1. Introduction

Manufacturing Consumption of Energy 1994 provides estimates on energy consumption in the manufacturing sector of the U.S. economy.[1] The estimates are based on data from the 1994 Manufacturing Energy Consumption Survey (MECS). The MECS, administered by the Energy Information Administration (EIA), is the most comprehensive source of national-level data on energy-related information about the manufacturing industries.

Manufacturing Energy Consumption Surveys

To determine how energy is used in the manufacturing sector, EIA gathers information from a national representative sample of the manufacturing establishments that transform input materials or substances into new products, assemble components, or perform blending operations.[2] In 1994, of the approximately 380 thousand manufacturing establishments in the United States, the MECS sample represented about 250 thousand of the largest establishments. Those establishments account for approximately 98 percent of U.S. economic output from manufacturing and an expected similar proportion of manufacturing energy use. The amount of energy an establishment uses is collected for all of its operations and not solely for the amount of energy used in manufacturing its product.

The 1994 MECS is EIA's fourth survey of the manufacturing sector. Previous manufacturing surveys were conducted in 1986, 1989, and 1992 (for reporting years 1985, 1988, and 1991, respectively). The next manufacturing survey will be conducted for reporting year 1998, with subsequent surveys being conducted every 4 years thereafter.

The sample design of the 1985, 1991, and 1994 surveys differed somewhat from that of the 1988 survey, which necessitates that care be exercised when comparing estimates from the four surveys. The 1988 sample represented 100 percent of manufacturing energy use, but it included statistical adjustments to account for 2 percent of the population, namely the smallest manufacturing establishments. The 1985, 1991, and 1994 samples represented 98 percent of the population, without any statistical adjustment.

The MECS is conducted under the authority of the Federal Energy Administration Act of 1974, Public Law 93-275, as amended, and Section 205 of the Department of Energy Organization Act, Public Law 95-91, as amended by Section 3102 of the Omnibus Budget Reconciliation Act of 1986, Public Law 99-509.[3]

On behalf of EIA, the Manufacturing and Construction Division of the Bureau of the Census collects and compiles the data. All data reported to the Bureau of the Census are confidential under the provisions of Section 9, Title 13, of the U.S. Code. EIA gratefully acknowledges the cooperation of the respondents in supplying the information used to produce the estimates in this report.

Organization of This Report

This introductory chapter is followed by three more chapters:

- Chapter 2 presents the reader with a brief summary of what is new in the 1994 MECS, along with four questions that demonstrate how the new data can be used to analyze energy consumption by the manufacturing sector.

- Chapter 3 presents profiles for the four major energy-consuming manufacturing industries: the petroleum refining, chemical, paper, and primary metal industries.

[1]The energy data used in this report do not reflect adjustments for losses in electricity generation or transmission.

[2]The manufacturing sector is composed of establishments classified in Standard Industrial Classification 20 through 39 of the U.S. economy as defined by the Office of Management and Budget. The manufacturing sector is a part of the industrial sector, which also includes mining; construction; and agriculture, forestry, and fishing.

[3]The EIA also conducts energy consumption surveys in the residential, commercial buildings, and residential transportation sectors: the Residential Energy Consumption Survey (RECS); the Commercial Buildings Energy Consumption Survey (CBECS); and, until recently, the Residential Transportation Energy Consumption Survey (RTECS).

- Chapter 4 presents "How Changing Energy Markets Affect Manufacturing," a feature article analyzing the effects of changes in the natural gas and electricity markets on the manufacturing sector.

Seven appendices follow the chapters:

- Appendix A presents detailed statistical tables that provide measures of data reliability (relative standard errors) as factors in the rows and columns of the data tables.[4]

  The tables presented in this publication have been enhanced in two ways. First, additional data have been incorporated into tables that were present in 1991. Most of the time, those additional data are "the number of establishments," collected for the first time in the 1994 MECS. An example is Table A1: a Part 5 has been added to present the number of establishments.

