement Program*, DOE/CE-0184 (Washington, DC, May 1987).

Of the 20 industry groups, three were excluded entirely from the Efficiency Program because no corporations could be identified that consumed one-trillion Btu of energy in a single two-digit industry group, the minimum energy consumption criterion for inclusion in the program. Ten industry groups had different estimates due to differences in the populations covered by the two programs. Only four industry groups (SIC 21, 28, 29, and 33) had estimates that were not significantly different between the two programs.

Energy Consumption

The energy consumption measure used by the Efficiency Program for the calculation of energy efficiency ratios was described under the section titled "Reporting Requirements" in this appendix. For all industry groups except paper and allied products (SIC 26), this measure of consumption is similar to the MECS measure known as total inputs of energy. For the paper and allied products industry group the measure of energy consumption used in the Efficiency Program was similar to the MECS measure known as offsite-produced energy.

As was described in Appendix A, it was necessary to calculate the MECS/ASM measures of energy efficiency change using the estimates of offsite-produced energy because this was the only measure for which comparable historical data were available. As a result, the estimates of energy efficiency change resulting from the two programs differ with respect to the definitions of energy consumption.

These different definitions, however, provide the basis for determining the extent to which shifting from offsite-produced energy sources to byproduct energy sources affected energy efficiency. The basic difference between the two definitions of energy consumption is that the MECS estimate of offsite-produced energy excludes byproduct fuels, while the Efficiency Program estimate includes byproduct fuels. Thus, all other things being equal, an increased use of byproduct fuels and a decreased use of offsite-produced fuels would be reflected as increased energy efficiency by the MECS/ASM, but not by the Efficiency Program.

Reference Year

The MECS/ASM estimates of energy efficiency change use 1980 as the reference year. The Efficiency Program used 1972 or 1978 as the reference year, and the choice between those two years was made by the respondent. The Efficiency Program reported changes in energy efficiency separately for those respondents choosing 1972 and 1978. However, nearly 95 percent of the 1985 energy consumption reported by the Efficiency Program was accounted for by respondents using 1972 as a reference year.

The Efficiency Program estimates of energy efficiency change presented in this report represent a weighted average of the 1972- and 1978-based estimates. The weighted averages were rebased to 1980 so they would be consistent with the MECS/ASM estimates. The weights for combining the 1972- and 1978-based estimates are the proportions of total energy consumption accounted for by each of the two groups.

Rebasing these weighted average energy efficiency change estimates to 1980 was accomplished by using only the average efficiency change ratios for any given industry group. The rebased estimate of energy efficiency change using 1980 as a reference year can be expressed as:

$$C'_{80,85} = \frac{C'_{b,85} - C'_{b,80}}{1 - C'_{b,80}} \quad , \tag{18}$$

where the subscript "*b*" indicates the weighted average of the 1972- and 1978-based estimates of change.

Equation (18) can be expressed in terms of the energy efficiency ratios, even though the numerical values of those ratios are not available for the Efficiency Program:

$$C'_{80,85} = \frac{\left(1 - \frac{R'_{85}}{R'_b}\right) - \left(1 - \frac{R'_{80}}{R'_b}\right)}{1 - \left(1 - \frac{R'_{80}}{R'_b}\right)} , \tag{19}$$

$$= \frac{\frac{R'_{80}}{R'_b} - \frac{R'_{85}}{R'_b}}{\frac{R'_{80}}{R'_b}} , \tag{20}$$

which reduces to:

$$C'_{80,85} = 1 - \frac{R'_{85}}{R'_{80}} , \tag{21}$$

which is identical in form to the MECS/ASM approach (see equation (17) in this appendix) for estimating energy efficiency change.

Conversion Factors for Electricity

Two factors are commonly used to convert kilowatthours of electricity to British thermal units. These are 3,412 Btu per kWh and 10,000 Btu per kWh. The lower conversion factor is typically used to determine the "usable work" which can be obtained from electricity. The higher conversion factor, on the other hand, is used to determine the total energy consumed to produce a kilowatthour of electricity, and is typically used in conjunction with utilities. The Efficiency Program used the conversion factor of 3,412 Btu per kWh to convert electricity consumption in all industries except chemicals and allied products (SIC 28), and petroleum and coal products (SIC 29). In those two industry groups, the Efficiency Program used a conversion factor of 10,000 Btu per kWh. The basis for this decision was that these two industry groups are heavy generators of electricity and a switchover from purchased to onsite-generated electricity would show up as decreased efficiency unless the offsite electricity use was accounted for by including the input energy used to generate it. The MECS, on the other hand, is an end use survey, and, accordingly, the most appropriate conversion factor for electricity is 3,412 Btu per kWh. This factor was used for the electricity consumption estimates in all industry groups.

