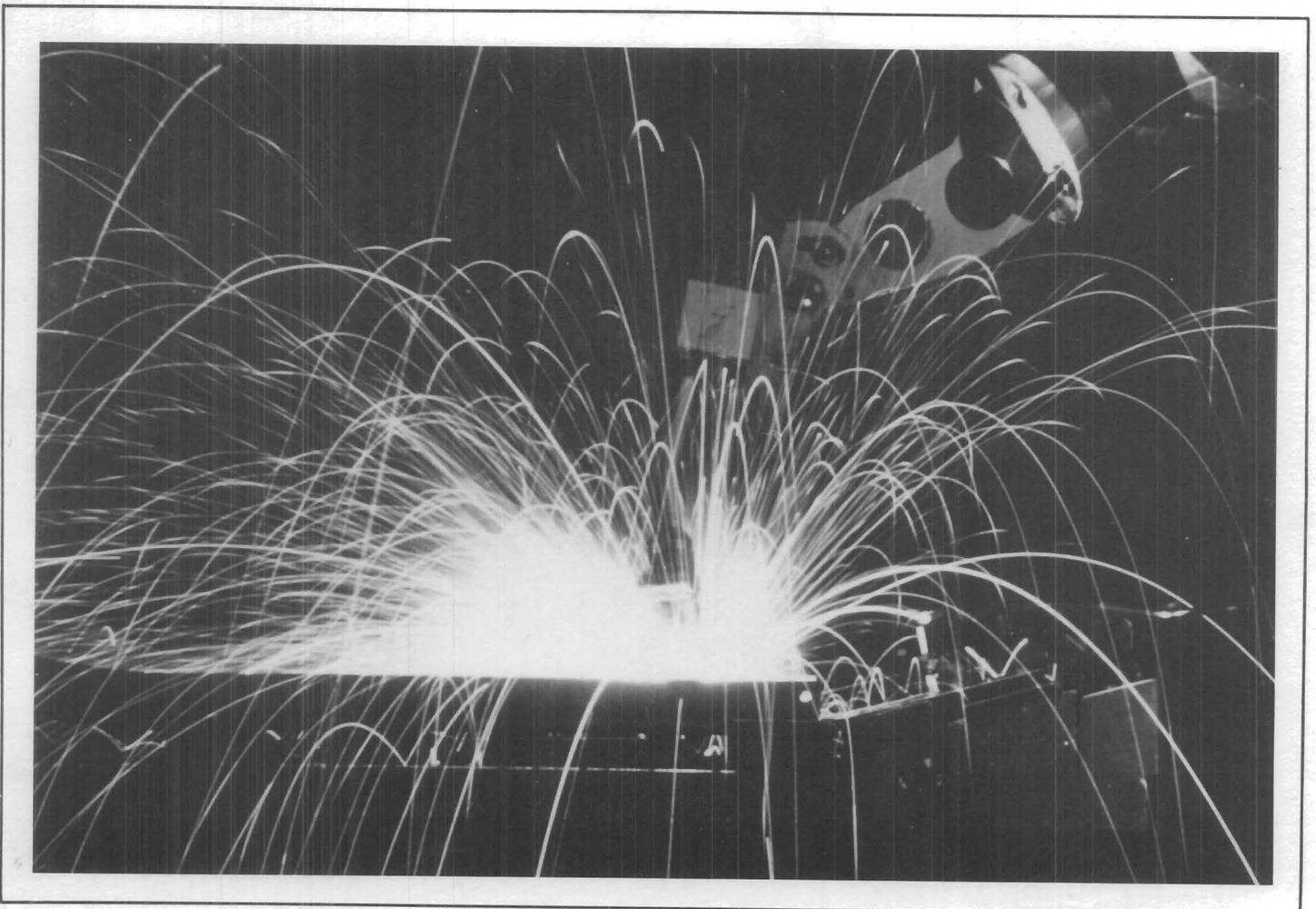


Energy Information Administration

# EIA

## Manufacturing Energy Consumption Survey: Methodological Report 1985



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**Manufacturing Energy Consumption Survey:**  
**Methodological Report**  
**1985**

**Energy Information Administration**  
**Office of Energy Markets and End Use**  
**U.S. Department of Energy**  
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# Introduction

In 1986, the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) implemented the 1985 Manufacturing Energy Consumption Survey (MECS). Forms EIA-846(F) and EIA-846(S) were used to collect data on energy consumption, fuel-switching capability, and related matters from a probability sample of establishments, designed to represent the manufacturing sector of the U.S. economy. The MECS is a statistical data collection system designed to produce descriptive statistics related to energy use in the manufacturing industries. This report describes the development of and the methodology for implementing the MECS system.

EIA conceived, designed, and developed the 1985 MECS as a single survey. However, during the OMB clearance process, fuel-switching questions were removed from the original MECS survey, and subsequently approved as a separate data collection. The EIA-846(F) was mailed on July 14, 1986, to collect basic energy-consumption and expenditures data, and the EIA-846(S) was mailed on November 28, 1986, to collect data on fuel-switching capability. Form EIA-846(S) was mailed to a subset of respondents to Form EIA-846(F) and was preprinted, for reference, with the fuel consumption data reported by the establishment on the EIA-846(F). Future MECS will be collected on a single consolidated form.

The MECS system was developed at EIA, and the data collection was administered by the Industry Division of the Bureau of the Census under an interagency agreement. Under the terms of the agreement, the Census Bureau granted several EIA staff members the status of sworn Census employees, so that they could participate fully in all aspects of the survey administration. The concept of a general-purpose energy-consumption data base for the manufacturing industries in the United States, the development and research of survey content and data issues, and the design of the survey instrument were accomplished by EIA. The construction of a sampling frame, the actual sampling process, survey administration, data processing, and disclosure analysis were performed by the Census Bureau. Specifications for the frame, sample, and estimators were developed by EIA in conjunction with the Census Bureau. Quality control, respondent support, and data editing were performed jointly, with final responsibility for data quality resting with EIA.

The information obtained from the MECS will be used to construct a data base for the manufacturing sector concerning its acquisition, consumption, and disposition of energy, and its fuel-switching capability. The MECS provides data needed for analyses in DOE, other Federal agencies, State governments, and the private sector. Most important, it is the only data set on the energy consumption of the manufacturing sector that is both statistically reliable and comprehensive.

From 1974 through 1981, the Census Bureau provided EIA with data on consumption of purchased fuels and electric energy. Fuel stocks data were provided for 1978-1981. These data were available in "Fuels and Electric Energy Consumed," an EIA-funded supplement to the "Annual Survey of Manufactures" (ASM). This supplement provided benchmarks for energy consumption in the manufacturing sector and was the principal source of energy data for analysts and policymakers throughout the United States. The MECS system was designed to collect more comprehensive energy data than were collected previously, while providing as much continuity as possible with the previous ASM series.

This report describes the history of the development of the MECS system and the methodology used in implementing the two MECS forms administered in 1986 to collect 1985 data. Both Forms EIA-846(F) and EIA-846(S) are parts of the MECS survey system, resulting from the same development and consensus-building process. Therefore, MECS development will be discussed as a unified whole and the two forms mentioned separately only when they are being discussed specifically.

Development of the MECS system was authorized under the Federal Energy Administration Act of 1974, as amended (FEAA, Public Law 93-275). Collection of 1985 data was justified by use of Section 13(b) of the FEAA, 15 U.S.C. 772(b). Future MECS are required under Title 3, Subtitle B, of Public Law 99-509.

# Purpose of the Survey

The MECS system is EIA's primary data collection activity concerning energy consumption and related data in the manufacturing industries of the United States. Its primary purpose is to provide a comprehensive national baseline statistical data set for energy consumption in these industries.

The core data collected by the MECS are purchases and expenditures by energy source, fuel use, nonfuel use of energy sources, and short-term fuel-switching capability. These data are comparable to energy data collected by EIA for other end-use sectors (residential, residential transportation, and commercial buildings) and are an important part of EIA's coordinated end-use consumption data base.

The MECS system provides essential input to EIA's legislatively-mandated modeling and forecasting activities, and provides data on other topics of interest to the DOE, including fuel switching, storage capacity of certain energy sources, and onsite generation and cogeneration of electricity. The MECS system will also provide the means to track changes in the consumption of purchased fuels, nonpurchased fuels, and fuel-like feedstocks, within specific industries and geographic areas. These types of information are critical to understanding and describing energy consumption and are in demand not only by government policy analysts but also by analysts in the private sector. Such tracking capability provides critical input for the analysis of proposed energy policies, contingency planning for emergencies, and, in general, contributes to an understanding of the factors influencing the demand for energy. While the ability to track changes in energy consumption is a key consideration in energy analysis, of equal importance is an understanding of why these changes take place. The MECS system, therefore, provides the means to account for the influence of the physical and economic characteristics of the establishment on energy consumption.

# Types of Data to be Collected by the MECS

The issues addressed on the MECS questionnaires were chosen by means of an iterative development process that balanced the data requirements of potential users of MECS data against the difficulties that manufacturers indicated they would have in providing the data. This section of the report describes the issues addressed by the 1985 MECS. The detailed process of identifying issues for inclusion in the MECS is described in Appendix A.

Data items on the questionnaires were collected separately for each eligible energy source at an establishment (see Glossary). The following data issues were addressed on the 1985 MECS questionnaires:

- Quantities of energy sources purchased
- Expenditures for quantities of energy sources purchased
- Quantities used as fuels at the establishment
- Quantities used for nonfuel purposes (feedstocks and raw material inputs) at the establishment
- The short-term capability of the establishment to use alternate fuels
- Onsite generation and sales of electricity
- Quantities of renewable energy sources used as fuel
- Quantities of fuels generated and used onsite
- The storage capacity of major petroleum-based energy sources at the establishment.

Economic data were not collected by the 1985 MECS but were provided by the Census Bureau. This was made possible by designing the MECS sample as a subsample of the ASM, allowing direct linkage of ASM economic data and MECS energy data for analytical purposes.

The MECS is designed as a survey of manufacturing establishments, rather than of major energy-using processes or pieces of equipment within establishments. Certain within-establishment characteristics, such as counts of major energy-using equipment, counts of buildings by type of activity, use of complex feedstock streams, and fuel consumption by detailed end use, were initially considered for collection. However, collecting data on these issues would have resulted in a longer and more burdensome survey than was practical to implement. Therefore, data were not collected on any within-establishment characteristics.

Two economic issues which were frequently mentioned by potential data users were not addressed by the 1985 MECS because they could not be defined precisely enough to provide meaningful data. Investment in energy conservation was not included because it could not be clearly separated from other reasons for replacing or updating equipment. Capacity utilization was not addressed at this point because a method could not be devised to define the concept for many establishments meaningfully, especially those that manufacture multiple products.

Of the data issues that were included on the 1985 MECS, one item, nonfuel use of energy sources, was not collected from petroleum refineries. These establishments already report detailed production data to EIA as part of the Monthly Refinery Report, Form EIA-810 (See Appendix B). Instead of requesting refiners to report similar data on the MECS form, EIA chose to construct nonfuel use data from the production data already in its possession. (See chapter on Adjustments to the Sample for a detailed discussion.)

# The Manufacturing Sector and Its Relationship To the Population Surveyed by the 1985 MECS

For purposes of both the ASM and the MECS, the manufacturing sector is a population of manufacturing establishments. Technically, it includes all establishments operating predominantly in at least one of the Major Industrial Groups 20 through 39 as defined by the 1972 edition of the Standard Industrial Classification (SIC) Manual (see Glossary). Eligible establishments were physically located within the 50 States and the District of Columbia, and, additionally, were operating as manufacturers at the end of 1984.

In 1985, EIA chose the Census Bureau to administer data collection activities for the MECS. One result of this decision was the use of the ASM mail sample as the sampling frame for MECS. The mail sample is a probability sample of about 56,000 manufacturing establishments that receive the ASM questionnaire. This sample represents the approximately 225,000 establishments eligible for inclusion in the quinquennial Census of Manufactures. The particular ASM mail sample used as the frame for drawing the MECS sample was based on the detailed 1982 Census of Manufactures, updated through 1984 from Internal Revenue Service (IRS) lists of new manufacturing establishments. This frame consisted of a list of all establishments in the 1984 ASM, minus establishments that ceased manufacturing in 1984. It did not contain establishments that began operations in 1984 and continued to operate in 1985, or establishments with too few employees to be eligible for inclusion in the mail sample. For most industries, between 5 and 9 employees are required for inclusion in the mail sample, but in a few industries, the requirement may be as high as 19 employees.

The mail sample provides much, but not all, of the data used to produce ASM statistics for the entire manufacturing sector. The remainder is provided by the nonmail file, which contains all establishments not represented by the mail sample. These establishments (generally, those with fewer than approximately five to nine employees), receive neither ASM nor Census of Manufactures forms, but are represented by employment, payroll, and four-digit SIC data taken from IRS and Social Security Administration (SSA) records. These three data items are used to impute the contribution of establishments on the nonmail file to economic characteristics measured by the ASM mail questionnaire. The combination of the weighted mail sample data and the contribution of the nonmail file represents the entire manufacturing sector.

In addition to representing small establishments, the nonmail file is used to represent new manufacturing establishments as identified from IRS records. The largest of these new establishments are transferred to the mail sample for the next ASM data collection, but single-establishment companies with fewer than 35 employees are retained in the nonmail file even if they are eligible for inclusion in the mail sample. This subset of new establishments, therefore, is not represented by the mail sample until the next Census of Manufactures, when all establishments are reviewed and the mail sample is recreated from the updated population.

Because of the relatively small effect of the nonmail establishments, the MECS sample covers only that part of the manufacturing sector represented by the ASM mail sample (which is used as the MECS frame). This population accounts for well over 90 percent of the manufacturing employment and payroll, and presumably accounts for the large majority of energy use by the manufacturing sector. Data from the nonmail file can be used to calculate rough surrogate measures of the proportion of the entire manufacturing sector, or a specific part of the manufacturing sector, that is not represented by the MECS.

Undercoverage measures were calculated as the difference between a simple inflation estimate of fuel consumption for the MECS population, and an employment-adjusted MECS estimate of fuel consumption for the more inclusive population. Undercoverage in SIC category  $s$  was estimated as:

$$U_s = \frac{F_{hs}}{M_{hs}} M_{ts} - F_{hs} = F_{hs} \frac{M_{ts} - M_{hs}}{M_{hs}} = F_{hs} \frac{M_{is}}{M_{hs}} \quad (1)$$

where  $F_{hs}$  = Total fuel consumption for establishments in SIC  $s$  of the mail file, as estimated from the MECS sample;

$M_{hs}$  = Total employment from the mail file, in SIC  $s$ ;

$M_{ts}$  = Total employment from the mail and nonmail file, in SIC  $s$ ; and

$M_{is}$  = Total employment from the nonmail file, in SIC  $s$ .

Relative undercoverage of estimates of fuel consumption is defined as the absolute undercoverage divided by the corresponding MECS sample estimate of fuel consumption. Relative undercoverage in SIC  $s$  was estimated as:

$$U(\text{rel})_s = \frac{1}{F_{hs}} U_s = \frac{1}{F_{hs}} F_{hs} \frac{M_{is}}{M_{hs}} = \frac{M_{is}}{M_{hs}} \quad (2)$$

the ratio of employment in the nonmail file to employment represented by the MECS sample.

Similarly, the relative undercoverage for consumption over all industries was estimated as the sum of the individual industry values divided by total consumption:

$$U(\text{rel}) = \frac{1}{\sum_{s=20}^{39} F_{hs}} \sum_{s=20}^{39} U_s = \frac{1}{\sum_{s=20}^{39} F_{hs}} \cdot \sum_{s=20}^{39} F_{hs} \frac{M_{is}}{M_{hs}} \quad (3)$$

All of these measures of undercoverage are based on the assumption that within each industry group, the ratio of energy consumption to employment is the same for establishments represented by the MECS sample as for establishments on the nonmail list. This assumption is speculative and cannot be directly tested because energy data are not collected from nonmail establishments.

Therefore, these measures should only be used as rough approximations of the level of undercoverage of energy use in the MECS. However, data from the mail establishments do show a relatively high correlation between employment and consumption.

Table 1 lists, by industry, the Relative Standard Errors (RSE) of estimates of total fuel consumption calculated from the sample, and estimates of relative undercoverage. RSE's are estimates, expressed as percentages, of the degree of uncertainty associated with estimates derived from the sample. They, therefore, estimate uncertainty resulting from sampling, and not uncertainty resulting from other sources of error, such as imperfections in the frame or errors in reporting. Estimates based on the MECS sample are based on large enough sample sizes that the distribution of the MECS estimator can be assumed to be approximately normal, by appeal to the Central Limit Theorem. Therefore, for approximately two-thirds of the possible MECS samples that could be selected from the mail list used as the ASM frame (that is, all possible MECS subsamples from all possible ASM samples), the percent difference between the MECS sample estimate of a characteristic and the value of that characteristic over all possible samples will be less than one RSE.

The relative undercoverage measures given in Formulas (2) and (3) measure approximately how completely the MECS sample represents the manufacturing sector. Again, the applicability of these measures to consumption is directly related to the assumption that coverage of employment approximates coverage of fuel consumption within major industries and industry groups. The undercoverage measures presented in Table 1 give some idea of the effect of using a noncomprehensive frame on estimates derived from the sample.

Comparing the two measures of variability gives some sense of how the directional effect of undercoverage compares with the amount of random uncertainty in MECS fuel consumption estimates caused by sampling error. For example, total British thermal unit (Btu) consumption in all industries nationwide in 1985 was associated with an RSE of 2 percent and a relative undercoverage of 3 percent (see Table 1). A relative undercoverage of 3 percent suggests that the MECS sample represents approximately 97 percent of the energy consumption in the manufacturing sector.

These comparisons pertain only to total fuel consumption for the categories listed in Table 1. They should not be extrapolated to detailed geographic or industry classifications, or to estimates for individual fuels.

Table 1 indicates that an estimated 3 percent of the fuel consumption in the entire manufacturing sector was not covered by the MECS sample. In addition, relative undercoverage was 5 percent or less for all 10 of the 4-digit industries, and 12 of the 20 Major 2-digit Industry Groups, used as sampling categories in the MECS. Estimated undercoverage in five of the eight remaining Major Industry Groups was approximately 6 to 7 percent of the total fuel consumed in those SIC's.