  Secondly, new tables have been added. New tables are A7, "floorspace"; A29, "demand-side management"; A32, A34-A36, A38-A40, and A45, "fuel switching"; and A47, "wood used as energy."

- Appendix B explains the sample design of and the estimation and implementation procedures for the MECS.
- Appendix C discusses the quality of the data.
- Appendix D provides copies of the forms used to collect the MECS data, Forms EIA-846 A through C, on which the estimates in this report are based, unless otherwise noted.
- Appendix E provides a map of the U.S. Census Regions and Divisions.
- Appendix F describes the major industrial groups and selected industries.
- Appendix G presents metric conversion factors.
- Appendix H lists related energy consumption publications for readers interested in earlier MECS publications or consumption reports for other sectors.

A glossary of statistical and engineering terms used in this report follows the appendices.

A Guide to the Tables in This Report

Energy	Table
Consumption	A1-A6
End Use	A9, A10
Management	A24, A25
Operating Ratios	A23
Sources	A44
Technology	A26, A27
Electricity	
Demand	A11
Generation	A12, A13
Sales	A14
Purchased Energy	
Consumption	A15, A16
Expenditures	A17-A19
Average Prices	A20-A22
Fuel Switching	A28-A40
Square Footage	A7, A8
Motors	A41, A42
Wood	A43

[4]To better serve the user community, EIA has made those tables and other, more detailed, tables available electronically at http://www.eia.doe.gov/emeu/mecs/contents.html.

2. New in the 1994 MECS

1994 MECS Sample

In 1994, the MECS sample size was increased by roughly 40 percent. The increase allows the Energy Information Administration (EIA) to publish separate estimates for 52 industries and industry groups, nine more than in the 1991 MECS. The larger sample also provided reliable data for energy consumption at the geographic level of nine Census divisions.

New 1994 Data

In addition to the new data analyzed on these two pages, cogeneration technologies, biomass, number of establishments, and square footage, other new data are available from the 1994 MECS. For the first time, data on actual fuel switching between natural gas and fuel oil are available. Other newly available data cover methods that manufacturers most commonly used to purchase and make modifications to electric motor systems, participation in the U.S. Department of Energy's Motor Challenge Program, and participation in the Environmental Protection Agency's Green Lights and Energy Star programs.

What Type of Cogeneration Technologies Did the Largest Cogenerator Use in 1994?

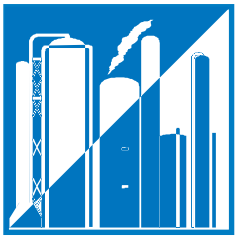
Paper Industry

The largest cogenerator, the paper industry, cogenerated 51 billion kilowatthours of electricity in 1994 (Table A12). The cogeneration technology most used was the steam turbine supplied by bed boilers (61 percent of the cogenerated electricity). Twenty-three percent of the paper industry's cogeneration occurred in establishments where two or more different types of cogeneration technologies were used (Table A13).

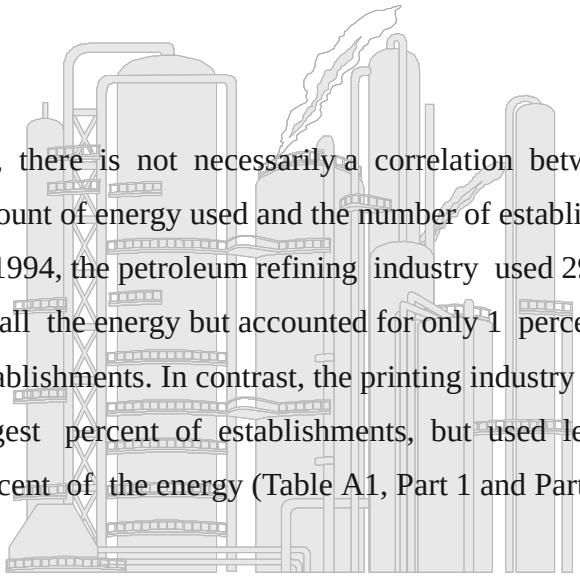
What Types of Biomass Are Used as an Energy Source, How Much Is Used, and by Whom?