Appendix D

Descriptions of Industry Groups

Appendix D

Descriptions of Industry Groups

This appendix contains descriptions of the 20 industry groups taken from the 1972 SIC Manual.[26] The manufacturing establishment and the SIC system were generally described in Appendix A.

SIC 20--Food and Kindred Products

This major group includes establishments manufacturing or processing foods and beverages for human consumption, and certain related products, such as manufactured ice, chewing gum, vegetable and animal fats and oils, and prepared feeds for animals and fowls.

SIC 21--Tobacco Manufactures

This major group includes establishments engaged in manufacturing cigarettes, cigars, smoking and chewing tobacco, and snuff, and in stemming and redrying tobacco.

SIC 22--Textile Mill Products

This major group includes establishments engaged in performing any of the following operations: (1) preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine, and cordage; (2) manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn; (3) dyeing and finishing fiber, yarn, fabric, and knit apparel; (4) coating, waterproofing, or otherwise treating fabric; (5) the integrated manufacture of knit apparel and other finished articles from yarn; and (6) the manufacture of felt goods, lace goods, nonwoven fabrics, and miscellaneous textiles.

SIC 23--Apparel and Other Textile Products

The major group, known as the cutting-up and needle trades, includes establishments producing clothing and fabricating products by cutting and sewing purchased woven or knit textile fabrics and related materials such as leather, rubberized fabrics, plastics, and furs.

SIC 24--Lumber and Wood Products, Except Furniture

This major group includes logging camps engaged in cutting timber and pulpwood; merchant sawmills, lath mills, shingle mills, cooperage stock mills, planing mills, and plywood mills and veneer mills engaged in producing lumber and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or wood substitutes.

SIC 25--Furniture and Fixtures

This major group includes establishments engaged in manufacturing household, office, public building, and restaurant furniture; and office and store fixtures.

SIC 26--Paper and Allied Products

This major group includes the manufacture of pulps from wood and other cellulose fibers, and from rags; the manufacture of paper and paperboard; and the manufacture of paper and paperboard into converted products such as paper coated off the paper machine, paper bags, paper boxes and envelopes.

SIC 27--Printing and Publishing, and Allied Industries

This major group includes establishments engaged in printing by one or more of the common processes, such as letterpress, lithography, gravure, or screen; and those establishments which perform services for the

[26]Office of Management and Budget, Standard Industrial Classification Manual, pp. 59 - 211.

printing trade, such as bookbinding, typesetting, engraving, photoengraving, and electrotyping. This major group also includes establishments engaged in publishing newspapers, books, and periodicals, regardless of whether or not they do their own printing.

SIC 28--Chemicals and Allied Products

This major group includes establishments producing basic chemicals, and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of products: (1) basic chemicals such as acids, alkalies, salts, and organic chemicals; (2) chemical products to be used in further manufacture such as synthetic fibers, plastics materials, dry colors, and pigments; (3) finished chemical products to be used for ultimate consumption such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries such as paints, fertilizers, and explosives.

SIC 29--Petroleum Refining and Related Industries

This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

SIC 30--Rubber and Miscellaneous Plastics Products

This major group includes establishments manufacturing rubber products such as tires, rubber footwear, mechanical rubber goods, heels and soles, flooring, and rubber sundries.

SIC 31--Leather and Leather Products

This major group includes establishments engaged in tanning, currying, and finishing hides and skins, and establishments manufacturing finished leather and artificial leather products and some similar products made of other materials. Leather converters are also included.

SIC 32--Stone, Clay, Glass, and Concrete Products

This major group includes establishments engaged in manufacturing flat glass and other glass products, cement, structural clay products, pottery, concrete and gypsum products, cut stone, abrasive and asbestos products, etc., from materials taken principally from the earth in the form of stone, clay, and sand.