**Table 1. A Comparison of MECS Sample RSE's for Fuel Consumption Estimates with Estimates of Relative Undercoverage**

SIC Code	Major Industry Groups and Selected Industries	RSE (Percent)	Relative Undercoverage (Percent)
20	Food and Kindred Products.....	5	4
21	Tobacco Manufactures .....	6	1
22	Textile Mill Products .....	3	2
23	Apparel and Other Textile Products .....	8	6
24	Lumber and Wood Products .....	11	12
25	Furniture and Fixtures .....	7	6
26	Paper and Allied Products .....	3	3
2621	Paper Mills .....	3	1
2631	Paperboard Mills .....	7	1
27	Printing and Publishing .....	6	10
28	Chemicals and Allied Products .....	2	3
2819	Industrial Inorganic Chemicals, nec* .....	9	2
2821	Plastics Materials and Resins .....	8	1
2869	Industrial Organic Chemicals, nec* .....	3	1
2873	Nitrogenous Fertilizers .....	3	2
29	Petroleum and Coal Products .....	3	1
2911	Petroleum Refining .....	3	1
30	Rubber and Misc. Plastics Products.....	3	7
31	Leather and Leather Products .....	12	3
32	Stone, Clay and Glass Products .....	3	6
3241	Cement, Hydraulic .....	5	1
33	Primary Metal Industries .....	4	2
3312	Blast Furnaces and Steel Mills .....	5	1
3334	Primary Aluminum .....	8	1
34	Fabricated Metal Products .....	4	5
35	Machinery, Except Electrical .....	4	6
36	Electric and Electronic Equipment.....	3	3
37	Transportation Equipment .....	2	2
38	Instruments and Related Products .....	6	4
39	Miscellaneous Manufacturing Industries .....	8	10
--	Total U.S. ....	2	3

\*nec: not elsewhere classified.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(F), 1985 Manufacturing Energy Consumption Survey.

The MECS sample in the three remaining Major Industry Groups (SIC's 24, 27, and 39) had higher levels of relative undercoverage (10 to 12 percent). The lesser coverage of the MECS sample in these SIC's reflects the domination, and frequent turnover, of small establishments in these industry groups.

The data in Table 1 suggest that the data user needs to be aware of undercoverage when interpreting MECS data. Estimates of RSE's are typically available for sample surveys and their use and interpretation is familiar to most data users. Estimates of undercoverage, however, are often not available because they require knowledge of true values of characteristics of the population being sampled. The values presented in Table 1 do not capture all of the nonsampling error present in the MECS sample, but they do provide approximate indicators of how completely the MECS represents energy consumption in the entire manufacturing sector and industrial categories within it.

In summary, consumption estimates from the MECS sample closely represent the entire manufacturing sector in most, though not all, cases. A useful working definition of the manufacturing sector that is closely represented by the MECS can be defined, however. The manufacturing sector, as represented by the entire MECS sample, consists of establishments that:

- 1) are physically located within the 50 States and the District of Columbia;
- 2) were in business at the end of 1984;
- 3) were assigned to one of the manufacturing industries (SIC Major Industry Groups 20 through 39) for purposes of administering the mail portion of the 1985 ASM.

# Creating Measures of Size For Establishments In the MECS Frame

In order to select a sample of establishments for the MECS, a probability structure was needed to relate the eventual MECS sample to the population of manufacturing establishments it was intended to represent. Certain constraints were inherent in the structure, because the MECS sample was planned as a subset of an ASM sample which had already been selected according to its own probability structure. However, the ASM survey also provided a benefit to the development of the MECS probability structure. The economic and energy-related data collected for the ASM sample provided valuable information to control the assignment of probabilities for the MECS so as to maximize the precision of MECS estimates.

The manufacturing establishment population is highly skewed with respect to energy use; that is, a relatively small proportion of the population accounts for a large proportion of total consumption. In such situations, a sample based on probabilities of selection that are proportional to the characteristic of interest can estimate population characteristics much more precisely than a sample of the same size selected randomly. The ASM survey collected several items of information which could potentially have been used to derive MECS probabilities: economic measures such as total employment, value of product shipments, and value added by manufacture, as well as energy-related measures such as total cost of fuels, quantities of purchased electricity, and for some large establishments that had been in ASM surveys in previous years, consumption of fuels for years as recent as 1981.

The first step in deriving selection probabilities was to attach a measure of size to each establishment in the ASM sample. These measures of size would be used as surrogates of the relative amounts of energy consumption among establishments. Eventual probabilities of selection for the MECS were to be derived directly from the relative size indicators. Because informal studies of ASM data showed that energy cost was more highly correlated with consumption than was any economic measure, a decision was made to derive measures of size based on energy-related data rather than economic data.

The measure of size that was derived was an estimate of 1984 consumption of purchased fuels and electric energy. There were two distinct methods for computing the estimate. For establishments in the MECS frame that had also been in the 1981 ASM sample, the size measure was given by

$$TBtu_j = \frac{C_{84j}}{\hat{C}_{84j}} F_{81j} + (3.412 \times 10^6) \cdot E_{84j}$$

where

$E_{84j}$  = Megawatthours (Mwh) of purchased electricity for establishment  $j$  as reported on the 1984 ASM

$F_{81j}$  = Total consumption of purchased fuels for establishment  $j$  in millions of British thermal units (mmBtu), as reported on the 1981 ASM

$C_{84j}$  = Total cost of purchased fuels for establishment  $j$  as reported on the 1984 ASM

$\hat{C}_{84j}$  = An estimate of the 1984 cost of  $F_{81j}$  for establishment  $j$ , computed as a sum of fuel-specific costs at the establishment. Each fuel cost was derived by multiplying the reported consumption of the fuel in 1981 by its 1981 price as determined from the reported consumption and expenditure data, and then multiplying the result by a national-level inflation index for that fuel covering the period 1981-1984. The inflation indexes were computed from the Producer Price Index (PPI) series

$3.412 \times 10^6$  = The standard conversion factor of 3.412 mmBtu/Mwh of electricity consumption.

For establishments that were not in the 1981 sample, total 1981 consumption was not available and the estimated 1984 cost of that consumption could not be calculated. For those establishments the 1981 fuel-specific consumption and expenditures at the establishment level were replaced with comparable totals for the 4-digit SIC category into which the establishment was classified. Thus, the formula for the measure of size became

$$TBtu_j = \frac{C_{84j}}{\hat{C}_{s84}} \cdot F_{s81} + (3.412 \times 10^6) \cdot E_{84j}$$

where  $F_{s81}$  and  $\hat{C}_{s84}$  were the totals for the 4-digit SIC code associated with establishment  $j$ .

TBtu was, at best, a rough approximation to the actual consumption of purchased fuels and electric energy at the establishment during 1984, because of changes in product mix at the establishment between 1981 and 1984 and local differentials in fuel price inflation from the average measure available from the PPI series. However, this rough surrogate was considered to be a superior predictor of consumption, and, thus, a better measure of size, than any function of economic variables that could be devised.

# MECS Sample Design

The MECS sample was designed through a two-part process to produce the highest quality data achievable. First, preliminary estimates of expected sampling error and desired sampling error were used to develop an estimate of total sample size, thereby allowing estimation of resource requirements. Second, existing ASM data were used to allocate the sample to the different industries of interest. Overall, this process took into account survey objectives, characteristics of the manufacturing sector, characteristics of the properties to be estimated, and operational constraints caused by finite available resources.

The distribution of manufacturing establishments with respect to characteristics of interest (for example, fuel consumption, feedstock consumption) was of primary importance to the MECS sample design. Many economic characteristics, such as employment, value of shipments, and energy consumption, are concentrated heavily among large establishments, even though small establishments are numerically dominant. In addition, these economic characteristics are generally correlated with one another, so that a sample design efficient for one of them should be reasonably efficient for all of them.

These characteristics are also distributed unequally among industries, as well as between size groups. This is especially true of energy consumption. In 1981, for example, of more than 400 industries (represented by 4-digit SIC codes), which comprise the manufacturing sector, 10 accounted for over 50 percent of the total consumption of electricity and purchased fuels.<sup>1</sup>

For the reasons discussed above, sample allocation was concentrated in the largest energy-consuming industries and the most energy-consumptive establishments. From a sampling perspective, this means that the MECS sample design would result in the highest quality estimates of characteristics of interest by emphasizing large establishments, both with respect to sample allocation among strata, and probability of selection proportional to size within strata.

The primary classification variable used for both sampling and for analyzing MECS data is SIC category. The most important groupings in the manufacturing sector for analysis purposes are the 20 Major Industry Groups (2-digit SIC's) and the 10 most energy-consumptive industries (4-digit SIC's) shown in Table 2. Within these groups, the target RSE's for estimates of Btu consumed, for total consumption, and by individual energy source, were:

- Two percent for energy intensive SIC's in which the MECS was expected to collect substantial information on feedstock use, consumption of byproduct fuels, electricity cogeneration, or short-term fuel switching (SIC's 20, 22, 26, 28, 2911, 30, 33, 35, 36, and 37)
- Five percent for the remaining 2-digit SIC's and the 9 remaining energy intensive 4-digit SIC's
- Ten percent for four major energy sources (electricity, natural gas, coal, and residual fuel oil), in any of the 30 SIC categories that contribute more than 1 percent to the total consumption of that energy source in the manufacturing sector.

Information from two energy consumption surveys previously conducted by EIA indicated that a sample size of approximately 12,000 manufacturing establishments, sampled with probability proportional to 1984 energy use, would be sufficient to achieve the specified target RSE's. This estimate of total sample size was used for preparing estimates of resource requirements for conducting the survey. After the Census Bureau was chosen to administer the 1985 MECS, more detailed analyses of sample allocation and expected precision were performed. These analyses provided EIA with the optimum allocation of sampling effort among industries and with establishment size (as measured by estimated energy consumption).

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<sup>1</sup>U.S. Department of Commerce, Bureau of the Census, *1982 Census of Manufactures Fuels and Electric Energy Consumed: Part 1, Industry Groups and Industries* Pub. MC81-S-4 (Part 1), Washington, DC: U.S. Government Printing Office, June 1983.

There was also a structural limitation to achievable RSE's for the 10 four-digit SIC's sampled. The MECS sample, for these SIC's, contained all establishments in the ASM sample (which was used as the MECS frame). Therefore, the sample size in these categories could not be increased, even if optimal sample allocation required it. The only 4-digit category that looked as if it might fall short of RSE targets because of this limitation was SIC 3241, the hydraulic cement industry.

Sample allocation, and prediction of the RSE's that would result from a particular allocation, were developed from a trial sample selection performed by the Census Bureau. This trial consisted of selecting a subsample of specified size from the 1981 ASM using the MECS sample selection procedure. The sample was used to estimate the consumption items, their variances, and their RSE's. The sample was designed to yield approximately 10,000 establishments, corresponding to a sample mail-out of 12,000 forms and a 17 percent nonresponse rate from all sources. RSE's from this sample are shown in the column labeled "Trial" in Table 2.

RSE's achieved from the MECS for its consumption measure equivalent to use of purchased fuels and electric energy were fairly well in line with target values. Of the 20 two-digit industry groups, 14 had RSE's below, at, or within 1 percent of the target values. Of the six remaining SIC's, four (SIC's 23, 24, 25 and 31) were relatively minor energy consumers. The other two, SIC 20 and SIC 35, had relatively low RSE's (4 percent each), but their targets were very low. Some minor adjustment of sample size in future cycles of the MECS may be considered based on these data. Of the 10 4-digit industries, only two substantially missed their targets: SIC 2819 and SIC 3334. Interestingly, the industry of original concern, SIC 3241, met its target. Because all ASM sample establishments in the 4-digit industries were also in the MECS, no sampling adjustments are possible here.

One identifiable potential source of differences between RSE targets and error levels actually achieved is the random error contribution caused by nonresponse, especially among establishments selected for the MECS with certainty. This component is reflected in MECS variance estimates and can have a significant effect on total error. The effect would be especially noticeable in SIC's with few establishments, or SIC's with only a few large establishments among many smaller ones. Further discussion of this issue can be found in the chapter on MECS Estimators.

Allocation of the sample among the 30 sampling and estimation groups was done proportional to their estimated population variance of total 1984 consumption of purchased fuels and electricity (TBtu). The methods for estimating TBtu are described in detail in the chapter on Creating Measures of Size for Establishments in the MECS Frame. This information was incorporated into the sample design by sampling with probability of selection proportional to the energy-related measure of size of the establishment. As mentioned previously in the chapter on Creating Measures of Size for Establishments in the MECS Frame, such a sampling method results in better allocation of the sample within sampling groups than a random sampling approach, because the sample emphasizes more energy-consumptive establishments.

In summary, the following are the major characteristics of the MECS sample design:

- Available resources resulted in a desired sample size of approximately 12,000 manufacturing establishments. This relatively small sample, approximately 5 percent of the total number of establishments in the target population, accounted for about 80 percent of the total estimated fuel consumption in the manufacturing sector.
- The sample was allocated among 30 industry-based sampling groups, proportional, as far as possible, to the estimated population variance of fuel consumption in each group.
- Within sampling groups, each establishment was assigned a probability of selection into the MECS sample such that the overall probability of selection from the manufacturing sector was proportional to its estimated 1984 consumption of purchased fuels and electricity.
- Each establishment in the manufacturing sector was eligible for inclusion in the MECS sample, conditional upon its selection into the 1984 ASM sample used as the MECS sampling frame.

Table 2. Precision Targets for MECS, RSE's Obtained from a Trial Sample, and RSE's Actually Achieved by the MECS Sample, for Measures of Purchased Fuel and Electric Energy Consumption

SIC Code	Major Industry Groups and Selected Industries	Relative Standard Errors (Percent)		
		Targets	Trial	Achieved
20	Food and Kindred Products.....	2	2	4
21	Tobacco Manufactures .....	5	5	6
22	Textile Mill Products.....	2	2	3
23	Apparel and Other Textile Products.....	5	5	8
24	Lumber and Wood Products.....	5	5	10
25	Furniture and Fixtures .....	5	5	7
26	Paper and Allied Products .....	2	NA	3
2621	Paper Mills .....	5	1	3
2631	Paperboard Mills .....	5	1	6
27	Printing and Publishing.....	5	5	6
28	Chemicals and Allied Products.....	2	NA	2
2819	Industrial Inorganic Chemicals, nec* .....	5	1	9
2821	Plastics Materials and Resins .....	5	2	4
2869	Industrial Organic Chemicals, nec* .....	5	1	3
2873	Nitrogenous Fertilizers .....	5	3	3
29	Petroleum and Coal Products .....	5	NA	4
2911	Petroleum Refining.....	2	1	4
30	Rubber and Misc. Plastics Products.....	2	2	3
31	Leather and Leather Products.....	5	6	12
32	Stone, Clay and Glass Products .....	5	NA	3
3241	Cement, Hydraulic.....	5	9	5
33	Primary Metal Industries.....	2	NA	3
3312	Blast Furnaces and Steel Mills.....	5	1	4
3334	Primary Aluminum .....	5	4	8
34	Fabricated Metal Products .....	5	3	4
35	Machinery, Except Electrical .....	2	3	4
36	Electric and Electronic Equipment.....	2	2	3
37	Transportation Equipment .....	2	1	2
38	Instruments and Related Products .....	5	5	5
39	Miscellaneous Manufacturing Industries.....	5	5	6

\*nec: not elsewhere classified.

NA= Not available.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, Form EIA-846(F), 1985 Manufacturing Energy Consumption Survey.

# The Sampling Method

The sampling method used for MECS was a two-stage process. The first stage of sampling was the ASM sample chosen by the Census Bureau and used by EIA as the MECS frame. The second stage of sampling was the MECS sample chosen from the ASM sample. The same sampling methodology was used to choose the ASM sample and MECS subsample.

Because the ASM sample is a probability sample, each establishment in the MECS frame has an associated probability of selection from the population of manufacturing establishments of interest to the MECS. These probabilities can be used in conjunction with ASM data to produce estimates of characteristics of the original population. This in turn allows a subsample (in this case the MECS sample) to be selected from the ASM that maintains a known relationship to the original population. Total consumption of purchased fuels and electricity (TBtu) was the data item derived from ASM values, that when combined with the probability of selection into the ASM, was used to create probabilities of selection for the MECS.

Theoretically, the most precise estimates of energy consumption from the 1985 MECS sample could be achieved if establishments were chosen for the MECS sample with overall probabilities of selection proportional to their actual consumption of fuels and electricity in 1985. The data to be measured are not available, but much of the advantage of sampling proportional to actual consumption can still be realized by utilizing an available variable that is highly correlated with consumption. For MECS, the chosen variable was the estimate of total 1984 consumption (TBtu). The actual method of calculating TBtu was described in the chapter on Creating Measures of Size for Establishments in the MECS Frame.

As explained in the previous chapter, to control the amount of sampling variability in consumption estimates for individual industries and industry groups, sampling for MECS was carried out separately within each of the 30 categories shown in Table 2. If the MECS had been a single-stage sample from the manufacturing population, the overall probability of selection for establishment  $j$  in SIC group  $s$  would have been:

$$\pi_{sj} = m_s \cdot \frac{(TBtu)_{sj}}{\sum_{k=1}^{N_s} (TBtu)_{sk}}$$

where  $m_s$  is the desired MECS sample size in group  $s$ ,  $N_s$  is the corresponding population size, and  $(TBtu)_{sj}$  is the size measure as previously defined, for establishment  $j$  in SIC  $s$ .

However, because  $(TBtu)_{sj}$  is only available for establishments in the MECS frame (ASM sample),  $\pi_{sj}$  must be estimated as:

$$P_{sj} = m_s \cdot \frac{(TBtu)_{sj}}{\sum_{k=1}^{n'_s} (1/Q_{sk}) \cdot (TBtu)_{sk}}$$

where  $n'_s$  is the number of establishments in the ASM sample in SIC group  $s$ , and  $Q_{sk}$  is the probability of selection of ASM sample establishment  $k$  in SIC  $s$  from the establishment population. The denominator of  $P_{sj}$  is the weighted estimate of total Btu in SIC  $s$  of the population, based on the ASM sample.