In the manufacturing sector, biomass, used as an energy source, consists of agricultural wastes, wood directly harvested from trees, wood residues from mill processing, and wood-related and paper-related refuse. In 1994, biomass accounted for 831 trillion Btu of energy used for heat, power, and electricity generation, and wood residues from mill processing accounted for 61 percent of that amount. The paper industry used the most biomass, 49 percent in 1994. The next largest user, the lumber industry, accounted for 33 percent, followed by the food industry, which accounted for 13 percent (Table A43).

Do the Industries That Consume the Most Energy Also Have the Largest Number of Establishments?



Petroleum Refining Industry



No, there is not necessarily a correlation between the amount of energy used and the number of establishments. In 1994, the petroleum refining industry used 29 percent of all the energy but accounted for only 1 percent of the establishments. In contrast, the printing industry had the largest percent of establishments, but used less than 1 percent of the energy (Table A1, Part 1 and Part 5).

Do the Industries That Have the Most Square Footage Also Have High Energy Intensities?

Chemical Industry

No, in the manufacturing sector, there is not necessarily a correlation between square footage and the intensity of energy use. The chemical industry had the largest amount of floorspace of any of the major users of energy (808 million square feet). That amount of floorspace was only about 67 percent as much as the industry with the most floorspace--the fabricated metal industries. The energy intensity for the chemical industry was 21 times higher than the energy intensity for the fabricated metal industries (6.6 million Btu per square foot versus .31 million Btu per square foot). The chemical industry accounted for almost 25 percent of manufacturing energy use, while the fabricated metal industries accounted for only 2 percent (Tables A7 and A1, Part 1).

3. Industry Profiles: Major Energy Consumers

In 1994, there were 246,855 manufacturing establishments in the manufacturing population covered by the MECS that used at least one energy source. Just 9 percent of the establishments accounted for almost 78 percent of all of the energy used in the manufacturing sector as measured by "Total First Use of Energy for All Purposes." Those establishments belong to only four major industry groups, defined by 2-digit Standard Industrial Classification (SIC) codes. This chapter presents individual profiles of each of the four major energy-consuming industries.

The Four Major Energy Consumers in the Manufacturing Sector

Petroleum and Coal Products (SIC 29). The petroleum refining industry is the largest consumer of energy in the manufacturing sector. Large amounts of energy are used to produce energy. Establishments in this group are engaged primarily in refining petroleum, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

Chemicals and Allied Products (SIC 28). The chemical industry includes establishments producing basic chemicals. It also includes establishments that use predominately chemical processes to manufacture products used in further manufacture, producing such products as synthetic fibers and plastics; or as a final product for consumption, such as drugs and cosmetics; or as materials and supplies, such as paints and fertilizers.

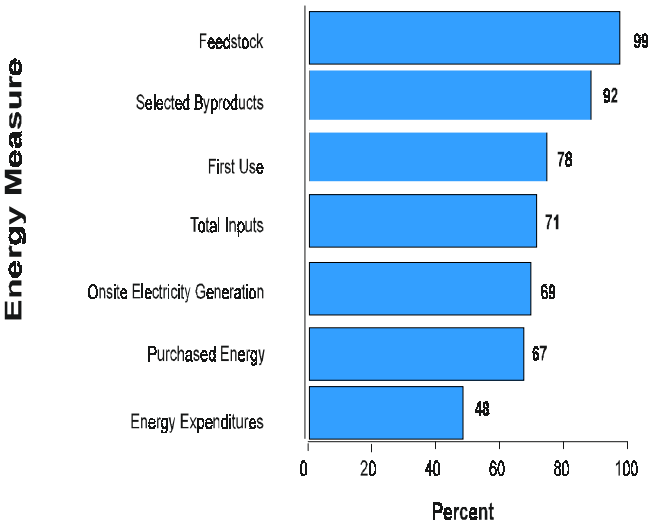
Paper and Allied Products (SIC 26). The paper industry includes establishments called pulp mills that are engaged primarily in the manufacture of pulps from wood and other cellulose fibers, rags, wastepaper, and straw. It also includes paper and paperboard mills, which manufacture paper and convert paper into products such as napkins and paperboard.