SIC 33--Primary Metal Industries

This major group includes establishments engaged in the smelting and refining of ferrous and nonferrous metals from ore, pig, or scrap; in the rolling, drawing, and alloying of ferrous and nonferrous metals; in the manufacture of castings and other basic products of ferrous and nonferrous metals; and in the manufacture of nails, spikes, and insulated wire and cable. This major group also includes the production of coke.

SIC 34--Fabricated Metal Products, Except Machinery and Transportation Equipment

This major group includes establishments engaged in fabricating ferrous and nonferrous metal products such as metal cans, tinware, hand tools, cutlery, general hardware, nonelectric heating apparatus, fabricated structural metal products, metal forgings, metal stampings, ordnance (except vehicles and guided missiles), and a variety of metal and wire products not elsewhere classified.

SIC 35--Machinery, Except Electrical

This major group includes establishments manufacturing machinery and equipment, other than electrical equipment and transportation equipment.

SIC 36--Electrical and Electronic Machinery, Equipment, and Supplies

This major group includes establishments manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and utilization of electrical energy. The manufacture of household appliances is included in this group, but industrial machinery and equipment powered by built-in or detachable electric motors are classified in Major Group 35.

SIC 37--Transportation Equipment

This major group includes establishments engaged in manufacturing equipment for transportation of passengers and cargo by land, air, and water. Important products produced by establishments classified in this major group include motor vehicles,

aircraft, guided missiles and space vehicles, ships, boats, railroad equipment, and miscellaneous transportation equipment such as motorcycles, bicycles, and snowmobiles.

SIC 38--Instruments and Related Products

This major group includes establishments engaged in manufacturing instruments (including professional and scientific) for measuring, testing, analyzing, and controlling, and their associated sensors and accessories; optical instruments and lenses; surveying and drafting instruments; surgical, medical, and dental instruments, equipment, and supplies; ophthalmic goods; photographic equipment and supplies; and watches and clocks.

SIC 39--Miscellaneous Manufacturing Industries

This major group includes establishments primarily engaged in manufacturing products not classified in any other manufacturing major group. Industries in this group fall into the following categories: jewelry, silverware and plated ware; musical instruments; toys, sporting and athletic goods; pens, pencils, and other office and artists' materials; buttons, costume novelties, miscellaneous notions; brooms and brushes; caskets; and other miscellaneous goods.

Appendix E

Related EIA Publications on Energy Consumption

Appendix E

Related EIA Publications on Energy Consumption

These publications are available from the National Energy Information Center or the Superintendent of Documents. See the inside cover of this report on how to obtain copies of these publications.

In addition to the reports listed below, public use data tapes for the residential, residential transportation and commercial sectors are available from the National Technical Information Service (NTIS). To obtain information on how to order tapes, you may call NTIS at 703/487-4807.

Please note that the prices quoted are subject to change.

Industrial Sector

Manufacturing Energy Consumption Survey: Fuel Switching Capability, 1985; December 1988, DOE/EIA-0515(85), GPO Stock No. 061-003-00601-9, $3.50.

Manufacturing Energy Consumption Survey: Methodological Report, 1985; November 1988, DOE/EIA-0514(85), GPO Stock No. 061-003-00595-1, $6.00.

Manufacturing Energy Consumption Survey: Consumption of Energy, 1985; November 1988, DOE/EIA-0512(85), GPO Stock No. 061-003-00594-2, $6.00.

"Manufacturing Sector Energy Consumption, 1985 Provisional Estimates," *Monthly Energy Review*, January 1987, DOE/EIA-0035(87/01), pp. vii-x.

Report on the 1980 Manufacturing Industries' Energy Consumption Study and Survey of Large Combustors; February 1983, DOE/EIA-0358, GPO Stock No. 061-003-00293-5, $5.00.

Industrial Energy Consumption, "Survey of Large Combustors: Report on Alternate Fuel-Burning Capabilities of Large Boilers in 1979"; February 1982, DOE/EIA-0304, GPO Stock No. 061-003-0233-1, $2.50.

Methodological Report of the 1980 Manufacturing Industries Survey of Large Combustors (EIA-463); March 1982, DOE/EIA-0306 (no GPO Stock No.).

Residential Sector

Housing Characteristics

Housing Characteristics 1987; May 1989, DOE/EIA-0314(87), GPO Stock No. 061-003-00619-1, $13.00.

Residential Energy Consumption Survey: Housing Characteristics 1984; October 1986, DOE/EIA-0314(84), GPO Stock No. 061-003-00499-7, $12.00.