Of course, the MECS sample was subselected from the ASM sample rather than being chosen directly from the population, so that ASM probabilities of selection had to be taken into account.  $P_{sj}$ , the desired overall probability of selection for the MECS, can be thought of as the product of two probabilities, so that the previous expression can be written

$$P_{sj} = Q_{sj} \cdot R_{sj} = m_s \cdot \frac{(TBtu)_{sj}}{\sum_{k=1}^{n'_s} (1/Q_{sk}) (TBtu)_{sk}},$$

where  $R_{sj}$  is the conditional probability of selecting establishment  $j$  into the MECS sample given that it has already been selected into the ASM.

The desired sampling probabilities for subselection into the MECS sample from the ASM mail sample are, therefore:

$$R_{sj} = (1/Q_{sj}) \cdot m_s \cdot \frac{(TBtu)_{sj}}{\sum_{k=1}^{n'_s} (1/Q_{sk}) (TBtu)_{sk}}.$$

The process for determining MECS probabilities of selection is iterative. At each stage, if any  $R_{sj}$  is greater than or equal to 1, that establishment is assigned a MECS probability of subselection of 1. The MECS probability of subselection ( $R_{sj}$ ) is then recalculated for the remaining establishments after removing the total weighted TBtu of the certainty cases from the denominator of the probability formula. Any additional cases with new  $R_{sj}$  of at least 1.0 are set aside as MECS certainties. The process is repeated until all cases are classified as certainties for MECS, or have  $R_{sj}$ 's less than 1. The final probabilities of subselection for MECS are either 1.0 or

$$R_{sj} = \frac{1}{Q_{sj}} \cdot (m_s - m'_{1s}) \cdot \frac{(TBtu)_{sj}}{\sum_{k=1}^{n'_s - m'_{1s}} (TBtu)_{sk}/Q_{sk}},$$

where  $m'_{1s}$  is the number of establishments in SIC group  $s$  with a MECS subselection probability of 1. The only exception to this method of assigning probabilities was for establishments that would receive overall probabilities of selection ( $Q_{sj} \cdot R_{sj}$ ) less than 0.002. Their MECS probabilities of subselection were adjusted to keep their overall probability of selection at 0.002. This restriction controlled the range of weights for cases that were eventually selected for the MECS, and thus was a control on sampling error.

In the sampling method used for MECS, each manufacturing establishment was sampled independently of the selection or nonselection of every other establishment. This was accomplished by generating a random number between 0 and 1 for each establishment, and comparing it to  $R_{sj}$ . If  $R_{sj}$  was as large or larger than the random number, the establishment was taken into the MECS sample. If, however,  $R_{sj}$  was less than the random number the establishment was excluded from the sample. Because each establishment is selected into or rejected from the MECS sample independently of all other establishments in the MECS frame, this sampling method does not result in a fixed sample size. The expected value of the actual sample size equals the desired sample size, however (see Appendix E). In the 1985 MECS, for example, the expected sample size was 11,972 establishments, but the actual sample size was 12,065 establishments.

The processes just described to subselect MECS sample establishments are analogous to the processes used to select the ASM sample. Further information on this methodology can be found in the summary methodological report for the Annual Survey of Manufactures.<sup>2</sup>

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<sup>2</sup>U.S. Department of Commerce, Bureau of the Census, *The Annual Survey of Manufactures: A Report on Methodology*. Technical Paper No. 24, Washington, D.C.: U.S. Government Printing Office, February 1971.

# Design of the EIA-846(F) and EIA-846(S) Forms

The 1985 MECS was collected on two forms administered sequentially: the EIA-846(F), which collected all MECS data except fuel switching, and the EIA-846(S), which collected fuel-switching data. In the future, MECS will be simplified by consolidating all questions on a single form. To facilitate understanding of the 1985 MECS forms and their relationship to future MECS forms, the forms design process is described below in detail.

The process of designing the forms for the 1985 MECS began with the identification of data issues as described in Appendix A, and then proceeded in an iterative process both within EIA, and between EIA, the Office of Management and Budget (OMB) and manufacturers. By the middle of 1984, the issues that would be addressed by the MECS system had been identified, and preliminary design work was begun on what was then a single MECS questionnaire. Subsequent evolution of the design of the questionnaire addressed the optimum way to present data issues, and the depth to which issues should be explored, but the basic issues themselves remained essentially unchanged. This evolution occurred as a result of:

- discussions within EIA
- continued input of manufacturers via Federal Register Notice responses and public hearing testimony
- discussions with manufacturing representatives and site visits to specific manufacturing establishments
- a pilot study.

These sources of information gave EIA an improved understanding of the level of detail of data that manufacturers could reasonably be expected to provide while still supplying EIA with enough detail to make the resulting data meaningful. The two principal results of these internal discussions of manufacturers' comments were that:

- The section on short-term fuel switching was not initially approved by OMB, but was later approved as a separate form after the passage of Public Law 99-509 (Title 3, Subtitle B).
- An accounting approach for collecting basic consumption data at the establishment was dropped. The accounting approach (reporting sources of input and output of energy sources, and obtaining consumption by a series of additions and subtractions) was intended to clarify energy flows and allow EIA to determine the components that represent energy use. In the end, basic consumption data were collected directly with no questions about conversion of energy sources within the establishment or shipments of energy sources.

The major versions of the MECS questionnaires also are reproduced in Appendix C. Included are the questionnaire commented on at the public hearings in May 1985, the Pilot Study version of the questionnaire (Form EIA-846), the form submitted to OMB for final approval, and the questionnaires administered as part of the full-scale survey (Forms EIA-846(F) and EIA-846(S)).

The forms design process can be divided into five stages. These are:

- 1) Initial development of the basic questionnaire (mid-1984 through the public hearing on May 20, 1985).
- 2) Simplification and reemphasis of fuel switching to address only oil-related switching and deleting of the accounting approach to estimating consumption. (May 20, 1985, public hearing through the OMB clearance process for the pilot study in October 1985).

- 3) Administration of a pilot version of the MECS questionnaire (Form EIA-846) to a purposive sample of 100 manufacturing establishments. The purpose of the pilot study was to evaluate the effectiveness of the proposed MECS questionnaire for collecting energy consumption data from manufacturers in a clear, easily understood manner. (December 1985 through February 1986).
- 4) Clearance of the final simplified Form EIA-846(F), without the section on fuel switching and with the provision that refinery data on feedstocks would be obtained from EIA records rather than from the Form EIA-846(F). (This form was approved June 5, 1986, and mailed on July 14, 1986.)
- 5) Clearance of a redesigned fuel-switching section as Form EIA-846(S), after Congress mandated the inclusion of fuel switching in the MECS system. (This form was approved November 4, 1986, and mailed on November 28, 1986.)

The following descriptions trace the development of each of the three basic sections of the MECS data collection, which are:

- consumption measures and related data for combustible energy sources
- detailed data on inputs and uses of noncombustible energy sources such as electricity and steam
- data on short-term fuel-switching capability based on actual consumption.

Basic consumption and related data concerning combustible energy sources would have been collected on Sections I and II of the form commented on at the public hearing (see Appendix C). An accounting approach was used on this form to arrive at fuel consumption, but had already been abandoned as a means of unduplicating total (fuel plus feedstock) consumption within an establishment and between establishments.

Additional items appearing on this form are questions concerning the average Btu content of coal consumed, beginning and end-of-year inventories, transfers of energy sources into and out of the establishment, offsite use of energy, and total quantity used as boiler fuel. Of these, inventories, transfers, and use offsite were included as part of the accounting approach to determining fuel use; average Btu content of coal, and fuel used in boilers were included as free-standing items.

Dropping the accounting framework also led to dropping the items on transfers. Inventories, Btu content, and consumption of boiler fuel were determined to be too burdensome to collect for an initial MECS survey. In addition, the questions concerning energy sources extracted onsite and produced onsite from other energy sources were combined into a single question ascertaining total quantity produced onsite. These changes rendered the section ascertaining reportable energy sources (Section I of the public hearing version of the questionnaire) unnecessary, so that section was deleted from subsequent versions of the questionnaire. Section I, from this point forward, refers to the portion of the questionnaire designed to collect consumption-related data for combustible energy sources.

The results of the pilot study showed that this version of Section I was easily understood by representatives of manufacturing establishments. Therefore, the only basic change made to Section I between the pilot version of the questionnaire and Form EIA-846(F) was to request petroleum refineries to enter their identification number for an already-existing EIA survey (the EIA-810, Monthly Refinery Report, see Appendix F for an example of the form). Refiners were not to enter their feedstock data on the EIA-846(F), since they would be determined from EIA-810 data already in the possession of EIA.

The section addressing the acquisition and use of noncombustible energy sources, especially electricity and steam, remained almost unchanged between the May 20, 1985, version of the questionnaire and the EIA-846(F) that was actually administered in July 1986. The only changes made were to combine all types of renewable sources for the questions requesting quantities of electricity and steam generated onsite. This part of the questionnaire was labeled Section III on the public hearing version of the questionnaire, and Section II on all subsequent versions.

The fuel-switching section appears to change the most through time, but the version eventually administered as the Form EIA-846(S) is basically a simplified version of the one discussed at the May 20, 1985, public hearing. After the public hearing, the concept of fuel switching that was to be used in the MECS was redefined to include only detailed potential switching out of oil and total potential switching into oil (see Section III of the pilot questionnaire and of the questionnaire submitted to OMB). The version of fuel switching in the OMB submission (Section III) was the one rejected by OMB as part of the proposed Form EIA-846(F). When the necessity of collecting fuel-switching data was revived by Congressional mandate in October 1986, this version of Section III could not be redesigned as a free-standing questionnaire.

A free-standing version of Section III (fuel switching) had to be designed in such a way that fuel consumption data from the EIA-846(F) could be preprinted on it to provide a reference for the respondents to fuel switching. The resulting Form EIA-846(S) collected data for switching away from five major energy sources. The redesigned form did allow EIA to collect more detailed data on fuel switching than would have been collected on the form originally submitted to OMB (compare Section III of the version submitted to OMB with Form EIA-846(S)).

# Survey Administration and Quality Control

To guarantee the confidentiality of data provided by the respondents to MECS, EIA contracted with the Bureau of the Census to provide the frame and sample, and to administer the data-collection and data-processing phases of the survey. Section 9 of Title 13, U.S. Code provides legal guarantees of confidentiality for data provided to the Census Bureau by survey respondents. All MECS data are retained at the Bureau of the Census, and EIA receives only aggregate statistics that have undergone disclosure analysis.

Design of specifications for data processing, and the data processing operations themselves, were done at the Census Bureau headquarters in Washington, DC. The packaging and mailing of the forms, receipt of the forms, initial quality control, and data entry were done at the Census Bureau's field office in Jeffersonville, Indiana.

Choosing the Census Bureau to administer the 1985 MECS has several advantages in addition to assuring confidentiality to survey respondents. The most important of these are:

- The 1985 MECS sample could be taken as a subsample of the Census Bureau's Annual Survey of Manufactures (ASM). Respondent burden and survey duplication could, therefore, be reduced by matching establishment-level economic data available from the 1985 ASM to energy data from the 1985 MECS, instead of requesting them again as part of the MECS.
- The Census Bureau's frame of manufacturing establishments could be used as the frame for MECS, thus, saving considerable frame development costs that would have essentially duplicated the ongoing efforts of the Census Bureau.
- The Census Bureau's history in working with the manufacturing industries meant that many existing administrative tasks such as survey mailout, forms receipt, data entry, and computer editing could be accomplished by adopting pre-existing procedures.

Sworn Census Employee status was granted to the four EIA personnel responsible for the technical design work on the MECS. These personnel were subject to the same background checks as all other Census employees and are subject to the same laws and penalties regarding disclosure of confidential Census data. For purposes of the 1985 MECS, they were, in actuality, unpaid Census employees. The role of these Sworn Census Employees was twofold: to advise on the development and implementation of the procedures used to administer the survey and construct a cleaned data set for analysis, and to provide the main line of respondent support and quality control in cases where the respondent appeared to have difficulty completing the forms. The Census Bureau determined that these roles were appropriate for Sworn Census Employees and were critical to the success of the survey.

Much of the data quality control work performed on the 1985 MECS for both Forms EIA-846(F) and EIA-846(S), was done in Jeffersonville by Sworn Census Employees in conjunction with the staff of the Data Preparation Division at the Census Bureau. The approach taken was to emphasize communication with respondents and quality control, while the forms were still in the possession of the respondents, or as soon as possible after the forms were received in Jeffersonville.

The quality control strategy was implemented in two ways. First, a telephone number was printed on the forms so that respondents could call with technical questions concerning the completion of the questionnaires. Telephone lines were staffed by the same Sworn Census Employees that had designed the MECS system and forms. Second, all forms were screened for completeness and quality by Census personnel in Jeffersonville as soon as possible after receipt. Difficult cases, or cases in which forms did not pass this basic screening were referred to Sworn Census Employees for resolution. The Sworn Census Employees travelled to Jeffersonville to review these cases, often resolving them within a few weeks of their receipt. This approach had two positive effects:

- It established the MECS as a viable, closely-monitored survey in the minds of respondents. Several respondents who were recontacted expressed strong positive impressions of the level of technical support EIA provided as part of conducting the MECS.
- It enabled EIA to act as a resource to the Census Bureau staff in Jeffersonville. The 1985 MECS was a new survey and was administered on a very tight time schedule. The presence of EIA Sworn Census Employees in Jeffersonville enabled the staff there to resolve potential administrative difficulties with the survey rapidly.

# Editing of the Data

Data editing, as discussed in this chapter, consists of all data retrieval and verification procedures implemented after MECS questionnaires were received by the Census Bureau. It does not include technical support offered as a result of respondent inquiries. The editing procedures apply to Forms EIA-846(F) and EIA-846(S).

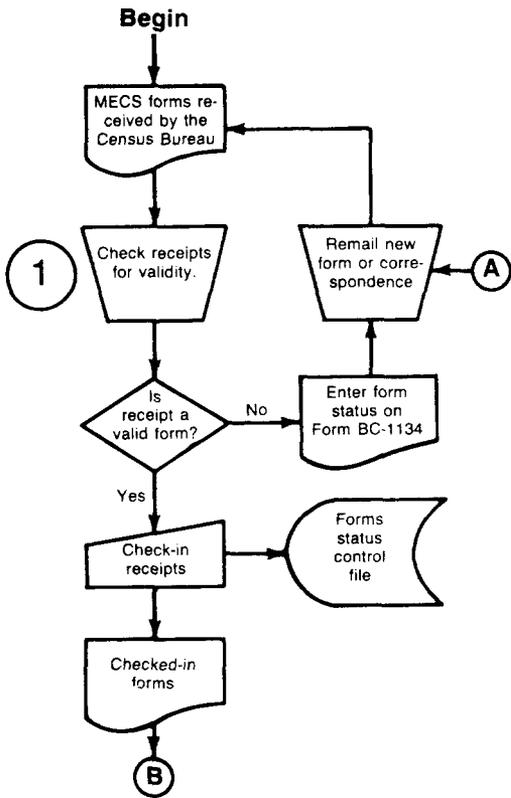
The flow of forms and data are illustrated in Figure 1. Checks for data quality, and verification and retrieval of data, were performed at four points in this process (labeled 1 through 4 in Figure 1).

- 1) MECS forms and correspondence were examined upon arrival at the Census Bureau. Correspondence without accompanying forms, requests for time extensions, and forms packages returned by the Postmaster as undeliverable, were separated from returned questionnaires for separate handling. Valid returned questionnaires were forwarded directly to check-in on the status control file. Postmaster returns were researched and remailed if appropriate. The status control file was updated using information from correspondence not checked in. Questionnaires returned blank the first time were marked and remailed at this stage. Questionnaires received blank a second time were not remailed.
- 2) All checked-in forms were examined for completeness, legibility and a few major logical consistencies by clerical staff at the Census Bureau. Any forms that failed this screening process were set aside for review by industry specialists and the Sworn Census Employees, as discussed in the previous chapter. Acceptable forms were forwarded directly to data entry.
- 3) All forms that were incomplete or, in some way, failed screening, were examined by industry specialists and Sworn Census Employees. These analysts attempted to collect missing data and verify unusual data by telephone contact with the individual who completed the questionnaire. In cases where it was deemed appropriate, decisions were made to remail forms to respondents or to declare establishments ineligible for the MECS because they went out of business or ceased manufacturing before the beginning of 1985. Once completed and verified, these forms were forwarded to data entry.
- 4) After a MECS data file had been created, all records on it were tested against a series of edits for consistency. These edits included both checks against corresponding data items from other parts of the MECS questionnaires and the 1985 ASM, and checks for outliers in the distributions of individual variables. Records with failed edits were output and data items were reviewed by industry specialists and Sworn Census Employees.

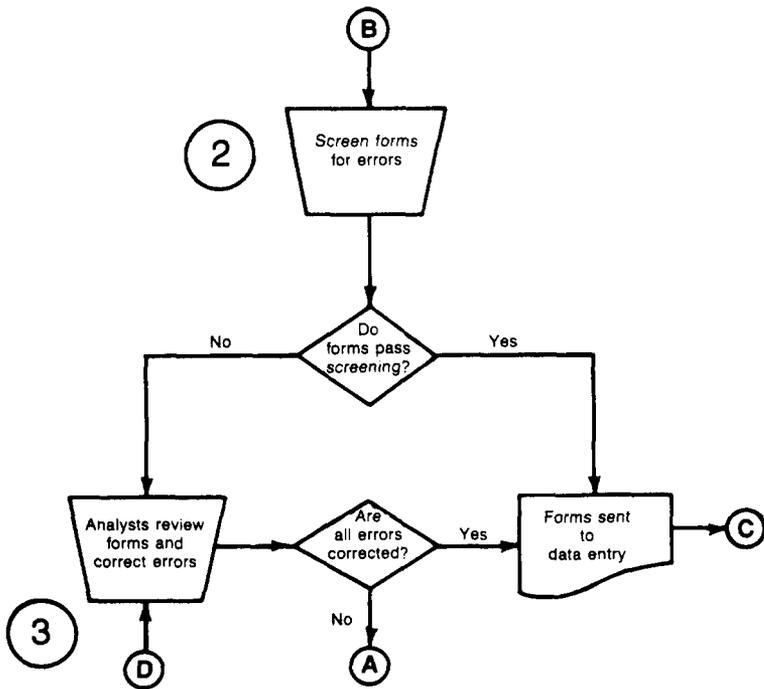
The overall strategy behind this organization of edits was to automate, as much as possible, the processes for handling the most basic problem cases and cases with inconsistencies not readily apparent. Most of the available effort was then concentrated on screening and review by industry specialists and EIA Sworn Census Employees.