Primary Metal Industries (SIC 33). The metal industries include establishments engaged in smelting and refining ferrous and nonferrous metals from ore, pig, or scrap. Also, refined metals, such as steel, iron, and aluminum, are rolled and turned into basic shapes, such as plates, sheets, strips, rods, bars, and tubing. Establishments participating in the manufacture of alloys and copper smelting also belong to this group.

Quantities of Energy and Expenditures for the Four Major Energy Consumers

In 1994, the four major energy consumers accounted for 99 percent of all energy consumed as feedstock and 92 percent of the byproduct energy (a secondary product from the feedstock use of energy or from the processing of nonenergy materials) (Figure 3.1). With feedstock excluded, these four industries accounted for 71 percent of the measure "Total Inputs of Energy for Heat, Power, and Electricity Generation." Although they purchased 67 percent of all purchased energy, they spent only 48 percent of all of the dollars spent on energy in the manufacturing sector. The four industries also generated the most electricity--69 percent of all electricity generated by the manufacturing sector.

Figure 3.1. Percent of Total Energy Measure by the Four Major Energy Consumers, 1994



Source: Energy Information Administration, 1994 Manufacturing Energy Consumption Survey.

Petroleum and Coal Products (SIC 29)

How Much Energy Did the Petroleum Refining Industry Use in 1994?

First Use of Energy for All Purposes:

- The petroleum refining industry used 6,339 trillion Btu of energy--29 percent of total manufacturing energy use.
- It used 50 percent as feedstock (a nonenergy use).

For Which Energy Sources Did the Petroleum Refining Industry Spend the Most Dollars?

Energy Expenditures:

- Forty-seven percent of the expenditures were for natural gas, with an average price of $2.26 per 1,000 cubic feet--25 percent lower than the average price for the rest of the manufacturing sector.
- Most of the remaining expenditures were for electricity--38 percent in 1991 (the most recent year for which data were available).

What Were the Most Important Energy End Uses?

End Use of Total Inputs of Energy for Heat, Power, and Electricity Generation:

- Machine drives accounted for 80 percent of net electricity use.
- Boiler fuel accounted for 52 percent of residual fuel oil use; process heating accounted for 40 percent.
- Process heating accounted for 68 percent of liquefied petroleum gas use; boiler fuel accounted for 21 percent.
- Process heating accounted for 67 percent of distillate fuel oil use.

Between 1991 and 1994, What Changed in the Amount of Energy Purchased and Its Cost?

Quantity of Purchased Energy (Annualized Rates):

- Total purchased energy decreased 2.3 percent.

Expenditures and Average Prices (Annualized Rates):

- Total expenditures decreased 2.7 percent.
- Natural gas expenditures grew 2.1 percent and average prices grew 1.2 percent.

Chemicals and Allied Products (SIC 28)

How Much Energy Did the Chemical Industry Use in 1994?

First Use of Energy for All Purposes:

- The chemical industry used 5,328 trillion Btu of energy--25 percent of total manufacturing energy use.
- It used 46 percent as feedstock (a nonenergy use).
- Ninety-five percent of all liquefied petroleum gas (LPG) used in the manufacturing sector was used by this industry, mostly as feedstock.

For Which Energy Sources Did the Chemical Industry Spend the Most Dollars?

Energy Expenditures:

- In 1994, the chemical industry accounted for 26 percent of all energy expenditures in the manufacturing sector.
- Of total expenditures, electricity accounted for 30 percent, LPG accounted for 30 percent, and natural gas accounted for 30 percent..

What Were the Most Important Energy End Uses?

End Use of Total Inputs of Energy for Heat, Power, and Electricity Generation:

- Machine drives accounted for 62 percent of net electricity use.
- Boiler fuel accounted for 62 percent of residual fuel oil use.
- Boiler fuel accounted for 49 percent of natural gas use; process heating accounted for 33 percent.
- Boiler fuel accounted for 95 percent of coal use.