Residential Energy Consumption Survey: Housing Characteristics, 1982; August 1984, DOE/EIA-0314(82), GPO Stock No. 061-003-00393-1, $7.00.

Residential Energy Consumption Survey Housing Characteristics, 1981; August 1983, DOE/EIA-0314(81), GPO Stock No. 061-003-00330-3, $6.50.

Residential Energy Consumption Survey: Housing Characteristics, 1980; June 1982, DOE/EIA-0314, GPO Stock No. 061-003-00256-1, $11.00.

Residential Energy Consumption Survey: Characteristics of the Housing Stock and Households, 1978; February 1980, DOE/EIA-0207/2, GPO Stock No. 061-003-00093-2, $4.25.

Residential Energy Consumption Survey: Conservation; February 1980, DOE/EIA-0207/3, GPO Stock No. 061-003-00087-8, $6.00.

Preliminary Conservation Tables from the National Interim Energy Consumption Survey; August 1979, DOE/EIA-0193/P (no GPO Stock No.).

Characteristics of the Housing Stock and Households: Preliminary Findings from the National Interim Energy Consumption Survey; October 1979, DOE/EIA-0199/P (no GPO Stock No.).

Consumption and Expenditures

Household Energy Consumption and Expenditures 1987, Part 1: National Data; October 1989, DOE/EIA-0321/1(87).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985, Part 1: National Data; March 1987, DOE/EIA-0321/1(84).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985, Part 2: Regional Data; May 1987, DOE/EIA-0321/2(84).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 1: National Data; November 1984, DOE/EIA-0321/1(82), GPO Stock No. 061-003-00411-3, $7.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 2: Regional Data; Dec. 1984, DOE/EIA-0321/2(82), GPO Stock No. 061-003-00414-8, $9.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 1: National Data; Sept. 1983, DOE/EIA-0321/1(81), GPO Stock No. 061-003-00340-1, $6.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 2: Regional Data; October 1983, DOE/EIA-0321/2(81), GPO Stock No. 061-003-00357-5, $8.00.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 1: National Data; Sept. 1982, DOE/EIA-0321/1(80), GPO Stock No. 061-003-00278-1, $7.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 2: Regional Data; June 1983, DOE/EIA-0321/2(80), GPO Stock No. 061-003-00319-2, $7.00.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part 1: National Data (Including Conservation); April 1981, DOE/EIA-0262/1, GPO Stock No. 061-003-00191-2, $6.50.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part II: Regional Data; May 1981, DOE/EIA-0262/2, GPO Stock No. 061-003-00189-1, $8.50.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1978 Through March 1979; July 1980, DOE/EIA-0207/5, GPO Stock No. 061-003-00131-9, $7.50.

Single-Family Households: Fuel Oil Inventories and Expenditures: National Interim Energy Consumption Survey; December 1979, DOE/EIA-0207/1, GPO Stock No. 061-003-00075-4, $3.50.

Other Publications on the Residential Sector

End-Use Consumption of Residential Energy (Article), pp. vii-xiv, Monthly Energy Review, July 1987, DOE/EIA-0035(87/07).

Residential Energy Consumption Survey: Trends in Consumption and Expenditures 1978-1984 June 1987, DOE/EIA-0482, GPO Stock No. 061-003-00535-7, $12.00.

Residential Conservation Measures; July 1986, SR/EEUD/86/01 (no GPO Stock No.).

An Economic Evaluation of Energy Conservation and Renewable Energy Tax Credits; October 1985, Service Report (no GPO Stock No.).

Residential Energy Consumption and Expenditures by End Use for 1978, 1980, and 1981; December 1984, DOE/EIA-0458, GPO Stock No. 061-003-00415-6, $4.50.

Weatherization Program Evaluation, SR-EEUD-84-1; August 1984 (available from the Office of the Assistant Secretary for Conservation and Renewable Energy, Department of Energy).

Residential Energy Consumption Survey: Regression Analysis of Energy Consumption by End Use; October 1983, DOE/EIA-0431, GPO Stock No. 061-003-00347-8, $5.00.

National Interim Energy Consumption Survey: Exploring the Variability In Energy Consumption; July 1981, DOE/EIA-0272, GPO Stock No. 061-003-00205-6, $5.00.