The screening process was revised as questionnaires came in containing unexpected anomalies. The computerized edits, on the other hand, followed strict guidelines developed prior to the start of the editing process. These guidelines are reprinted in Appendix D. The forms that were reviewed by analysts were those with difficulties that could not be resolved using strict protocols. Such cases were dealt with individually.

**Figure 1. Flowchart of the Data Editing Process for the 1985 MECS**

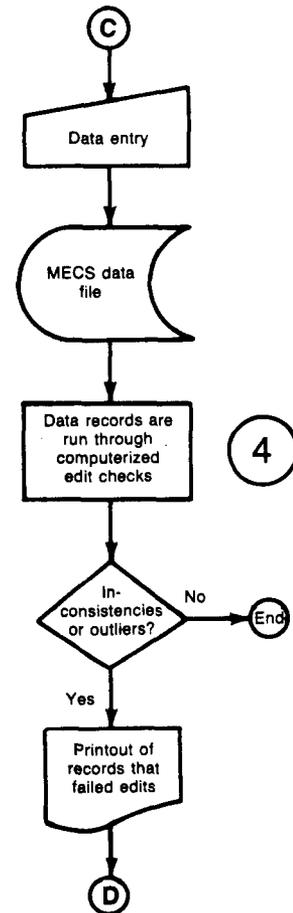
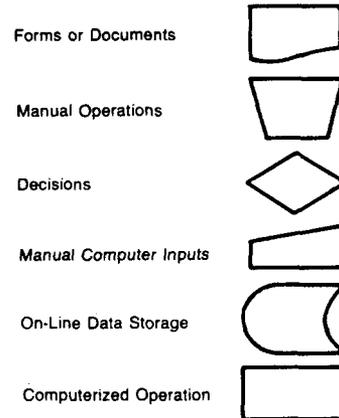


**Check-in of forms and correspondence**



**Verification and retrieval of data**

**Legend of symbols:**



**Electronic data processing**

# Adjustments to the Sample

Two types of adjustments were performed on the MECS sample records before they could be used to produce energy consumption-related statistics.

- The inverse probabilities of selection were adjusted to account for nonrespondent establishments, establishments deleted from the MECS frame by oversight, and establishments that ceased manufacturing during 1985. This adjustment was applied to all establishments that responded to the EIA-846(F).
- Energy consumption for nonfuel purposes was constructed for petroleum refineries, using existing data available from Form EIA-810 (Monthly Refinery Report).

## Adjustment of Form EIA-846(F)

Before the data submitted by MECS respondents could be used to produce estimates of characteristics of the manufacturing sector, the basic MECS probabilities of selection ( $P_{sj} = Q_{sj} \cdot R_{sj}$ ) of these establishments had to be adjusted to account for nonresponse; establishments that began operations in 1984; and establishments that went out of business or out of scope during 1985. An adjustment factor,  $A_{sc}$ , was computed for each of 90 adjustment cells, defined by the 30 SIC sampling categories crossed with three size classes, as defined below. The product of the adjustment factors and the inverse of the basic probabilities of selection are the adjusted MECS inflation weights, which are used to produce estimates of various population characteristics and the standard error associated with each estimate. Thus, the adjusted weight for generating all MECS estimates is:

$$W_{scj} = A_{sc} \cdot (1/P_{scj})$$

for establishment  $j$  in SIC  $s$  and size class  $c$ . The adjusted weights ( $W_{scj}$ ) can be interpreted as meaning that each respondent establishment  $j$  represents itself and similar unsampled establishments, as well as similar nonrespondent establishments in the manufacturing sector.

The MECS estimator for the national total of characteristic  $Y$  can, therefore, be expressed as:

$$\hat{Y} = \sum_s \sum_c A_{sc} \sum_{j=1}^{m'_{scr}} (1/P_{scj}) \cdot y_{scj} = \sum_s \sum_c \sum_{j=1}^{m'_{scr}} W_{scj} \cdot y_{scj} ,$$

where  $y_{scj}$  = the reported value of  $Y$  for establishment  $j$  in SIC  $s$  and size class  $c$ ;

$m'_{scr}$  = number of MECS respondents in SIC  $s$  and size class  $c$ ;

$c$  = size-class subscript, with three possible classes:

- 1) certainty establishments ( $P_{scj} = 1.0$ );
- 2) large noncertainty establishments ( $0.2 < P_{scj} < 1.0$ );
- 3) small noncertainty establishments ( $P_{scj} \leq 0.2$ ).

$W_{scj}$  = the adjusted inflation weight for establishment  $j$  in SIC  $s$  and size class  $c$ .

The following characteristics of the ASM sample used as the MECS frame are pertinent in understanding why and how the adjustment factors were utilized:

- Each year, all establishments in the ASM sample identified as having been sold to multiestablishment companies are tracked by the Census Bureau. They are kept in the ASM sample if they are still active and operate in the manufacturing sector. Establishments that were sold, but do not meet these criteria, are automatically dropped from the ASM sample.
- New employer identification numbers (EIN's), supplied to the Census Bureau by the IRS along with employment and payroll data, are used to add a "birth cohort" to the mail file each year. All establishments in this cohort that have at least 35 employees are contacted by the Census Bureau to ascertain if they were given a new EIN because of a change in ownership. Establishments that represent new operations are added to the ASM sample with certainty.
- The "birth cohort" in a given year is not accounted for in the ASM sample until the following data collection year. Thus, 1985 births were first represented on the 1986 ASM, which was mailed at the beginning of 1987.

The coverage of the 1985 MECS sample duplicates the coverage of the 1985 ASM mail sample, with the following exceptions:

- 1) Establishments in the 1984 "birth cohort" that were included in the 1985 ASM mail sample were inadvertently omitted from the version of the ASM sample used as the MECS frame. This group is accounted for in the MECS by being represented in the weight adjustment.
- 2) Establishments that ceased operations during 1985 were not mailed MECS forms if their status was determined prior to the mailout of the MECS forms. Establishments in the MECS sample that were not so identified were mailed Form EIA-846(F), and either responded with part-year data for 1985 or were nonrespondents to the survey.

To calculate  $A_{sc}$  for each adjustment category, the size measure  $TBtu$  was calculated for each establishment in the 1984 "birth cohort", whether or not it ceased operation in 1985.  $TBtu$  for these establishments was calculated by exactly the same method as was used to calculate  $TBtu$  for establishments in the ASM sample used as the MECS frame, but that were not in the ASM sample in 1981 (see chapter on Creating Measures of Size for Establishments in the MECS Frame). The only difference was that cost of fuels and inflation adjustments were based on 1985 rather than 1984 data, since that was the first available ASM data.  $TBtu$  for birth establishments in SIC s were, thus, calculated as:

$$TBtu_j = \frac{C_{85j}}{\hat{C}_{s85}} F_{s81} + (3.412 \times 10^6) E_{85j}$$

The adjustment factors  $A_{sc}$  were calculated using  $TBtu$ , rather than using weighted establishment counts, so that the resulting adjusted weights would reflect the sample design strategy of allocating and sampling proportional to estimated consumption of purchased fuels and electricity ( $TBtu$ ). Calculating  $A_{sc}$  based on weighted  $TBtu$  results in adjusted weights, for noncertainty establishments, that remain proportional to  $TBtu$ . The formula for calculating  $A_{sc}$ , therefore, is:

$$A_{sc} = \frac{\sum_{j=1}^{m'_{sc} - m'_{scd}} (1/P_{scj}) TBtu_{scj} + \sum_{j=1}^{n'_{scb} - n'_{scbd}} TBtu_{scj} + 1/2 \sum_{j=1}^{m'_{scd}} (1/P_{scj}) \cdot TBtu_{scj}}{\sum_{j=1}^{m'_{scr}} (1/P_{scj}) \cdot TBtu_{scj}}$$

where  $m'_{sc}$  = total MECS sample size, in SIC s, size class c;

$m'_{scd}$  = number of 1985 deaths (including 1984 births) that were MECS nonrespondents, in SIC s, size class c;

$n'_{scb}$  = number of 1984 ASM births, in SIC s, size class c;

$n'_{scbd}$  = number of 1985 ASM deaths that were also 1984 births, in SIC s, size class c;

The numerator of the formula for  $A_{sc}$  represents the total estimated consumption of purchased fuels and electricity for all establishments to be represented in published MECS estimates of energy consumption. Each of the three terms represents part of this total.

- 1) The first term represents all establishments in the manufacturing sector that were in operation throughout 1984 and 1985, and establishments that ceased manufacturing in 1985 but filed a completed MECS form for their part-year operations.
- 2) The second term accounts for all ASM establishments that began manufacturing in 1984 and continued to manufacture throughout 1985. Since no sampling of births was conducted for either the ASM or the MECS, the TBtu values in this term are unweighted.
- 3) The third term represents all establishments that ceased manufacturing in 1985 and also did not complete a MECS questionnaire. This term is multiplied by one-half, under the assumption that, on the average, these establishments manufactured for 6 months during 1985.

The denominator of the formula for  $A_{sc}$  represents that part of the manufacturing sector accounted for by the data reported by MECS respondents. The  $A_{sc}$ , in effect, ratio-adjust weighted data from MECS respondents to estimated totals for the part of the manufacturing sector initially targeted by the MECS frame and sample design. The weighted TBtu measure serves as the control variable for the adjustment procedure.

The effect of adjusting MECS probabilities of selection ( $P_{scj}$ ) in this way is to use the data for MECS respondents to estimate for the part of the population represented by survey nonrespondents (including those that ceased operations in 1985), and for establishments in the 1984 birth cohort that were not included in the MECS frame.

Adjustment factors varied considerably by SIC category and size class. For certainty establishments the 30 values of  $A_{sc}$  ranged from 1.00 to 1.25, with a median value of 1.045 and 5 values exceeding 1.10.  $A_{sc}$  values for large noncertainties ranged from 1.02 to 1.52, with a median value of 1.13 and 5 values exceeding 1.20. For the small noncertainties,  $A_{sc}$  ranged from 1.00 to 1.55, with a median value of 1.21 and 4 values exceeding 1.40.

## Adjustment of Form EIA-846(S)

Fuel-switching data for the MECS system were collected on the supplemental EIA-846(S) questionnaire, administered subsequent to Form EIA-846(F). An additional, subsequent data collection provided further "opportunity" for response errors and data discrepancies that would not exist in a single, unified data collection. Four major issues resulted from the design and implementation of Form EIA-846(S) that required data adjustments. These issues, and the methods used to deal with them, can be summarized as follows:

- 1) Of the sample establishments that submitted complete data on Form EIA-846(F), 433 listed electricity as their only energy source consumed for heat and power. These establishments were generally small, as and belonged to industry groups with low-intensity energy use. Thus, they would not be expected to have the capability to substitute for their electricity use. Therefore, to reduce processing costs and eliminate response burden for these establishments, they were excluded from the EIA-846(S) mailout. All capabilities to switch from electricity to alternate fuels were imputed as 0 for these cases.
- 2) As mentioned in the Introduction, fuel and electric energy consumption from Form EIA-846(F) were preprinted in the appropriate spaces of row one of Form EIA-846(S) as a reference for fuel-switching respondents. To meet the November 26, 1986, mailout date for Form EIA-846(S), only those MECS cases with acceptable consumption data available as of November 7 were included in the mailout. Establishments that submitted Form EIA-846(F) after November 7, and all establishments that had returned Form EIA-846(F), but whose consumption data had not yet been cleared for use, were not mailed Form EIA-846(S). These establishments contributed to MECS totals for energy consumption but their fuel-switching capability is unknown. Therefore, all potential fuel-switching data items for these cases were assigned to the category "not ascertained."
- 3) Some of the establishments that were mailed Form EIA-846(S) did not respond. These cases were also handled by assigning "not ascertained" status to all potential fuel-switching data items.
- 4) Some establishments that responded to Form EIA-846(S) changed one or more of the preprinted consumption numbers that had been transferred from Form EIA-846(F). Those cases were assigned to Census Bureau analysts, who followed up as necessary to reconcile all differences.

An alternative to assigning "not ascertained" status in cases 2 and 3 would be to impute fuel-switching data, either by filling in data items on individual records, or by applying weight adjustments to EIA-846(S) respondents. These approaches were rejected because fuel switching is a complex issue, and many of the nonrespondents to the EIA-846(S) comprised a special group of cases--late respondents to Form EIA-846(F). Both of these limitations would have created additional suspicion about the already uncertain validity of imputed values.

## Data on Nonfuel Use of Energy Sources at Petroleum Refineries

Because petroleum refineries currently report extensive data on nonfuel uses of petroleum inputs (for example, refining operations, process losses) to EIA, refineries were not required to report these data separately as nonfuel uses of energy sources on the MECS. The item requesting quantities of energy sources used for nonfuel purposes (Form EIA-846(F), Item 8) was marked with an "R" by establishments that manufactured solely in SIC 2911 (petroleum refining). Establishments that entered an "R" in Item 8 were then requested to enter, in Item 10, the identification number they use when reporting detailed accounting data to EIA on Form EIA-810 (Monthly Refinery Report). Establishments that were primarily refineries, but had associated petrochemical plants, were requested to enter data on nonfuel uses of energy sources in Item 8 of MECS Form EIA-846(F) for the nonrefinery part of the plant only. They were to report their EIA-810 identification number in Item 10 to allow EIA to compile the establishments' energy source inputs to refining processes from monthly data already reported to EIA.

These special rules, which were designed to eliminate duplicative reporting and reduce burden, were confusing to many refiners. In the end, the rules created more burden than they saved for these respondents. Some refiners omitted data they were required to report, while others submitted data that were supposed to be suppressed by the special rules. In addition, some of the unnecessary data was internally inconsistent with other data items on the same form, or was incompatible with the data that would have been transferred from the EIA-810.

On reviewing the microdata for SIC 2911, the Census Bureau's staff, in conjunction with EIA's Sworn Census Employees, decided that they contained too many apparent errors to be used as a basis for report tabulations. Therefore, at EIA's request the Bureau undertook a case-by-case followup effort in that industry to collect revised data specifically for those items that were apparent errors. The followup effort was based on a clarified set of instructions developed by EIA to address the major sources of confusion. When revised data were collected in the followup, the original data item(s) on the MECS establishment file were replaced with the new data.

Even after the revised data were collected, difficulties remained while trying to merge them with the EIA-810 data to produce nonfuel consumption for SIC 2911. Some MECS establishments classified in SIC 2911 could not be matched with an EIA-810 case. Also, shipments of energy sources from refineries had to be excluded from nonfuel use at refineries, so that the consumption total would not duplicate energy use reported for other industries. Unfortunately, EIA-810 shipments of energy source products from refineries included shipments to colocated petrochemical plants. These plants were considered separate establishments for the EIA-810 system, but were sometimes considered part of the same establishment for purposes of the ASM (and, thus, the MECS). When this discrepancy in definition of the establishment occurred, consumption of products shipped to the petrochemical plant should have counted as consumption at the establishment rather than being subtracted out, for purposes of the MECS. There was no way to back out this class of shipments from the EIA-810 totals, and there was evidence that the amount of energy involved was substantial.

Because of these difficulties, EIA decided to revise the definition of nonfuel use of energy sources specifically for SIC 2911. Instead of estimating nonfuel use of individual petroleum products at refineries, EIA substituted a single value for the United States and each of the Census regions, equal to the Btu equivalent of all "nonenergy-source products" shipped from refineries, as reported by the EIA-810 system. The product classes categorized as "non-energy-source products" were those most likely to be considered raw materials rather than energy sources by the entities receiving them. Six product classes were included: special naphthas (solvents); lubricating oils; asphalt and road oil; waxes; and two products classified under the heading of petrochemical feedstocks; naphtha < 400° F end-point, and other oils > 400° F end-point.

The rationale behind this revised definition was that the Btu content of shipments of energy sources from refineries are accounted for by the end users that receive the products, and should not be associated with the refinery. The products mentioned above, however, would not be identified as energy sources by the eventual end users. If their energy content is to be accounted for anywhere, it has to be at the refinery. One advantage to this approach is that the energy content of nonenergy-source products is appropriately associated with the refinery establishment, whether the products are shipped to a petrochemical facility onsite, or are shipped offsite.

One concern might be that certain petrochemical feedstock inputs would be reported as energy sources by chemical plants. In this case, their Btu would be counted twice. Fortunately, inspection of MECS records for SIC 28 did not reveal any significant reported inputs of these kinds of materials.

The revised approach is not perfect. It does not account for refinery losses (waste, spillage, and industrial accidents). Also, shipments of unfinished oils, which are treated as energy sources by this approach, may not be classified as energy-source inputs by the receiving establishments. As long as these unfinished oils are shipped to another refinery for final processing, their Btu value will eventually be counted correctly. Unfinished oils that are shipped to nonrefinery establishments for final processing would be uncounted if the receiving establishment did not classify them as energy sources. Fortunately, the vast majority of shipments of unfinished oils are to other refineries.

# MECS Estimators

All energy consumption, and energy-related statistics, produced from MECS data are calculated by combining data collected from sampled establishments, with the adjusted sampling weights. These weights establish the relationship between the respondent sample establishments and the manufacturing sector (see chapters on Creating Measures of Size for Establishments in the MECS Frame and on Adjustments to the Sample). Two types of statistics are produced by MECS. One type is totals of characteristics (for example, total fuel oil consumption in the hydraulic cement industry). The second type estimates ratios of characteristics (for example, the amount of fuel consumed per dollar of value added in the manufacturing sector). All of these estimates are accompanied by their relative standard errors (RSE's), which provide a measure of the precision of the estimate. Derivations of these estimators are presented in Appendix F. A discussion of special properties of MECS variance and covariance estimators is presented in Appendix G.

The total value of any aggregate characteristic Y for the manufacturing sector is estimated as:

$$\hat{Y} = \sum_s \sum_c A_{sc} \sum_{j=1}^{m'_{scr}} (1/P_{scj}) y_{scj} = \sum_s \sum_c \sum_{j=1}^{m'_{scr}} W_{scj} \cdot y_{scj} ,$$

where  $A_{sc}$ ,  $m'_{scr}$ , and  $W_{scj}$  are as defined in the preceding chapter. Estimates for subgroups of the manufacturing sector (for example, by SIC or by Census region) are produced by summing over sample establishments within the subgroup.