Between 1991 and 1994, What Changed in the Amount of Energy Purchased and Its Cost?

Quantity of Purchased Energy (Annualized Rates):

- Total purchased energy increased 6.7 percent.
- Purchased electricity increased 6.2 percent.
- Purchased natural gas increased 5.7 percent.

Expenditures and Average Prices (Annualized Rates):

- Total expenditures grew 1.7 percent, while average prices fell 4.2 percent.
- Electricity expenditures grew 3.7 percent, while average prices fell 2.1 percent.
- Natural gas expenditures grew 9.7 percent and average prices increased 3.4 percent.

Paper and Allied Products (SIC 26)

How Much Energy Did the Paper Industry Use in 1994?

First Use of Energy for All Purposes:

- The paper industry used 2,665 trillion Btu of energy--12 percent of total manufacturing energy use.
- It used 35 percent of all residual fuel oil used in the manufacturing sector.

For Which Energy Sources Did the Paper Industry Spend the Most Dollars?

Energy Expenditures:

- Almost half of the expenditures were for electricity, with an average price of 4.1 cents per kilowatthour--8 percent lower than the average price paid by the rest of the manufacturing sector.
- Twenty-three percent of the expenditures were for natural gas with an average price of $2.61 per 1,000 cubic feet--11 percent lower than the average price for the rest of the manufacturing sector.

What Were the Most Important End Uses?

End Use of Total Inputs of Energy for Heat, Power, and Electricity Generation:

- Machine drives accounted for 80 percent of net electricity use.
- Boiler fuel accounted for 80 percent of residual fuel oil use.
- Boiler fuel accounted for 70 percent of natural gas use.
- Boiler fuel accounted for 98 percent of coal use.

Between 1991 and 1994, What Changed in the Amount of Energy Purchased and Its Cost?

Quantity of Purchased Energy (Annualized Rates):

- Purchased electricity increased 4.1 percent.
- Residual fuel oil purchases increased 4.2 percent.

Expenditures and Average Prices (Annualized Rates):

- Total expenditures grew 1.2 percent.
- Electricity expenditures grew 1.0 percent, while average prices fell 2.7 percent.

Primary Metal Industries (SIC 33)

How Much Energy Did the Metal Industries Use in 1994?

First Use of Energy for All Purposes:

- The metal industries used 2,462 trillion Btu of energy--11 percent of total manufacturing energy use.
- It used 39 percent as feedstock (a nonenergy use).
- Ninety-five percent of all coke and breeze used in the manufacturing sector was used by this industry.
- Forty percent of coal used in the manufacturing sector was used by the metal industries, mostly as feedstock.

For Which Energy Sources Did the Metal Industries Spend the Most Dollars?

Energy Expenditures:

- Sixteen percent of all energy expenditures for the manufacturing sector were in this industry.
- Almost two-thirds of the expenditures in this industry occurred in the blast furnace and steel mills industry (SIC 331).

What Were the Most Important End Uses?

End Use of Total Inputs of Energy for Heat, Power, and Electricity Generation:

- Process heating accounted for 24 percent, machine drives accounted for 30 percent, and electrochemical processes accounted for 36 percent.
- Boiler fuel accounted for 70 percent of residual fuel oil use; process heating accounted for 30 percent.
- Boiler fuel accounted for 83 percent of coal use.
- Process heating accounted for 76 percent of natural gas use.

Between 1991 and 1994, What Changed in the Amount of Energy Purchased and Its Cost?

Quantity of Purchased Energy (Annualized Rates):

- Purchased coal increased by 7.7 percent.
- Purchased coke and breeze increased 25.2 percent.

Expenditures and Average Prices (Annualized Rates):

- Total expenditures grew 2.1 percent.
- Coal expenditures grew 3.3 percent, while average prices fell 3.6 percent.
- Coke and breeze expenditures grew 16.8 percent, while average prices fell 4.8 percent.