National Interim Energy Consumption Survey: Exploring the Variability in Energy Consumption--A Supplement;

October 1981, DOE/EIA-0272/S, GPO Stock No. 061-003-00217-0, $4.50.

Energy Use by U.S. Households; November 1980, DOE/EIA-0248 (brochure, no GPO Stock No.).

Commercial Sector

Characteristics of Buildings

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1986; September 1988, DOE/EIA-0246(86), GPO Stock No. 061-003-00580-2, $16.00.

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; July 1985, DOE/EIA-0246(83), GPO Stock No. 061-003-00439-3, $7.50.

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; A Supplemental Reference, DOE/EIA-M008, $22.95. Available from the National Technical Information Service (NTIS), Order No. DE-85015581.

Nonresidential Buildings Energy Consumption Survey: Fuel Characteristics and Conservation Practices; June 1981, DOE/EIA-0278, GPO Stock No. 061-003-00200-5, $9.00.

Nonresidential Buildings Energy Consumption Survey: Building Characteristics; March 1981, DOE/EIA-0246, GPO Stock No. 061-003-00171-8, $6.50.

Consumption and Expenditures

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings Consumption and Expenditures 1986; May 1989, DOE/EIA-0318(86), GPO Stock No. 061-003-00613-2, $19.00.

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings, Consumption and Expenditures 1983; September 1986, DOE/EIA-0318(83), GPO Stock No. 061-003-00496-2, $13.00.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 1:Natural Gas and Electricity; March 1983, DOE/EIA-0318/1, GPO Stock No. 061-003-00298-6, $9.50.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 2: Steam, Coal, Fuel Oil, LPG, and Total Fuels; December 1983, DOE/EIA-0318(79)/2, GPO Stock No. 061-003-00366-4, $6.00.

Residential Transportation Sector

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles 1985; April 1987, DOE/EIA-0464(85), GPO Stock No. 061-003-00521-7, $8.50.

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1983; January 1985, DOE/EIA-0464(83), GPO Stock No. 061-003-00420-2, $4.50.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981; February 1983, DOE/EIA-0328, GPO Stock No. 061-003-00297-8, $4.75.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, June 1979 to December 1980; April 1982, DOE/EIA-0319 (no GPO Stock No.).

Cross-Sector

Natural Gas: Use and Expenditures; April 1983, DOE/EIA-0382, GPO Stock No. 061-003-00307-9, $5.50.

Planned Publications

Household Energy Consumption and Expenditures 1987, Part 2: Regional Data; planned for Nov. 1989.

Household Vehicles Energy Consumption 1988; planned for Dec. 1989.

Public Use Tapes

Residential and Residential Transportation Sectors

Residential Energy Consumption Survey: 1987 and Residential Transportation Energy Consumption Survey: 1988; planned for February 1990.

Residential Energy Consumption Survey: 1984 and Residential Transportation Energy Consumption Survey, 1985; Order No. PB87-186540/HAA.

Residential Energy Consumption Survey: 1982 and Residential Transportation Energy Consumption Survey, 1983; Order No. PB85-221760/HAA.

Residential Energy Consumption Survey: Housing Characteristics, 1981; Consumption and Expenditures, 1981-1982; Monthly Billing Data; Order No. PB84-120476/HAA.

Residential Energy Consumption Survey: Consumption and Expenditures, 1980-1981; Monthly Billing Data; Order No. PB84-166230/HAA.

Residential Energy Consumption Survey: Housing Characteristics, Annualized Consumption and Expenditures, 1980-1981; Order No. PB83-199554/HAA.

Residential Energy Consumption Survey: HouseholdTransportation Panel Monthly Gas Purchases and Vehicle and Household Characteristics, 6/79-9/81; Order No. PB84-162452/HAA.

Residential Energy Consumption Survey: Household Screener Survey, 1979-1980; Order No. PB82-114877/HAA.

Residential Energy Consumption Survey: Household Monthly Energy Consumption and Expenditures, 1978-1979; Order No. PB82-114901/HAA.

National Interim Energy Consumption Survey (Residential), 1978; Order No. PB81-108714/HAA.

Commercial Sector

Nonresidential Buildings Energy Consumption Survey: 1986 Data; Order No. PB90-500034.

Nonresidential Buildings Energy Consumption Survey: 1979 and 1983 Data; Order No. PB88-245162.