Ratio statistics are produced for MECS using a combined ratio estimator. The formula for this estimator, expressed in terms of aggregate characteristics Y and X that form its numerator and denominator, is:

$$\hat{R} = \frac{\hat{Y}}{\hat{X}} = \frac{\sum_s \sum_c \sum_{j=1}^{m'_{scr}} W_{scj} \cdot y_{scj}}{\sum_s \sum_c \sum_{j=1}^{m'_{scr}} W_{scj} \cdot x_{scj}} .$$

Estimates of ratios are based only on data from the MECS sample establishments, whether the data were collected on the MECS or on the ASM questionnaire. ASM data can be combined with MECS data because the ASM sample was used as the MECS frame, and because the MECS sample is a probability sample with respect to both the ASM frame and the ASM sample. Published ASM estimates of economic statistics are not used to produce these ratio estimates, because the ASM represents the entire manufacturing sector, whereas MECS does not represent the very small establishments in the manufacturing sector. The effect of this difference is discussed in detail in the chapter on the Manufacturing Sector and Its Relationship to the Population Surveyed by the 1985 MECS. Thus, a statistic  $\hat{X}$ , calculated by dividing a MECS statistic  $\hat{Y}$  by the MECS-based ratio  $\hat{Y}/\hat{X}$  will not exactly equal the corresponding ASM-based statistic.

For each MECS estimate of a total or a ratio, an estimate of precision can be produced. The relative standard error (RSE) is the form used in all MECS publications. The RSE of an estimate is defined as the ratio of the standard error of the estimate (the square root of its variance) to the estimate itself. In algebraic form

$$RSE(\hat{Y}) = \sqrt{\frac{\text{Variance}(\hat{Y})}{(\hat{Y})^2}} ,$$

for any total or ratio estimator  $\hat{Y}$ . The variance formula for estimates of totals, for the sampling method used in MECS is:

$$\text{Variance}(\hat{Y}) = S^2(\hat{Y}) = \sum_s \sum_c \sum_{j=1}^{m'_{sc}} (y_{scj})^2 \cdot \frac{(1 - P_{scj})}{P_{scj}^2},$$

under the assumption that all sampled establishments responded to the survey. This formula is discussed in detail in Appendix F.

This same formula, however, is commonly used for samples containing some nonresponse by replacing the unadjusted probabilities of selection with probabilities of selection that have been adjusted for nonresponse. The variance formula then becomes:

$$S^2(\hat{Y}) = \sum_s \sum_c \sum_{j=1}^{m'_{scr}} (y_{scj})^2 \cdot \frac{(1 - (P_{scj}/A_{sc}))}{P_{scj}^2/A_{sc}^2},$$

which, when written in terms of adjusted sampling weights, reduces to:

$$\begin{aligned} S^2(\hat{Y}) &= \sum_s \sum_c \sum_{j=1}^{m'_{scr}} (y_{scj})^2 \cdot A_{sc}^2 \cdot \left[ \frac{1}{P_{scj}^2} \right] \cdot \left[ 1 - \frac{1}{A_{sc} (1/P_{scj})} \right] \\ &= \sum_s \sum_c \sum_{j=1}^{m'_{scr}} (y_{scj})^2 \cdot W_{scj}^2 \cdot (1 - (1/W_{scj})) \\ &= \sum_s \sum_c \sum_{j=1}^{m'_{scr}} (y_{scj})^2 \cdot W_{scj}^2 \cdot \frac{W_{scj} - 1}{W_{scj}} \\ &= \sum_s \sum_c \sum_{j=1}^{m'_{scr}} (y_{scj})^2 \cdot W_{scj} \cdot (W_{scj} - 1) \end{aligned}$$

Including nonresponse adjustments ( $A_{sc}$ ) in the variance formula increases the estimates of variance in two ways, over what they would have been with no nonresponse:

- A component of unit nonresponse that can be considered random under the assumptions of the weight adjustment procedure;

- A component of variance contributed by certainty establishments (which do not contribute to sampling variance if nonresponse is zero), that results from inflating  $1/P_{scj}$  by  $A_{sc}$ .

The corresponding variance estimator used for ratios is:

$$S^2(\hat{R}) = (1/\hat{X})^2 \sum_s \sum_c \sum_{j=1}^{m'_{scr}} (y_{scj} - \hat{R} \cdot x_{scj})^2 \cdot W_{scj} \cdot (W_{scj} - 1) ,$$

where  $\hat{R} = (\hat{Y}/\hat{X})$

This estimator provides a suitable approximation of the actual sample variance based on the assumption that  $\hat{X}$  is a sufficiently precise estimate of  $X$ . Classical statistics suggests that "sufficiently precise" corresponds to a relative standard error of 10 percent or smaller.<sup>3</sup>

For purposes of analytic presentation, data users may create ratio statistics from published MECS aggregates. By far the most common such ratio is the proportion, a ratio for which the parameter  $X$ , estimated by the denominator  $\hat{X}$ , "encompasses" parameter  $Y$ , estimated by  $\hat{Y}$ . That is, each member of the establishment population that contributes to the total for  $\hat{Y}$  also contributes to the total for  $\hat{X}$ , and  $x_{scj} \geq y_{scj}$  for all establishments. It can be shown that, specific to the MECS sample design and estimation methodology, a useful upper bound for the variance of a proportion ratio

$$\hat{R} = \frac{\hat{Y}}{\hat{X}}$$

is

$$[RSE(\hat{R})]^2 = \frac{1}{\hat{X}^2} \left[ S_{\hat{Y}}^2 (1 - 2\hat{R}) + S_{\hat{X}}^2 (\hat{R}^2) \right]$$

Justification for this expression is found in Appendix H.

<sup>3</sup>W.G. Cochran, *Sampling Techniques*, Third Edition. (John Wiley & Sons, New York, NY, 1977), p. 153.

## Appendix A

### **Identification of Issues**

## Appendix A

# Identification of Issues

The data issues addressed in the MECS questionnaire were identified by a two-stage process. First, data needs were clarified based on discussions within EIA, other agencies of the Federal Government, and other potential data users. The resulting list of issues was then pared down after extensive discussion within EIA, based on knowledge of industry capabilities and concerns. Knowledge was acquired via EIA site visits to manufacturing establishments and from written and oral comments received from manufacturers and their trade associations. This process resulted in a MECS system that collects a variety of energy consumption measures of importance to a broad cross-section of data users without placing undue response burden on manufacturers.

The following specific approaches, listed roughly in chronological order of their occurrence, were used to obtain information:

- On February 27, 1984, EIA published a Federal Register Notice (49 FR 7188) inviting public comments on the development of a MECS. Ninety responses were received of which 40 were from data providers (27 manufacturers and 13 manufacturers' trade associations) and 50 were from potential data users (7 DOE, 13 other Federal government, 14 State government, and 16 nongovernmental data users).
- During 1984, a total of 55 interviews or correspondence (34 representing 9 entities within DOE, and 21 representing 9 outside agencies) identified data needs within DOE and other Federal agencies.
- During 1984, a total of 50 interviews or correspondence (17 representing 7 States, 14 representing 9 universities, 19 representing other private users of the data) identified the data needs of State energy officials and private users of data.
- Between June and November 1984, EIA staff members conducted a series of site visits at 20 manufacturing establishments throughout the United States. The visits were made to gain a better understanding of the ways in which manufacturers use energy in their facilities, and to find out the types of data that they could provide with relatively little difficulty.
- On March 21, 1985, EIA published a notice in the Federal Register (50 FR 11486) that invited public comment on the proposed Form EIA-846. The notice also announced that public hearings on proposed Form EIA-846 would be held in Denver, Colorado, and Washington, DC. The Washington, DC hearing was held on May 20, 1985. The Denver hearing was canceled for lack of response. Sixty-five responses were received of which 54 were from data providers (36 manufacturers and 18 manufacturers' trade associations) and 11 were from potential data users (one DOE, five other Federal government, two State government, and three nongovernment). Of these, six manufacturers and three trade associations testified at the public hearing in Washington, DC.
- Between October 18, 1985, and January 1986, EIA tested a pilot version of a consolidated MECS questionnaire on a nonrandom sample of 100 manufacturing establishments chosen from Dun & Bradstreet's "Dun's Market Identifiers" file. The sample was chosen to represent industries where complex situations regarding energy use were thought to occur. Each respondent in the pilot study was interviewed to evaluate the questionnaire. Respondents were not required to report actual energy consumption data on this form, but were given the option of reporting disguised data.
- During the last half of 1985 and the first half of 1986, OMB provided potential respondents with the opportunity to comment on the proposed MECS as part of the approval process for the MECS.

Potential data users supported instituting a MECS, and, in most cases, were specific about their data needs. The justifications for these needs were stated quite specifically in responses of the Department of Defense (DOD), the Department of Commerce (DOC), the State governments, and among the fuel and energy suppliers. Consultants and university researchers provided more general justifications. Data items requested were fairly uniform across all groups contacted. The most frequently requested items were:

- Fuel cost and consumption
- Cogeneration
- Fuel switching
- Renewable energy sources
- Fuels enerated and used onsite
- Feedstocks.

Items requested less frequently were:

- Fuel inventories
- Storage capacity
- End-uses of energy.

Most potential users of MECS data requested that any MECS developed be compatible with economic data from the ASM. Several users also requested that MECS data be compatible with the former "Fuels and Electric Energy Consumed" supplement to the ASM. A detailed compilation of the requests and suggestions of potential users is available in the justification document for the MECS that was submitted to the OMB requesting approval for the survey.

The topics suggested by data users were among the issues most closely researched during the site visit process. The establishments that were visited were medium to large facilities representing 8 of the 10 most energy-consumptive 4-digit industries, and several other 2-digit industry groups.

Site visits usually started with a discussion between EIA staff and the energy manager, operating officers, and/or other personnel familiar with energy use at the establishment. The discussion followed the outline of a prearranged agenda provided to the establishment well in advance of the meeting. Items on the agenda included a description of the establishment's energy-using processes; its recordkeeping practices; the availability of recorded data on a list of specific data items that EIA was considering to include in the MECS; and the respondent's conception of more involved subject areas such as capacity utilization, within-establishment end uses of energy, and fuel-switching capability. Following the discussion, EIA staff were given a tour of the manufacturing and powerhouse facilities at the establishment.

The site visits helped the MECS development process significantly by providing clear guidance on issues such as:

- the difficulty in measuring many faceted concepts such as capacity utilization and detailed end uses of energy within the establishment
- the importance of byproduct and waste product energy sources as fuel in some industries
- the role of redundant as well as multiple-fired equipment in providing fuel-switching capability

- the effect on fuel-switching capability of constraints such as binding contracts, interruptible fuel supplies, environmental and safety regulations, and maintenance requirements
- the planning and operation of an integrated cogeneration facility within an establishment's energy delivery system.

Several of the industry representatives who arranged and participated in the site visits provided additional assistance by critiquing versions of the MECS questionnaire after the site-visit process was completed.

## Appendix B

# **A Description of Data Items in Existing Surveys that Potentially Duplicate Data Collected by the MECS System**

## Appendix B

# A Description of Data Items in Existing Surveys that Potentially Duplicate Data Collected by the MECS System

The importance of both the manufacturing industries and energy issues make it inevitable that both are covered, to some extent, by surveys that predate the MECS system. This section describes data collected by these surveys in relation to the requirements of the MECS system. An additional purpose is to consolidate and clarify what energy data are collected presently. Users of the MECS system will then have a guide to related energy data that may be a supplement to MECS data for the specialized data user.

EIA carefully examined several survey instruments to ascertain to what extent they overlap the EIA-846(F) and EIA-846(S). These instruments are: Form CE-189, Industrial Energy Efficiency Program; Form EIA-3, Quarterly Coal Consumption Report--Manufacturing; Form EIA-5, Coke Plant Report--Quarterly; Form EIA-810, Monthly Refinery Report; FERC Form 1, Annual Refinery Report; Form EIA-714, Annual Electric Power System Report; FERC Form 1, Annual Report of Major Electric Utilities; and Bureau of the Census Form MA-1000(MU), Annual Survey of Manufactures (ASM). Each of these energy data collection systems was established to collect a specific set of data for specific, narrowly defined purposes.

All of these surveys, except the ASM, are censuses that require submissions from all members in a narrow portion of the manufacturing or electric-utility populations. MECS, however, is a probability sample survey that requires submissions from only selected members of the manufacturing industries. The surveys can be summarized as follows:

- The Quarterly Coal Consumption Report (EIA-3) -- provides data on consumption of coal only. Its information is collected only from manufacturing establishments that are known to consume coal for purposes other than coke production. The list of such establishments contains about 1,000 of the 300,000-plus manufacturing establishments in the United States. There are no data on inputs, dispositions, and consumption for energy sources other than coal.
- The Quarterly Coke Plant Report (EIA-5) -- produces balance statistics on input and output for the small universe of coking plants, including statistics on the consumption and disposition of the raw materials used to produce coke and statistics on the production and disposition of coke.
- Monthly and Annual Refinery Reports (EIA-810 and EIA-820) -- are complementary data collection systems that survey petroleum refineries. From the universe of approximately 400 refineries and blenders in the United States, these reports collect data on inputs of crude oil and other unfinished products, outputs of petroleum products, and onsite consumption of energy. In cases in which the establishment that houses a refinery also contains separate petrochemical processing, only refinery activities are reported. Thus, these refinery data systems are not designed to cover all energy use in refining establishments comprehensively.
- The Industrial Energy Conservation Program Report (CE-189) -- was collected for the last time in 1986 for 1985 consumption data. It was a census of very large energy-consuming establishments, and produced national estimates of total consumption by fuel at the 2-digit SIC level. The CE-189 survey targeted the most energy-consuming corporations in all Major Industry Groups (2-digit SIC's). Data were aggregated to the trade association or corporation level before being reported to DOE, and so were unsuitable for producing energy consumption statistics for individual industries (4-digit SIC's) or geographic regions.

- The Annual Survey of Manufactures (MA-1000(MU)) -- is primarily an economic survey, producing information on such characteristics as employment, payroll, value of shipments, capital expenditures, and total cost of materials. The ASM collects limited energy data on total cost of purchased fuels, cost and quantity of purchased electricity, quantity of electricity generated onsite, and quantity of electricity sold. ASM establishments are defined identically to MECS establishments, and the MECS sample is a subsample of the ASM.
- The Census of Manufactures (MA-1000 plus industry supplements) -- is conducted by the Census Bureau for years ending in the digit 2 or the digit 7 (for example, 1982 and 1987). The CM, like the ASM, collects primarily economic data, but also collects the same limited energy-related data as described above for the ASM.
- Annual Electric Power System Report (EIA-714) and Annual Report of Major Electric Utilities (FERC-1) -- collect some limited information on purchases and transfers of electricity by utilities, including sales and transfers from industrial sources to utilities. Data are reported by utilities in megawatthours per year for each individual supplier on Form EIA-714, Annual Electric Power System Report. The EIA-714 is completed by approximately 400 of the 3,200 utilities in the United States. The report is filed by electric utility systems (which may include one or more utilities) whose generation exceeds a certain threshold, and who provides electricity to retail customers. Data gathered via the FERC Form 1 include the quantity and value of electricity purchases and transfers from electric utilities and other nonutility sources. Because these sources are listed by name and not categorized by type of nonutility entity, sales by the manufacturing industries are not separated from the sales from other nonutility sources.

## Appendix C

### **Questionnaires and Instructions For MECS and Major Draft Versions of MECS Forms**

## Appendix C

# Questionnaires and Instructions For MECS and Major Draft Versions of MECS Forms

This Appendix Contains the following forms used in the 1985 MECS Data Collection.

- 1) ASM Form MA-1000(MU).
- 2) Public Hearing Version of the MECS Questionnaire, published in the Federal Register (50 FR 11486), March 21, 1985.
- 3) Pilot Study Version of the MECS Questionnaire, administered from December 1985 through February, 1986.
- 4) Clearance Version of the MECS Questionnaire, submitted to OMB in March 1986.
- 5) Final Version of Form EIA-846(F).
- 6) Final Version of Form EIA-846(S).

DUE DATE



U.S. DEPARTMENT OF COMMERCE  
BUREAU OF THE CENSUS

**MA-1000 (MU)**  
FORMERLY MA 1000 MU

# 1982 ANNUAL SURVEY OF MANUFACTURES

NOTE: The Annual Survey of Manufactures Form MA 1000(MU) is the first sheet of the 1982 Census of Manufactures form.

NOTICE - Response to this inquiry is required by law (title 13, U.S. Code). By the same law, your report to the Census Bureau is confidential. It may be seen only by sworn Census employees, and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

BUREAU OF THE CENSUS  
1201 East Tenth Street  
Jeffersonville, Indiana 47134

Note - PLEASE READ ALL ACCOMPANYING INSTRUCTIONS

Item 1A - Employer Identification Numbers  
Is the Employer Identification (EI) Number printed in the upper right of the address box the SAME as that used for this establishment on its latest 1982 Employer's Quarterly Federal Tax Return, Treasury Form 941?

094 1 YES 2 NO - Enter current EI Number - 9 digits

201 TAB  
202 IND-4  
203 AREA  
204 INFL  
205 CCS

Employer Identification (EI) Number

Item 1B - Physical location  
a. Is this establishment located in the State, county, and place shown at the right?  
Complete a, b, and c. If blank or incomplete, please complete (1) through (4).

(1) Number and street  
(2) City, village, or other place  
(3) County  
(4) ZIP code  
(e) If you corrected lines 1, 2, 3, give year moved to new location

b. Is this establishment physically located inside the legal boundaries of the city, town, village, etc., indicated in part a(2)?  
095 1 YES 2 NO 3 No legal boundaries 4 Don't know  
c. Type of municipality indicated in part a(2)?  
096 1 City, village, or borough 2 Town or township 3 Other or don't know

Item 1C - Organizational status  
Mark X in the ONE box which best describes this establishment during 1982.

003 1 Individual proprietorship  
2 Partnership  
3 Cooperative association (taxable)  
4 Cooperative association (tax exempt)  
5 Government - Specify  
6 Corporation (do not mark if any form of cooperative association)  
7 Other - Specify

HOW TO REPORT  
Figures for dollars, plant hours, KWH should be rounded to thousands. However, you may enter figures to nearest unit. Carefully enter your figures in the correct columns.  
e.g. if payroll is \$1,125,628, report either

Table with columns for 1982 and 1981, and sub-columns for Mil., Thou., Dol. and Kilowatt hours.

Item 2 - Number of employees at this establishment  
a. March  
b. May  
c. August  
d. November  
e. Sum of lines a-d  
f. Average number (Divide line e by 4)  
g. All other employees (pay period of March 12)  
h. TOTAL f and g (item 2)

Item 5 - Cost of materials and services used  
a. Cost of materials, parts, components, containers, etc. used  
b. Cost of products bought and sold as such  
c. Cost of fuels consumed for heat or power  
d. Cost of purchased electricity (See item 6)  
e. Cost of contract work done for you by others  
f. TOTAL (item 5)

Item 3A - Annual payroll for employees in item 2, before deductions  
a. Production workers' wages  
b. All other salaries and wages  
c. TOTAL (item 3A)

Item 6 - Quantity of electricity  
a. Purchased electricity (quantity comparable to cost as reported in item 5c)  
b. Generated electricity (gross less generating station use)  
c. Electricity sold or transferred to other establishments

Item 3B - Employer's cost for fringe benefits (supplemental labor costs)  
(Exclude from items 3A and 3C)  
a. Legally required including Social Security  
b. Payments for voluntary programs  
c. TOTAL (item 3B)

Item 7 - Inventories of this establishment at end of year (Report both years)  
Report inventories at cost or market using generally accepted accounting methods. For inventories at LIFO cost, use the sum of the LIFO amount plus the LIFO reserve for completing a through e(2).  
a. Finished goods  
b. Work in process  
c. Materials, supplies, fuels, etc.  
TOTAL INVENTORIES - Sum of lines a through c equals d

Item 3C - First quarter payroll, before deductions  
Total payroll for the first quarter (Jan.-Mar.)

Report the following breakdown of line (d):  
e. (1) Amount not subject to LIFO costing  
(2) Amount subject to LIFO costing  
Report the following applicable to line e(2):  
f. (1) Amount of the LIFO reserve  
(2) LIFO value of line e(2)  
NOTE - The sum of lines e(1) f(1) and f(2) should equal line d.

Item 4 - Plant hours worked by production workers  
a. January through March  
b. April through June  
c. July through September  
d. October through December  
e. TOTAL (item 4)

Item 8 - Depreciable assets, capital expenditures, and retirements  
Refer to the instruction manual for detailed instructions including how to report leasing arrangements.  
a. Gross value of depreciable assets - usually original cost at beginning of year  
b. Capital expenditures for new buildings and machinery  
c. Capital expenditures for used buildings and machinery  
d. Retirements and disposition of depreciable assets (i.e. gross value of assets sold, retired, scrapped, destroyed, etc.)  
e. Gross value of depreciable assets at end of year (should equal lines 8a, 8b, 8c, 8d)  
Item 9 - Depreciation charges for the year  
Item 10 - Rental payments - Mark X if 0

Item 11A - Total shipments and other receipts  
For 1982 report the total value of products shipped and other receipts as entered in item 1B. This value should be completely comparable to the total reported for 1981. If the two figures are not comparable, please explain in the reasons why in the remarks section. (Reporting by product class is not required for 1982.)

Table with columns for 1982 and 1981, and sub-columns for Total, Buildings and other structures (exclude land), Machinery and equipment, and Total.

CENSUS USE  
PENALTY FOR FAILURE TO REPORT  
CONTINUE ON PAGE 2

<b>Item 11B - Shipments to other domestic plants of your company</b> (This is a breakout of the total value of shipments reported in item 11A)		Key M Thru Do	1982
Report the value of products shipped to other domestic plants of your establishment for fabrication or manufacture.			
\$ 1,499 } \$2,000 }			
<b>Item 12 - Method of valuation for inventories not subject to LIFO costing</b>			
Using the inventory total reported for this establishment in item 7a(1) for 1982, please indicate the breakdown of that total value to the inventory valuation methods used.			
• Cost method - Report in column 1. • Market basis valuation used - Report in column 2.			
• Lower of cost or market - Report in column 1 at cost or in column 2 at market value. Indicate the methods and the amount of market value used in the value reported in item 7a(1) in the Remarks Section of this report.			
1 Cost	Method of valuation	Key	Amount at end of 1982 M Thru Do
a. First-in, First-out (FIFO)		181	
b. Average cost		182	
c. Standard cost		184	
d. Specific cost		185	
e. Other		186	
2 Market	a. Market used for valuation (use market over than cost)	187	
	b. Market not used for valuation	188	
<b>TOTAL (Equals the total reported in Item 7a(1) for 1982)</b>		189	
During the calendar year 1982 did you change the method of valuing the inventories that you reported for this establishment?			
1 YES - indicate the nature of the changes in remarks section.			
2 NO			
<b>Item 13 - Cost of purchased services</b> (See instruction manual)		<b>Item 14 - Breakdown of machinery and equipment expenditures by type reported in item 8b, column d (See instruction manual)</b>	
a. Repair of buildings and other structures		a. Automobiles, trucks, etc. for highway use	
b. Repair of machinery		b. Computers and peripheral data processing equipment	
c. Cost of purchased communication services (telephone, telegraph, etc.)		c. All other expenditures for new machinery and equipment	
		<b>TOTAL - Should be the same as Item 8b, column d</b>	
<b>Item 15A - Operational status</b> - Mark X in the circle which best describes the establishment at the end of 1982.			
(00) 1. In operation 2. Temporarily or seasonally inactive 3. Ceased operation 4. Sold or leased TO another operator - Give date at right AND enter name, etc. below 5. Acquired or leased FROM another operator - Give date at right AND enter name, etc. below			
			GIVE DATE - Enter figures only
			Month Year
			EI Number (9 digits)
<b>Item 15B - Not applicable to this report</b>			
<b>Item 16 - Checks to assure a complete and accurate report</b>			
The Bureau of the Census reviews your report for omissions, inconsistencies, and unusual ratios. To save you future correspondence about these problems, please make the following checks before returning your report.			
• Review the report carefully to see that no items are omitted for the year being covered. • Calculate and enter figures for the four reasonableness checks below, and review the results. • Correct your report for any errors you find and explain unusual figures in remarks. For most manufacturing establishments, the figures computed usually fall within the ranges indicated.			
Reasonableness checks	Calculation required for each check		Figures for survey year Usual range
a. Average hourly wages per production worker	Item 3Aa (Production workers' wages) / Item 4e (Total hours worked)		\$ hr. \$3-\$15
b. Hours worked per year per production worker	Item 4e (Total hours worked) / Item 2f (Average number of production workers)		Hrs. yr. 1000-3000
c. Salaries and wages per dollar of shipments	Item 3Ac (Total payroll) / Item 11A (Total value of shipments)		05%-95%
d. Materials cost per dollar of shipments	Item 5f (Total materials cost) / Item 11A (Total value of shipments)		05%-95%
e. Is the total of value of shipments (item 11A) greater than the sum for payroll (Item 3Ac) plus total cost of materials, etc. (item 5f)?			
YES NO - Explain in remarks			
REMARKS - Please use this space for any explanations that may be essential in understanding your reported data.			



SECTION II - NON-COMBUSTIBLE ENERGY SOURCES

Electricity

- 1a. During 1985, how much electricity was purchased from utilities or other firms, and delivered to the establishment? Quantity: \_\_\_\_\_ Kilowatthours
- 1b. What was the total expenditure for purchased electricity? \$ \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_
2. During 1985, how much electricity was transferred from outside establishments and delivered to the establishment? Do not include the purchases recorded in ITEM 1a. Quantity: \_\_\_\_\_ Kilowatthours
3. During 1985, how much electricity was generated onsite by cogeneration? Quantity: \_\_\_\_\_ Kilowatthours
4. During 1985, how much electricity was generated onsite from solar power, wind power, hydropower, and geothermal sources? Quantity: \_\_\_\_\_ Kilowatthours
5. During 1985, how much electricity was generated onsite by processes other than those covered in items 3 and 4? Quantity: \_\_\_\_\_ Kilowatthours
6. During 1985, how much electricity was sold to utilities? Include both sales and transfers for credit. Quantity: \_\_\_\_\_ Kilowatthours
7. During 1985, how much electricity was transferred to other establishments? Do not include amounts reported in ITEM 6. Quantity: \_\_\_\_\_ Kilowatthours

Steam

- 1a. During 1985, how much steam was purchased (from utilities or other firms) and delivered to the establishment? Quantity: \_\_\_\_\_ Million Btu
- 1b. What was the total expenditure for this purchased steam? \$ \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_
2. During 1985, how much steam was transferred from outside establishments and delivered to the establishment? Do not include the purchases recorded in ITEM 1a. Quantity: \_\_\_\_\_ Million Btu
3. During 1985, how much steam was generated onsite from solar power and geothermal sources? Quantity: \_\_\_\_\_ Million Btu
4. During 1985, how much steam was sold or transferred to other establishments? Quantity: \_\_\_\_\_ Million Btu

**SECTION III - FUEL SWITCHING CAPABILITY TO AND FROM OIL\***

**NOTE:**

- o This section deals with your ability to substitute alternate fuels for oil, and your ability to substitute oil for other fuels.
- o Indicate the change in volume of oil that you could accommodate, given your 1985 operating conditions and total consumption of combustible fuels.
- o "Fuel switching capability" is defined as your ability to vary your oil consumption by making use of existing multiple-fuel capabilities with, at most, minor adjustments in your physical plant.
- o Read the instructions concerning the definitions of "Maximum Technical Switching Capability" and "Practical Constraints" before proceeding with this section.

**\* Definitions:**

- o "Oil" refers to crude, residual, and distillate combined.
- o "Consumption" refers to the quantities in Section I, Column 6.
- o 1 barrel = 42 gallons.

Maximum Technical Switching Capability (Barrels) A	Switching Capability After Allowing for Practical Constraints (Barrels) B	Identification of Practical Constraints (If Columns A and B differ.) Enter Codes From the List Below.** C
---	---	--

**Part I: Switching Out of Oil**

(1) How much of the oil you consumed in 1985 could have been replaced by other fuels?	_____ bbl	_____ bbl	
(2) How much of the oil you consumed in 1985 could have been replaced by:			
natural gas.....	_____ bbl	_____ bbl	_ _ _ _
other fuel(s) (specify):			
_____	_____ bbl	_____ bbl	_ _ _ _
_____	_____ bbl	_____ bbl	_ _ _ _
_____	_____ bbl	_____ bbl	_ _ _ _

NOTE: The Sum of the entries in Item (2) must be equal to or greater than the entry in Item (1).

**Part II: Switching into Oil**

(3) What is the maximum amount of additional oil that could have been burned during 1985 in place of other fuels that were actually burned?	_____ bbl	_____ bbl	
(4) Of the additional oil reported in item (3), how much could have been used to replace:			
natural gas.....	_____ bbl	_____ bbl	_ _ _ _
other fuel(s) (specify):			
_____	_____ bbl	_____ bbl	_ _ _ _
_____	_____ bbl	_____ bbl	_ _ _ _
_____	_____ bbl	_____ bbl	_ _ _ _

NOTE: The Sum of the entries in Item (4) must be equal to or greater than the entry in Item (3).

\*\* Reasons for the difference between maximum technical capability to switch and capability to switch given practical constraints (column C).

- 1> Federal government environmental restriction(s).
- 2> State/Local government environmental restriction(s).
- 3> Binding contract in place.
- 4> Restrictions under the Powerplant and Industrial Fuel Use Act of 1978.
- 5> Fuel supply to the site cannot be established within 7 days of the decision to switch.
- 6> Fuel is byproduct of manufacturing process and would not have been switched from.

Other (specify):

7> \_\_\_\_\_

8> \_\_\_\_\_

9> \_\_\_\_\_

10> \_\_\_\_\_

SECTION IV - COMMENTS

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SECTION V - CERTIFICATION AND CONTACT PERSON

This report is substantially accurate and has been prepared in accordance with the instructions.										
Name of person to contact regarding this report					Telephone---->		Area code	Number	Extension	
Name of company					Address (Number and street, city, State, ZIP code)					
Period covered---->	From: No.	Day	Year	To: No.	Day	Year	Signature of authorized person		Title	Date



**SECTION III--FUEL SWITCHING FROM CRUDE OIL OR OIL PRODUCTS**

This section deals with your ability to substitute alternate fuels for oil, and your ability to substitute oil for other fuels. Indicate the change in volume of oil that you could accommodate, given your 1984 total consumption and operating conditions. "Fuel switching capability" is defined as your ability to vary your oil consumption by making use of existing multiple-fuel capabilities with, at most, minor adjustments in your physical plant. Read the instructions concerning the definitions of "Technical" and "Practical" ability to switch fuels before proceeding with this section.

<b>Definitions:</b> • "Oil" refers to crude, residual, and distillate combined. • "Consumption" refers to the quantities in Section I, Column 6. • 1 barrel = 42 gallons.	<b>Technical switching capability (barrels)</b> <b>A</b>	<b>Practical switching capability (barrels)</b> <b>B</b>	<b>Practical limitations to switching (if columns A and B differ)</b> Enter codes from the list below. <b>C</b>
(1) How much of the oil you consumed in 1984 could have been replaced by alternate fuels?	_____ bbl	_____ bbl	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
(2) How much of the oil you consumed in 1984 could have been replaced by: natural gas ..... other fuel(s) (specify): ..... ..... ..... (May add to more than total in (1))	_____ bbl _____ bbl _____ bbl	_____ bbl _____ bbl _____ bbl	
(3) Of your total 1984 energy consumption, what is the maximum that could have been in the form of oil?	_____ bbl	_____ bbl	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
<b>Reasons for the difference between technical capability to switch and practical capability to switch (column C).</b>			
1 Federal government environmental restriction(s). 2 State/Local government environmental restriction(s). 3 Binding contract in place. 4 Restrictions under the Powerplant and Industrial Fuel Use Act of 1978. 5 Fuel supply cannot be established within 30 days of the decision to switch.	<b>Other (specify):</b> 6 _____ 7 _____ 8 _____ 9 _____		

**SECTION IV - COMMENTS**

**COMMENTS**

**SECTION V - CONTACT PERSON**

Name of person to contact regarding this report	Telephone	Area code	Number	Extension	
Name of company	Actual location if different from mailing label (number and street, city, State, ZIP Code)				
Period covered	From: Mo. Day Year	To: Mo. Day Year	Signature of contact person	Title	Date

## Clearance Version of the MECS Questionnaire

### SECTION I - IDENTIFICATION OF PRIMARY ENERGY SOURCES

Please review the list of energy sources on this page. Mark the box next to all energy sources that were physically on the site of the establishment at some time during 1985, including those produced, purchased, used, transferred out, sold, or held in inventory at this establishment in 1985.

#### LIST OF PRIMARY ENERGY SOURCES

Mark. Here <1>	Code Number <2>	Energy Source <3>	Unit of Measurement for Reporting Amounts <4>	Average Btu per Unit of Measurement (Use HHV) <5>
<input type="checkbox"/>	11	Anthracite coal	Short Tons	
<input type="checkbox"/>	12	High sulfur bituminous coal	Short Tons	
<input type="checkbox"/>	13	Low sulfur bituminous coal	Short Tons	
<input type="checkbox"/>	14	High sulfur subbituminous coal	Short Tons	
<input type="checkbox"/>	15	Low sulfur subbituminous coal	Short Tons	
<input type="checkbox"/>	16	Lignite	Short Tons	
<input type="checkbox"/>	17	Coal coke and breeze	Short Tons	
<input type="checkbox"/>	21	Distillate (#1, #2, or #4 fuel oil and light diesel)	Barrels <42 gals.> (BBL)	
<input type="checkbox"/>	22	Residual (#5 or #6 fuel oil and navy special)	Barrels <42 gals.> (BBL)	
<input type="checkbox"/>	23	Crude Oil	Barrels <42 gals.> (BBL)	
<input type="checkbox"/>	31	Natural gas	1,000 cu. ft. (MCF)	
<input type="checkbox"/>	32	LPG, butane, propane	1,000 cu. ft. (MCF)	
<input type="checkbox"/>	41	Blast furnace gas	Million Btu (MMBtu)	
<input type="checkbox"/>	42	Coke oven gas	Million Btu (MMBtu)	
<input type="checkbox"/>	43	Petroleum coke	Million Btu (MMBtu)	
<input type="checkbox"/>	44	Refinery offgas (still gas)	Million Btu (MMBtu)	
<input type="checkbox"/>	45	Wood, bark, wood waste (50% moisture basis)	Million Btu (MMBtu)	
<input type="checkbox"/>	46	Pulping or black liquor (bone dry basis)	Short Tons	

Other primary energy sources, not listed above, that accounted for at least two percent of the total energy consumed at this establishment during 1985 (Do not include electricity or steam):

Mark Here <1>	Code Number <2>	Energy Source <3>	Unit of Measurement for Reporting Amounts <4>
<input type="checkbox"/>	51		Million Btu (MMBtu)
<input type="checkbox"/>	52		Million Btu (MMBtu)
<input type="checkbox"/>	53		Million Btu (MMBtu)
<input type="checkbox"/>	54		Million Btu (MMBtu)
<input type="checkbox"/>	55		Million Btu (MMBtu)
<input type="checkbox"/>	56		Million Btu (MMBtu)
<input type="checkbox"/>	57		Million Btu (MMBtu)
<input type="checkbox"/>	58		Million Btu (MMBtu)
<input type="checkbox"/>	59		Million Btu (MMBtu)

o Now COPY the code number (from column 2), name, and unit of measurement of all energy sources you checked on the list onto Section II.

o Proceed to Section II.