Glossary

Glossary

Anthracite: A hard, black, lustrous coal containing a high percentage of fixed carbon and a low percentage of volatile matter. It is often referred to as hard coal. For the purposes of the Manufacturing Energy Consumption Survey (MECS), anthracite contains approximately 23.031 million Btu per short ton.

Bituminous Coal: A soft coal (the most common solid fossil fuel) that is high in carbonaceous matter, with a volatility greater than anthracite and a calorific value greater than lignite. For the purposes of the MECS, bituminous coal used as a fuel contains approximately 22.012 million Btu per short ton. Bituminous coal used for coking contains approximately 26.8 million Btu per short ton.

Biomass: Organic (animal waste), nonfossil plant material constituting an exploitable energy source.

Blast Furnace Gas: Waste combustible gas generated in a blast furnace when iron ore is being reduced with coke to metallic iron. It is commonly used as a fuel within the steel works.

Breeze: The residue from the fine screenings of crushed coke.

British Thermal Unit (Btu): The amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit at or near 39.2 degrees Fahrenheit.

Butane (C_4H_{10}): A normally gaseous, paraffinic hydrocarbon extracted from natural gas or refinery gas streams. It includes isobutane (a branch-chain configuration) and normal butane (a straight-chain configuration). It is used primarily for blending into high-octane gasoline, for residential and commercial heating, and for industrial uses, especially the manufacture of chemicals and synthetic rubber.

Byproduct: A secondary or additional product resulting from the feedstock use of energy or processing of nonenergy materials. For example, the more common byproducts of coke ovens are coal gas, tar, and a mixture of benzene, toluene, and xylene (BTX).

Coal Coke: The strong, porous residue, consisting of carbon and mineral ash, that is formed when the volatile constituents of bituminous coal are driven off by heat in the absence of or with a limited supply of air. Coal coke is used primarily in blast furnaces.

Cogeneration: The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Coke Oven Gas: The mixture of permanent gases produced by the carbonization of coal in a coke oven at temperatures in excess of 1000 degrees Celsius.

Company (Firm): As used in the MECS, a company is an economic entity consisting of one or more physical locations, at least one of which is involved in manufacturing. If the company consists of a single physical location, the term is synonymous with manufacturing establishments.

Constant Dollar Output: As used in the MECS, the real or deflated value of shipments and receipts which excludes the effect of price changes.

Consumption: The use of energy as a source of heat or power, or as an input in the manufacturing process.

Conversion Factor: A number which translates units of one system into corresponding values of another system. Conversion factors are used to translate physical units of measure for various fuels into Btu equivalents.

Distillate Fuel Oil: A general classification for light fuel oils distilled during the refining process. Includes products known as Nos. 1,2, and 4 fuels oils; and Nos. 1,2, and 4 diesel fuels. It is used primarily for space heating, on-and-off-highway engine fuel, and electric power generation.

Energy Efficiency: As used in the MECS, the ratio of energy consumption to output measured in constant dollar value of shipments.

Establishment: As defined by the 1972 Standard Industrial Classification Manual, "...an economic unit, generally at a single physical location where business is conducted or where services or industrial operations are performed."

Ethane (C_2H_6): Ethane is used primarily as petrochemical feedstock for production of chemicals and plastic materials.

Ethylene (C_2H_4): Ethylene is used primarily as a petrochemical feedstock for numerous chemical applications and the production of consumed goods.

Expenditures: Funds spent for energy purchased and paid for, or delivered to a manufacturer during the 365-day period of calendar year 1985. For purposes of the MECS, the expenditure dollar amount includes State and local taxes and delivery charges.

Fossil Fuel: Any naturally occurring organic fuel, such as coal and natural gas.

Fuel: Any substance that can be burned to produce heat.

Fuel Use (of Energy): Use of energy in the production of heat, steam, power, or the generation of electricity.

Generation: The process of producing steam or electrical energy by transforming other forms of energy.

Geothermal Energy: How water or steam, extracted from reservoirs in the Earth's crust, which is generally supplied to steam turbines that drive generators to produce electricity.

Hydroelectric Power: Electricity generated by a turbine driven by falling water.

Hydrogen: A colorless, odorless, highly flammable, gaseous element; the lightest of all gases and the most abundant element in the universe.