SECTION II - QUANTITIES OF ENERGY SOURCES

a INSTRUCTIONS:	COPY FROM SECTION I				
	ENERGY SOURCE ONE	ENERGY SOURCE TWO	ENERGY SOURCE THREE	ENERGY SOURCE FOUR	ENERGY SOURCE FIVE
a. For each energy source checked in Section I, set up a separate column heading in Section II by copying the code number, name, and units of measurement exactly as shown in Section I. Ignore any unused columns.	Code Number: _____ Name: _____				
b. If more than 5 columns are needed, use extra sheets.	Units used for reporting: _____				
c. Enter a quantity of zero wherever a question does not apply to a given energy source.	//////	//////	//////	//////	//////
d. If recorded values are not readily available, carefully prepared estimates may be used.	//////	//////	//////	//////	//////
<b>b ENERGY SOURCE INPUTS TO THE ESTABLISHMENT SITE</b> (Questions 1 through 3)					
1. How much of the energy source, named in the column heading, was in the INVENTORY of this establishment at the end of calendar year 1984?	Quantity: _____				
2a. During 1985, how much of this energy source was PURCHASED from utilities, dealers, or other firms, and delivered to the establishment?	Quantity: _____				
2b. What was the total cost, including delivery charges, of this purchased energy source in 1985?	\$ _____, _____, _____	\$ _____, _____, _____	\$ _____, _____, _____	\$ _____, _____, _____	\$ _____, _____, _____
3. During 1985, how much of this energy source was TRANSFERRED from outside establishments and delivered to this establishment? (Do not include the purchases recorded in ITEM 2a)	Quantity: _____				
<b>c PRODUCED ON SITE</b> (Questions 4 and 5)					
4. During 1985, how much of this energy source was PRODUCED ON SITE at this establishment from captive mines or wells?	Quantity: _____				
5. During 1985, how much of this energy source was PRODUCED ON SITE as a result of the use of feedstocks, raw materials, ingredients, or additives to a product (e.g., wood chips, products and by-products of chemical processes)? INCLUDE ONLY THOSE ENERGY SOURCES THAT WERE USED AS FUELS ON THIS SITE IN 1985.	Quantity: _____				
<b>d SUM OF ENERGY SOURCE INPUTS AND PRODUCTION</b>					
6. Enter the sum of ITEMS 1, 2a, 3, 4, & 5.	Quantity: _____				

SECTION II - QUANTITIES OF ENERGY SOURCES (continued)

o INSTRUCTIONS FOR SECTION II, PAGE 2:	COPY FROM SECTION I				
	ENERGY SOURCE ONE	ENERGY SOURCE TWO	ENERGY SOURCE THREE	ENERGY SOURCE FOUR	ENERGY SOURCE FIVE
a. Transfer the energy source code number, energy source name, and units used for reporting from Section II, page 1 to the corresponding columns on this page, and continue with question 7 below.	Code Number: _____ Name: _____ Units used for reporting: _____	Code Number: _____ Name: _____ Units used for reporting: _____	Code Number: _____ Name: _____ Units used for reporting: _____	Code Number: _____ Name: _____ Units used for reporting: _____	Code Number: _____ Name: _____ Units used for reporting: _____
b. If more than 5 columns are needed, use extra sheets.					
c. Enter a quantity of zero wherever a question does not apply to a given energy source.					
d. If recorded values are not available, carefully prepared estimates may be used.					
<b>o ON SITE USE OF FEEDSTOCKS</b>					
7. During 1985, how much of this energy source was used onsite as a feedstock, raw material, ingredient, or additive to a product (e.g., coal for coking, petrochemical feedstocks)?	Quantity: _____				
<b>o OFFSITE USES</b>					
8. During 1985, how much of this energy source was used offsite for establishment-related purposes (e.g., delivery trucks, ships, airplanes, etc., which were fueled onsite but used offsite)?	Quantity: _____				
<b>o SUM OF ENERGY SOURCES ADJUSTED FOR FEEDSTOCK AND OFFSITE USES</b>					
9. Subtract ITEM 7 and ITEM 8 from ITEM 6. Enter amount.	Quantity: _____				
<b>o DISPOSITION OF ENERGY SOURCES (Questions 10 through 12)</b>					
10. During 1985, how much of this energy source was TRANSFERRED OR SOLD to other establishments? Include ALL establishments, whether or not they are part of the same corporation as this establishment.	Quantity: _____				
11. How much of this energy source was in the INVENTORY of this establishment at the end of calendar year 1985?	Quantity: _____				
<b>o TOTAL SALES, TRANSFERS, AND END OF YEAR INVENTORY</b>					
12. Enter the sum of ITEMS 10 and 11.	Quantity: _____				
<b>o TOTAL CONSUMPTION OF PRIMARY ENERGY SOURCES</b>					
13. Subtract ITEM 12 from ITEM 9. Enter Amount.	Quantity: _____				
<b>o TOTAL STORAGE CAPACITY</b>					
14. What was the TOTAL STORAGE CAPACITY for this energy source at this establishment at the end of calendar year 1985?	Quantity: _____				
<b>o ENERGY SOURCES OTHER THAN ELECTRICITY USED AS A BOILER FUEL</b>					
15. During 1985, how much of this energy source was used as a boiler fuel?	Quantity: _____				

SECTION III - NON-PRIMARY ENERGY SOURCES

Electricity

- 1a. During 1985, how much electricity was purchased from utilities or other firms, and delivered to the establishment? Quantity: \_\_\_\_\_ Megawatthours
- 1b. What was the total cost of this purchased electricity? \$ \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_
2. During 1985, how much electricity was transferred from outside establishments and delivered to the establishment? Do not include the purchases recorded in ITEM 1a. Quantity: \_\_\_\_\_ Megawatthours
3. During 1985, how much electricity was generated onsite by cogeneration? Quantity: \_\_\_\_\_ Megawatthours
4. During 1985, how much electricity was generated onsite from renewable sources?
  - a. from Solar Quantity: \_\_\_\_\_ Megawatthours
  - b. from Wind Quantity: \_\_\_\_\_ Megawatthours
  - c. from other renewable sources Quantity: \_\_\_\_\_ Megawatthours
5. During 1985, how much electricity was generated onsite by conventional generation and other processes besides cogeneration or renewable sources? Quantity: \_\_\_\_\_ Megawatthours
6. During 1985, how much electricity was sold to utilities? Include both sales and transfers for credit. Quantity: \_\_\_\_\_ Megawatthours
7. During 1985, how much electricity was transferred to other establishments? Do not include amounts reported in ITEM 6. Quantity: \_\_\_\_\_ Megawatthours

Steam

- 1a. During 1985, how much steam was purchased from utilities, dealers, or other firms, and delivered to the establishment? Quantity: \_\_\_\_\_ Million Btus
- 1b. What was the total cost of this purchased steam? \$ \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_
2. During 1985, how much steam was transferred from outside establishments and delivered to the establishment? Do not include the purchases recorded in ITEM 1a. Quantity: \_\_\_\_\_ Million Btus
3. During 1985, how much steam was generated onsite from renewable sources?
  - a. from Solar Quantity: \_\_\_\_\_ Million Btus
  - b. from other renewable sources Quantity: \_\_\_\_\_ Million Btus
4. During 1985, how much steam was sold or transferred to another establishment? Quantity: \_\_\_\_\_ Million Btus

SECTION IV - SWITCHING CAPABILITY FROM COAL, HEAVY OIL, DISTILLATE, AND NATURAL GAS

The purpose of this section is to obtain information on the technical capability of an establishment to substitute alternate energy sources for coal, heavy oil, distillate, and natural gas consumed in 1985. Read the instructions concerning the definition of technical capability to switch energy sources before proceeding with this section. Answer the following questions for COAL, HEAVY OIL, DISTILLATE, and NATURAL GAS, if applicable to your establishment.

Energy source being switched from.	Sum of quantities from Section II, ITEM 13 for the energy sources specified below.	How much of the quantity in column <2> was technically CAPABLE of being switched to another energy source?	Check energy sources that replaced or could have replaced part of the amount reported in column <3>. Substitute fuels need not have actually been used in 1985.	Enter the amount of the energy source reported in column <3> that was technically CAPABLE of being switched to the alternate energy source listed in column <4>.	Of the amount shown in column <5>, how much could not have been switched using this alternative energy source, for legal, logistical, or other reasons not related to technical capability?	Why couldn't the amount in column <6> be switched? List codes from the table below. Circle the code of the most important reason.
<1>	<2>	<3>	<4>	<5>	<6>	<7>
<b>FUEL SWITCHING FROM COAL</b>	Enter the sum of anthracite, low and high sulfur bituminous, low and high sulfur subbituminous, and lignite. Quantity: _____	Quantity: _____	(to heavy oil) (to distillate) (to natural gas) (to other <specify>) (to other <specify>)			
<b>FUEL SWITCHING FROM HEAVY OIL</b>	Enter the sum of crude plus residual. Quantity: _____	Quantity: _____	(to coal) (to distillate) (to natural gas) (to other <specify>) (to other <specify>)			
<b>FUEL SWITCHING FROM DISTILLATE</b>	Enter the amount of distillate. Quantity: _____	Quantity: _____	(to coal) (to heavy oil) (to natural gas) (to other <specify>) (to other <specify>)			
<b>FUEL SWITCHING FROM NATURAL GAS</b>	Enter the amount of natural gas. Quantity: _____	Quantity: _____	(to coal) (to heavy oil) (to distillate) (to other <specify>) (to other <specify>)			

Reasons why switching was not feasible (for column <7> of the Energy Source Switching Table):

Code	Reason
1	Federal government environmental restriction.
2	State/Local government environmental restriction.
3	Binding contract in place for the energy source listed in column <1>.
4	Restrictions of the Powerplant and Industrial Fuel Use Act of 1978.
5	Other (specify): _____
6	_____
7	_____
8	_____
9	_____

SECTION V - CERTIFICATION

CERTIFICATION - This report is substantially accurate and has been prepared in accordance with instructions.						
Name of person to contact regarding this report			Telephone---	Area code	Number	Extension
Name of company			Address (Number and street, city, State, ZIP code)			
Period covered---	From: Mo.   Day   Year	To: Mo.   Day   Year	Signature of authorized person		Title	Date

# Final Version of Form EIA-846(F)

OMB No. 1905-0169; Approval Expires March 31, 1988

**FORM EIA-846(F)**  
(8-5-86)

U.S. DEPARTMENT OF COMMERCE  
BUREAU OF THE CENSUS  
ACTING AS COLLECTING AND COMPILING AGENT FOR  
UNITED STATES DEPARTMENT OF ENERGY  
ENERGY INFORMATION ADMINISTRATION

## 1985 MANUFACTURING ENERGY CONSUMPTION SURVEY

**PLEASE COMPLETE  
THIS FORM AND  
RETURN TO**

**BUREAU OF THE CENSUS**  
1201 East Tenth Street  
Jeffersonville, Indiana 47132

**DUE DATE: August 15, 1988**

If you cannot file by the due date, a time extension request should be sent to the above address; please include your 11-digit Census File Number (CFN).

**NOTICE** — Response to this inquiry is required by law (Federal Energy Administration Act of 1974, as amended, P.L. 93-275). By Section 9 of Title 13, U.S. Code, your report to the Census Bureau is confidential. It may be seen only by sworn Census Bureau employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

In correspondence pertaining to this report, please refer to this Census File Number (CFN).

**PLEASE RETURN THIS COPY**

Please correct errors in name, address, and ZIP Code. ENTER street and number if not shown.

**NOTE** — Please read the enclosed instructions before filling out this form. Complete each item. If you have any questions, call (301) 763-7066.

Section I — COMBUSTIBLE ENERGY SOURCES											
Combustible Energy Source  (1)	Census use only  561 (2)	Units Used for Reporting  (3)	Quantity Purchased by and Delivered to this Establishment in 1985		Total Expenditure, Including Delivery Charges, of the Quantity in Column 4 (5)			Total Quantity Produced On-site During 1985  564 (8)	Quantity Consumed Onsite in 1985:		Design Storage Capacity as of 12/31/85  567 (9)
			562	(4)	Mil. 563	Thou.	Dol.		As a Fuel  565 (7)	For all Nonfuel Purposes (EIA-810 Respondents See "Special Procedures")  566 (8)	
Residual fuel oil (No.'s 5 and 6, navy special, bunker C)	216	Barrels									
Distillate fuel oil (No.'s 1, 2, and 4 fuel oils and diesel)	224	Barrels									
Crude oil and lease condensate	208	Barrels									
Motor gasoline	232	Gallons									
LPG (Ethane, ethylene, propane, propylene, butane, butylene)	240	Gallons									
Natural gas	307	1,000 cu. ft.									
Anthracite	406	Short tons									
Bituminous and subbituminous coal	414	Short tons									
Lignite	422	Short tons									
Coal coke	430	Short tons									
Breeze	448	Short tons									
Blast furnace gas	604	Million Btu									
Coke oven gas	612	Million Btu									
Still gas	620	Million Btu									
Petroleum coke	703	Barrels									
Roundwood (i.e., wood cut specifically for use as a fuel)	802	Million Btu									
Wood chips, bark, and wood waste (50% moisture basis)	810	Million Btu									
Waste materials (wastepaper, packing materials, etc.)	729	Million Btu									
Pulping or black liquor	737	Million Btu									
Waste oils and tars	711	Million Btu									
Biomass	901	Million Btu									
Hydrogen	638	Million Btu									
Other combustible energy sources: (List separately)		Million Btu									
		Million Btu									
		Million Btu									
		Million Btu									
		Million Btu									
		Million Btu									
		Million Btu									
		Million Btu									

**FOR ESTABLISHMENTS THAT COMPLETE THE MONTHLY REFINERY REPORT, FORM EIA-810**

Enter the 10-digit EIA ID number for this establishment as entered on form EIA-810 →  571

Please continue on reverse side

**Section II -- NON-COMBUSTIBLE ENERGY SOURCES**

<b>Part 1 -- ELECTRICITY</b>			
1a. During 1985, how much electricity was purchased by this establishment from utilities or other companies, and delivered to this establishment site?	501	109	
	Kilowatt-hours		
	Mil.	Thou.	kWh
b. What was the total expenditure for purchased electricity?	502		
	Dollars		
	Mil.	Thou.	Dol.
2. During 1985, how much electricity was transferred from outside establishments and delivered to this establishment? Do not include the purchases recorded in item 1a.	504		
	Kilowatt-hours		
	Mil.	Thou.	kWh
3. During 1985, how much electricity was generated onsite by cogeneration?	505		
	506		
	507		
4. During 1985, how much electricity was generated onsite from solar power, wind power, hydropower, and geothermal sources?	508		
	509		
	510		

<b>Part 2 -- STEAM</b>			
1a. During 1985, how much steam was purchased by this establishment from utilities or other companies and delivered to this establishment site?	501	505	
	502		
	Million Btu		
b. What was the total expenditure for this purchased steam?	503		
	Dollars		
	Mil.	Thou.	Dol.
2. During 1985, how much steam was transferred from outside establishments and delivered to this establishment? Do not include the purchases recorded in item 1a.	504		
	Million Btu		
	505		
3. During 1985, how much steam was generated onsite from solar power and geothermal sources?	506		
	507		
	508		

**Section III -- COMMENTS** — Please use this space for any explanations that may be essential in understanding your reported data.

551

**Section IV -- CERTIFICATION** — This report is substantially accurate and has been prepared in accordance with instructions.

Name of person to contact regarding this report — Print or type	553	Telephone		Period covered by this report —>	FROM: Mo.	Day	Year	TO: Mo.	Day	Year
	552	Area code	Number		Extension					
Address — Number and street				Signature of authorized person						
City	State	ZIP Code	Title	Date						

FORM EA-348(7) (6-5-86)

## INSTRUCTIONS FOR FORM EIA-846(F) MANUFACTURING ENERGY CONSUMPTION SURVEY

OMB No. 1905-0169. Approval Expires March 31, 1989

### A. Who Is Responsible For Conducting The Manufacturing Energy Consumption Survey?

The Manufacturing Energy Consumption Survey (MECS) was designed, and is being conducted, by the Energy Information Administration (EIA) of the U.S. Department of Energy. The survey is being administered and compiled by the U.S. Bureau of the Census.

### B. What Is The Purpose Of This Survey?

The Manufacturing Energy Consumption Survey (MECS) will collect data on energy consumption and usage patterns for the manufacturing sector of the U.S. economy. The information obtained from the MECS will be used to publish aggregate statistics on the consumption of energy for fuel and nonfuel uses, and on some energy-related issues such as energy prices and electricity generation onsite.

The MECS is not a regulatory survey and will not be used for regulatory purposes.

### C. How Is My Privacy Protected?

The confidentiality of your response to this survey is protected by law (title 13, U.S. Code). Your response may be seen only by sworn Census employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

### D. Who Should Report?

This survey is mandatory under the Federal Energy Administration Act of 1974, P.L. 93-275. A report is required from each establishment selected for the survey. No substitutions are permitted. Failure to respond may result in criminal fines, civil penalties, and other sanctions as provided by law.

### E. When Is The Report Due?

The questionnaire should be returned no later than August 15, 1986. Please use the enclosed return envelope. If it has been misplaced, send the questionnaire to —

Bureau of the Census  
1201 East Tenth Street  
Jeffersonville, Indiana 47132

### F. How Is A Manufacturing Establishment Defined?

A manufacturing establishment is 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. The assembly of components of manufactured products is also considered manufacturing. Also included is the blending of materials such as lubricating oil, plastics, resins, or liquors.

### G. What Activities Should Be Included?

Include all activities conducted within the establishment, e.g., manufacturing, fabricating, processing and assembly; maintenance of plant and equipment; use of vehicles onsite; receiving, shipping, warehousing and storage; research; recordkeeping; health, safety, cafeteria, and other services.

Exclude use of vehicles offsite, even if refueling is done at the establishment.

If an establishment operates as a single economic unit, but produces several lines of products, the report should cover the activities of the entire facility.

### H. What Period Should The Report Cover?

Data should be reported for the calendar year 1985. If your records are maintained on a fiscal year basis which does not coincide with the calendar year, but which ends between November 1 and February 28 inclusive, fiscal year data may be substituted. If your fiscal year ends between March 1 and October 31 inclusive, reasonable estimates for calendar year 1985 data will be acceptable.

If the selected establishment was acquired or sold during 1985, the report data should cover the period of operation by your company only.

### I. May Estimates Be Provided Rather Than Actual Data?

Actual data should be provided when available and obtainable. In the event that such records are not maintained or are not readily available, reasonable estimates may be substituted.

## Section I — COMBUSTIBLE ENERGY SOURCES

### General Instructions

Energy sources used in manufacturing can be divided into two groups: combustible (capable of being burned), and noncombustible (such as electricity, steam, and hot water). The purpose of section I is to obtain data on 1985 fuel consumption, feedstock use, storage capacity, and related data for the combustible energy sources.

Complete section I for all energy sources that will have a nonzero entry in columns 7, 8, or 9. Please report using the units indicated. Btu should be reported as higher heating value.