Inputs of Energy: As used in the MECS, inputs of energy is the total amount of energy used to produce heat and power and to generate electricity. It consists of:

- Energy consumed onsite as a fuel and produced offsite
- Energy consumed onsite as a fuel and produced onsite from nonenergy inputs
- Energy consumed onsite as a fuel and produced onsite from energy products.

Kilowatthour (kWh): A unit of work or energy, measured as 1,000 watts (1 kilowatt) of power expended for 1 hour. Once generated, 1 kWh is equivalent to 3,412 Btu.

Liquefied Petroleum Gases (LPG): Gas fuel in liquid form supplied as an energy source. The fuel is usually delivered by tank trucks and stored in a tank or cylinder until used. LPG includes ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas plant liquids.

Lignite: A brownish-black coal of low rank with a high percentage of inherent moisture and volatile matter content. It is also referred to as brown coal. For the purposes of the MECS, lignite contains approximately 22.012 million Btu per short ton.

Manufacturing Establishment: An economic unit at a single physical location where the mechanical or chemical transformation of materials or substances into new products is performed. These operations are generally conducted in facilities described as plants, factories, or mills and characteristically use power-driven machines and material-handling equipment. In addition, the assembly of components of manufactured products is considered manufacturing, as is the blending of materials such a lubricating oil, plastics, resins, or liquors. Manufacturing establishments are covered by SIC codes 20 through 39.

Manufacturing Sector: The universe of manufacturing establishments within the 50 States and the District of Columbia.

Megawatthours (mWh): A unit of work of energy, measured as 1 million watts (1 megawatt) of power expended for 1 hour.

Motor Gasoline: A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, obtained by blending appropriate refinery streams to form a fuel suitable for use in spark-ignition engines. Motor gasoline includes both leaded and unleaded grades of finished motor gasoline, blending components, and gasohol.

Natural Gas: A mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons

existing in the gaseous phase or in solution with oil in natural underground reservoirs at reservoir conditions. Natural gas may be subclassified as:

- Associated gas: Free natural gas, commonly known as gas-cap gas, which overlies and is in contact with crude oil in the reservoir.
- Dissolved gas: Natural gas which is in solution with crude oil in the reservoir at reservoir conditions.
- Nonassociated gas: Free natural gas not in contact with crude oil in the reservoir.

All natural gas volumes are reported in cubic feet at a pressure base of 14.73 psia, at 60 degrees Fahrenheit. For the purposes of the MECS, natural gas contains 1,032 Btu per cubic foot.

Nonfuel Use (of Energy): Use of energy as feedstock (for example, coal used to produce coke, crude oil used to produce petroleum products), raw materials, additives, or ingredients for products manufactures, or for any other purpose besides fuel use.

Offsite-Produced Energy: As used in the MECS, any energy source that was purchased or transferred from outside of the defined boundaries of the establishment in which it was consumed for the production of heat and power, and the generation of electricity. (See Purchased Fuels and Electricity.)

Petroleum Coke: A solid residue, high in carbon content and low in hydrogen, which is the final product of thermal decomposition in the condensation process of cracking crude oil. Petroleum coke can yield almost pure carbon or artificial graphite suitable for production of carbon or graphite electrodes, structural graphite, motor brushes, dry cells, and similar products.

Petrochemical Feedstock: Chemical feedstocks derived from petroleum and used principally for the manufacture of chemicals, synthetic runner, and a variety of plastics.

Plant: Commonly used as synonym for establishment. However, the term can also be used to refer to a particular process within an establishment.

Primary Energy Consumption: As used in the MECS, primary energy consumption is the total energy requirements (including raw material inputs and petrochemical feedstocks) of manufactures necessary to produce nonenergy goods. Primary energy consumption consists of:

- Energy consumed onsite as a fuel and produced offsite
- Energy consumed onsite for nonfuel purposes and produced offsite
- Energy consumed onsite as a fuel and produced onsite from nonenergy inputs
- Energy consumed onsite for nonfuel purposes and produced offsite from nonenergy inputs.

Primary Production: The principal product or group of products produced by a manufacturing establishment as determined by the relative shares of value added.

Propane (C_3H_8): It is used primarily for residential and commercial heating and cooling, and also as a fuel for transportation. Industrial applications include use as a petrochemical feedstock.

Propylene (C_3H_6): Propylene is used primarily as a petrochemical feedstock.

Pulping Liquor (Black Liquor): The alkaline spent liquor removed from the digesters in the process of chemically pulping wood. After evaporation, the liquor is burned as fuel in a furnace that permits the recovery of certain reusable chemicals.

Purchased Fuels and Electricity: As used in the Census Bureau's Annual Survey of Manufactures, any energy source that was purchased or transferred from outside of the defined boundaries of the establishment in which it was consumed for the production of heat and power, and the generation of electricity. (See Offsite-Produced Energy.)

Refinery: A plant, device, or process which heats crude oil so it separates into chemical components, which are then distilled off as more usable substances. Simple structure components vaporize first. Typical crude fractions are unstabilized gas, naphtha, kerosene and diesel range middle distillates, atmospheric gas oil, and atmospheric residual.

Relative Standard Error (RSE): A measure of the reliability or precision of a survey statistic. Relative Standard Error, or RSE, is expressed as a percent. It is derived as the standard error of a survey estimate, divided by the survey estimate, and multiplied by 100.

Roundwood: Wood cut specifically for use as a fuel.

Solar Energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Standard Industrial Classification (SIC): A set of codes developed by the Office of Management and Budget that categorize businesses into groups with similar economic activities.

Still Gas (Refinery Gas): Any form or mixture of gas produced in refineries by distillation, cracking, reforming, and other processes, the principal constituents of which are methane, hydrogen, ethane, ethylene, propane, propylene, butanes, butylene, etc. Still gas is used as a petrochemical feedstock and refinery fuel use.

Value Added: An unduplicated measure of output that includes wages and supplements, net interest,indirect business taxes, and corporate profits or income of unincorporated enterprises.

Value of Shipments: The net selling values received or receivable, f.o.b. plant, after discounts and allowances, and excluding freight charges and excise taxes.

Waste Materials: Otherwise discarded combustible materials which, when burned, produce energy for such purposes as space heating and electric power generation. The size of the waste may be reduced by shredders, grinders, or hammermills. Noncombustible materials, if any, may be removed. The waste may be dried and then burned, either alone or in combination with fossil fuels.

Waste Oils and Tar: Petroleum-based materials that are worthless for any purpose other than fuel use; for example, residual byproducts of chemical processes, residue from refining processes, or unsalable refinery byproducts.

Wood Waste: Wood byproducts used as a fuel. Included are limb wood, wood chips, bark, sawdust, forest residues, charcoal, and pulp waste.

DOE/EIA-0516(85)
Distribution Category UC-98

Manufacturing Energy Consumption Survey: Changes in Energy Efficiency 1980 - 1985

Energy Information Administration
Office of Energy Markets and End Use
U.S. Department of Energy
Washington, DC 20585

Contacts

General information about Energy Information Administration data on energy consumption, energy efficiency, or fuel-switching capabilities of the manufacturing sector can be obtained from Lynda T. Carlson, Director of the Energy End Use Division (202/586-1112).

Specific information regarding the contents or preparation of this publication and other publications in the Manufacturing Energy Consumption Survey series can be obtained from Dwight K. French, Chief of the Transportation and Industrial Branch (202/586-1126), or John L. Preston, Team Leader for the Manufacturing Energy Consumption Survey (202/586-1128). Robert K. Adler (202/586-1134) prepared the estimates of energy efficiency change. Jean Paananen (202/586-1800) is the contact on questionnaire content for the Manufacturing Energy Consumption Survey.

AFTER THE DECLARATION OF INDEPENDENCE OUR FOUNDING FATHERS WROTE SOMETHING EVEN MORE IMPORTANT.

Ten years after the signing of the Declaration of Independence our founding fathers created what historians have called the greatest single document struck off by the hand and mind of man.

Our founding fathers created the Constitution of the United States.

For the first time in history, power was granted by the people to the government, and not by the government to the people.

The freedom unleashed by the Constitution allowed Americans to develop their talents and abilities to the fullest. And attain what is now known the world over as the *American Dream*.

As we commemorate the Bicentennial of the Constitution, there is no better way for you as an American to reaffirm the principles for which our country stands than to learn more about the Constitution.

The words we live by.

THE CONSTITUTION

The words we live by

To learn more about the Constitution write: Constitution, Washington, D.C. 20599. The Commission on the Bicentennial of The U.S. Constitution. Ad Council

Energy Information Administration
U.S. Department of Energy
Forrestal Building, EI-231
Washington, DC 20585

Return Postage Guaranteed