### Special procedures for petroleum refining operations

Establishments that submit the monthly Refinery Report (Form EIA-810) to the EIA already provide some data that are requested by the MECS. In order to minimize duplication and burden, these establishments will not be required to complete certain portions of section I. Therefore, EIA-810 respondents should include an individual petroleum hydrocarbon as a separate energy source line item only if some of that product was burned as a fuel at your establishment in 1985. Do not report as separate line items those products that were exclusively input into the refining operation or sold. Any part of your establishment that is not covered by the EIA-810 (e.g., onsite petrochemical plants) is not covered by this special procedure. Report as separate line items any energy sources (e.g., petrochemical feedstocks) delivered from the refinery to the nonrefinery part of your establishment for processing.

### Specific Instructions

**Column 1** — Twenty two energy sources have been preprinted in column 1. If you consumed any additional energy sources onsite during 1985, please list them in the space provided in column 1.

**NOTE** — Include energy sources whose sole means of supply to this establishment in 1985 was as a byproduct provided that some or all of it was consumed as a fuel onsite during 1985.

**Column 3** — Please report all quantities in the units listed in column 3.

The following conversion factors may be useful:  
1 barrel = 42 gallons  
1 gallon of LPG = 4.5 pounds of LPG  
1,000 cubic feet of natural gas = 10.3 therms

**Column 4** — For each listed energy source, enter the quantity that was PURCHASED AND PAID FOR BY THE ESTABLISHMENT and delivered to this establishment site. Include quantities that were delivered in 1985, regardless of when payment was made. Exclude any quantities that were delivered from another establishment in your company even if these quantities were repurchased from them by your establishment. Also, exclude any quantities that were purchased and paid for by a central purchasing entity separate from this establishment. In addition, exclude any quantities for which payment was made in-kind.

**Column 5** — Enter the TOTAL EXPENDITURE for the purchased quantities reported in column 3. Include all expenditures regardless of when payment actually was made.

**Column 6** — Enter the total quantities that were produced onsite as —

- A BYPRODUCT of your establishment's manufacturing activities (e.g., coke, hydrogen, still gas, coke oven gas, wood chips, black liquor);
- OUTPUT FROM CAPTIVE (ONSITE) MINES AND WELLS in 1985. (e.g., natural gas, oil, coal);
- WASTE (e.g., wood scraps, packing materials, waste paper and cardboard, waste oil).

**Column 7** — Enter the QUANTITY THAT WAS CONSUMED AS A FUEL on this site for the production of heat, steam, power, or generated electricity in 1985.

**Column 8** — Enter the QUANTITY THAT WAS CONSUMED FOR ALL NONFUEL PURPOSES on this establishment site in 1985.

Include all quantities consumed as feedstocks (e.g., coal used to produce coke, crude oil used to produce petroleum products), raw materials, additives, or ingredients for products manufactured by this establishment.

**NOTE FOR ESTABLISHMENTS THAT SUBMIT THE MONTHLY REFINERY REPORT (EIA-810) TO THE EIA** — Report consumption for nonfuel purposes for ONLY those parts of your establishment that are not covered by the EIA-810 (e.g., onsite petrochemical plants). If this establishment is solely a refinery, enter the letter "R" in the spaces provided in column 8. Data for the refinery portion will be obtained from the EIA-810.

**Column 9** — Enter the TOTAL DESIGN STORAGE CAPACITY ONSITE as of December 31, 1985. Include any capacity that is dedicated or leased for storage of energy sources owned by other establishments. Report the shell capacity, i.e., the design capacity of storage tanks.

**EIA-810 ID NUMBER (At bottom of section I)** — Establishments that submit the Monthly Refinery Report (EIA-810) to the EIA are required to enter their 10-digit identification number. This number will allow the use of existing feedstock data to complete column 8 for these establishments.

## Section II — NONCOMBUSTIBLE ENERGY SOURCES

### General Instructions

The purpose of section II is to collect 1985 data for noncombustible energy sources, in particular electricity and steam. Part 1 of section II collects data that will provide important information on the components of electricity production, and permit an estimate to be made of the total consumption of electricity at your establishment. Part 2 of section II collects data on the additional contribution that steam makes to the total consumption of energy at your establishment through net transfers and steam generated onsite by renewable energy sources. Report other noncombustible energy sources, such as hot water, on a photocopy of part 2 of this section.

**Specific Instructions — Part 1 — Electricity**

**Item 1a** — Enter the quantity of electricity that was PURCHASED AND PAID FOR BY THIS ESTABLISHMENT and delivered to this establishment site. Include quantities that were delivered in 1985, regardless of when payment was made. Exclude any quantities that were delivered from another establishment in your company even if these quantities were repurchased from them by your establishment. Also, exclude any quantities that were purchased and paid for by a central purchasing entity separate from this establishment. In addition, exclude any quantities for which payment was made in-kind.

**Item 1b** — Enter the TOTAL EXPENDITURE for the purchased quantities reported in item 1a. Include all expenditures regardless of when payment actually was made.

**Item 2** — Enter the TOTAL QUANTITY OF ALL OTHER INPUTS OF ELECTRICITY FROM OUTSIDE THIS ESTABLISHMENT that were not reported in item 1a.

**Item 3** — For purposes of this item, electrical cogeneration is defined as the production of electric energy and another form of useful energy (such as heat or steam) through the sequential use of energy. Enter the QUANTITY OF ELECTRICITY COGENERATED from all energy sources, including renewable sources.

**Item 4** — Enter the TOTAL QUANTITY OF ELECTRICITY GENERATED DIRECTLY FROM SOLAR OR WIND POWER, GEOTHERMAL SOURCES, OR HYDROPOWER. Any electricity produced as part of a cogeneration process should be excluded (e.g., electricity generated from geothermal steam which is then itself used, should be included in item 3.)

**Item 5** — Enter the TOTAL QUANTITY OF ALL ELECTRICITY GENERATED BY DIESEL GENERATORS AND ALL OTHER MEANS NOT INCLUDED IN ITEMS 3 OR 4 ABOVE.

**Item 6** — For purposes of this item, utilities are companies that are engaged primarily in producing and/or delivering electricity.

**Item 7** — Report all dispositions of electricity not covered in item 6.

**Specific Instructions — Part 2 — Steam**

**NOTE** — If you keep your steam records in pounds rather than Btu's, and do not have conversion factors available, use a factor of 1,000 Btu per pound of steam.

**Item 1a** — Enter the quantity of steam that was PURCHASED AND PAID FOR BY THIS ESTABLISHMENT and delivered to this establishment site. Include quantities that were delivered in 1985, regardless of when payment was made. Exclude any quantities that were delivered from another establishment in your company even if these quantities were repurchased from them by your establishment. Also, exclude any quantities that were purchased and paid for by a central purchasing entity separate from this establishment. In addition, exclude any quantities for which payment was made in-kind.

**Item 1b** — Enter the TOTAL EXPENDITURE for the purchased quantities reported in item 1a. Include all expenditures regardless of when payment actually was made.

**Item 2** — Report all QUANTITIES OF STEAM BROUGHT IN FROM OUTSIDE THIS ESTABLISHMENT other than that reported in item 1a.

**Item 3** — Enter the TOTAL QUANTITY OF STEAM GENERATED ONSITE FROM SOLAR POWER AND GEOTHERMAL SOURCES.

**Item 4** — Enter the TOTAL QUANTITY OF STEAM SOLD OR TRANSFERRED to other establishments.

**Section III — COMMENTS** — Please use this space for any explanations that may be essential in understanding your reported data.

**Section IV — CERTIFICATION — Period covered by this report** — Enter the month and day of the beginning and the end of period your report covers. If a calendar year report: "From January 1 to December 31, 1985." If a fiscal year, specify which (such as "From December 1, 1984, to November 30, 1985."). If a part-year report is submitted because the establishment was not in operation or under your company's control for the entire year, specify the actual period covered: For example, "January 1, 1985 to August 15, 1985," or "June 1, 1985 to December 31, 1985."

# Final Version of Form EIA-846(S)

OMB No. 1905-0189; Approval Expires March 31, 1988

FORM **EIA-846(S)**  
(11-4-85)



U.S. DEPARTMENT OF COMMERCE  
BUREAU OF THE CENSUS  
ACTING AS COLLECTING AND COMPILING AGENT FOR  
UNITED STATES DEPARTMENT OF ENERGY  
ENERGY INFORMATION ADMINISTRATION



## 1985 MANUFACTURING ENERGY CONSUMPTION SURVEY

### PART II - FUEL SWITCHING CAPABILITY

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**BUREAU OF THE CENSUS**  
1201 East Tenth Street  
Jeffersonville, IN 47132

**DUE DATE: December 31, 1985**

If you cannot file by the due date, a time extension request should be sent to the above address. Please include your 11-digit Census File Number (CFN). Call (301) 763-7066 if you require any assistance with this form.

**NOTICE** - Response to this inquiry is required by law (Federal Energy Administration Act of 1974, as amended, P.L. 93-275). By Section 9 of Title 13, U.S. Code, your report to the Census Bureau is confidential. It may be seen only by sworn Census Bureau employees and may be used only for statistical purposes. The law also provides that copies retained in your files are immune from legal process.

In correspondence pertaining to this report refer to this Census File Number (First 11 digits of top line)

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Please correct errors in name, address, and ZIP Code. ENTER street and number if not shown.

**NOTE - Please read the enclosed instructions before filling out this form. See reverse side for examples.**

**CONTACT** - This survey is a supplement to Form EIA-846(F) "1985 Manufacturing Energy Consumption Survey." The person given as this establishment's contact was -

Name			
Telephone	Area code	Number	Extension

FUEL SWITCHING		FUEL TYPE FROM THE EIA-846(F) 1985 MANUFACTURING ENERGY CONSUMPTION SURVEY				
(a) Line No.	(b) Item	(c) Purchased electricity	(d) Natural gas	(e) Distillate fuel oil (No. 1, 2, and 4 fuel oils and diesel)	(f) Residual fuel oil (No. 5 and 6, navy special, and bunker C)	(g) Coal and coke (Anthracite, bituminous and subbituminous coal, lignite, coal cokes, and breeze)
1	1985 fuel consumption data as reported on the EIA-846(F) "1985 Manufacturing Energy Consumption Survey."	581 109 582 1,000 kWh	581 307 582 1,000 cu. ft.	581 224 582 Barrels	581 218 582 Barrels	581 455 582 Short tons
<i>Answer lines 2 through 11 as appropriate. Do not consider differences in fuel prices when estimating amounts.</i>						
2	Enter the amount of the quantity on line 1 that could not have been replaced within 30 days by another fuel in 1985.	583 1,000 kWh	583 1,000 cu. ft.	583 Barrels	583 Barrels	583 Short tons
3	Subtract line 2 from line 1 and enter the results. This represents the substitutable portion of line 1.	584 1,000 kWh	584 1,000 cu. ft.	584 Barrels	584 Barrels	584 Short tons
4	Report the maximum amount of the quantity shown on line 3 that could have been switched to each of the replacement fuels listed to the right. Do not report switching capability that would have required more than 30 days to implement.	Purchased electricity	585 1,000 cu. ft.	585 Barrels	585 Barrels	585 Short tons
5		Natural gas	586 1,000 kWh	586 Barrels	586 Barrels	586 Short tons
6		Distillate fuel oil	587 1,000 kWh	587 1,000 cu. ft.	587 Barrels	587 Short tons
7		Residual fuel oil	588 1,000 kWh	588 1,000 cu. ft.	588 Barrels	588 Short tons
8		Coal and coke	589 1,000 kWh	589 1,000 cu. ft.	589 Barrels	589 Barrels
9		LPG	590 1,000 kWh	590 1,000 cu. ft.	590 Barrels	590 Barrels
10	Do not consider differences in fuel prices when estimating amounts. Other - Specify	591 1,000 kWh	591 1,000 cu. ft.	591 Barrels	591 Barrels	591 Short tons
<b>NOTE</b> - The sum of lines 4 through 10 should be at least as large as the amount on line 3, and may be larger.						
11	Minimum lead time required to convert to your primary replacement fuel under the conditions described in the general instructions. If two or more replacement fuels have equivalent substitutability, select the one with the shortest lead time.	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days	1 <input type="checkbox"/> Less than 1 day 2 <input type="checkbox"/> 1 day to 1 week 3 <input type="checkbox"/> More than 1 week but within 30 days

**COMMENTS** - Please use this space or attach a separate sheet for any explanations that may be essential in understanding your reported data.

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**CERTIFICATION** - The data in this report are approximations, prepared in accordance with instructions.

Name of person to contact regarding this report - Print or type	543	Telephone			FROM: Mo.	Day	Year	TO: Mo.	Day	Year
	542	Area code	Number	Extension	Period covered by this report →					
Address - Number and street					Signature of authorized person					
City	State	ZIP Code		Title	Date					

**COMPLETION TIME** - Enter the estimated number of hours spent completing this form. (Include time required to read the instructions, assemble any necessary information, and enter the data.)

544 Hours

## INSTRUCTIONS FOR FORM EIA-846(S) 1985 MANUFACTURING ENERGY CONSUMPTION SURVEY PART II — FUEL SWITCHING CAPABILITY

### GENERAL INSTRUCTIONS

**PURPOSE** — This survey is a supplement to the EIA-846(F) 1985 Manufacturing Energy Consumption Survey. It is intended to measure the short-term (within 30 days) capability of your establishment to have used substitute fuels in place of those actually consumed in 1985.

- For purposes of this survey, capability to use substitute fuels means that this establishment's combustors (e.g., boilers, furnaces, ovens, blast furnaces) had the machinery or equipment in place (or available for installation) in 1985 so that fuel substitutions could actually have been introduced within 30 days, without extensive modifications.
- This survey is designed to collect information on your establishment's fuel switching capability in 1985. Capability is not determined by the relative prices of fuels; it depends only on the characteristics of your equipment and certain legal constraints. Fuel switching capability sets limits on the extent to which you could switch to a substitute fuel if you wanted to or needed to. It has **nothing** to do with whether you **would** switch if you could. **THEREFORE, RELATIVE PRICES OF FUELS ARE NOT RELATED TO FUEL SWITCHING CAPABILITY AND SHOULD BE IGNORED WHEN COMPLETING THIS QUESTIONNAIRE.**
- Base your approximations of fuel switching capability on your best recollection of the availability of substitute fuels and the physical condition of your equipment during 1985.
- Include switching capability that resulted from the use of redundant and/or standby combustors, and from combustors that were already equipped to fire alternative fuels.
- We recognize that records of fuel switching capability are not regularly maintained. Accordingly, reasonable approximations of fuel switching capability are acceptable for this survey. These approximations should be based on the judgement of a person knowledgeable about the fuel switching capability and operations of your establishment. They are not expected to be formal engineering estimates based on a day-by-day analysis of the operating levels of individual combustors and interactions between them. However, please try to respond as realistically as possible, given your actual operations in 1985.

### SPECIFIC INSTRUCTIONS

#### FUEL SWITCHING

**Line 1** — The fuel consumption numbers reported on form EIA-846(F) have been preprinted on line 1 to assist you in completing this form. If any of these numbers are incorrect please line through the incorrect number and enter the correct figure above it.

**Line 2** — Report the amount of the quantity preprinted in line 1 that could NOT have been replaced within 30 days by another fuel in 1985, even given a severe curtailment. Amounts may be nonswitchable due to limitations such as the following:

- The characteristics of your physical plant (e.g., single-fired combustors or the absence of redundant and/or standby combustors), or the requirements of your manufacturing process, limit switching.
- Binding fuel contracts are in place that limit your ability to switch fuels.
- Environmental regulations limit the amounts of potential replacement fuels that could be burned.

**Line 3** — Subtract line 2 from line 1 and enter the results. These values represent the quantities of fuels actually burned that COULD HAVE BEEN REPLACED within 30 days by another fuel in 1985.

**Lines 4 through 10** — Report the maximum amount of the quantity shown on line 3 that could have been replaced within 30 days by each of the fuels on lines 4 through 10, UNDER THE CONSTRAINTS LISTED IN THE INSTRUCTIONS FOR LINE 2.

**Line 11** — Mark the minimum lead time required to convert to the primary replacement fuel. If two or more replacement fuels have equivalent substitutability, select the one with the shortest lead time.

**Definitions:** kWh — Kilowatthour  
LPG — ethane, ethylene, propane, propylene,  
butane, isobutane, butylene, and mixtures  
Barrels — 42 gallons  
mcf — 1,000 cubic feet (10 ccf)

**BTU conversion factors:** If you need Btu conversions to approximate fuel switching capability, the values in the following table should be used. The resulting fuel switching approximations are to be reported in the units specified in the questionnaire, however.

Electricity	1 kWh = 3,412 Btu
Natural gas	1 cubic foot = 1,000 Btu
Distillate fuel oil	1 barrel = 5.8 million Btu
Residual fuel oil	1 barrel = 6.3 million Btu
Coal and coke	1 short ton = 23 million Btu

#### COMMENTS

Please provide any explanations that may be essential in understanding your reported data. Attach a separate sheet if necessary.

#### CERTIFICATION

**Period covered by this report** — Enter the month and day of the beginning and the end of the period your report covers. If a calendar year report: "From January 1 to December 31, 1985," if a fiscal year, specify which (such as "From December 1, 1984, to November 30, 1985). If a part-year report is submitted because the establishment was not in operation or under your company's control for the entire year, specify the actual period covered: For example, "January 1, 1985 to August 15, 1985," or "June 1, 1985 to December 31, 1985."

If you need further information to help in interpreting these instructions, see reverse side of report form for examples of fuel switching situations.

Call (301) 763-7066 if you require any assistance in completing the form.

## EXAMPLES OF FUEL SWITCHING SITUATIONS

### Example 1: Equipment Capability

The XYZ Manufacturing Plant consumed three energy sources as fuel in 1985: purchased electricity, natural gas, and residual fuel oil. The only use of natural gas and residual fuel oil was to fire, at an average 75 percent operating capacity, a gas/oil capable boiler where the switch in operating fuel could be made in a few hours. This boiler consumed 15 million cubic feet of natural gas (equivalent to 15 billion Btu) and 1,600 barrels of residual oil (equivalent to 10 billion Btu). Of the 6 million kWh of electricity, 5.3 million kWh was used for lighting and the running of machinery. The remaining 0.7 million kWh (equivalent to 2.5 billion Btu) was consumed in an electric boiler. This boiler was operated at an average 33 percent of its operating capacity, given the ongoing plant operation in 1985. However, the only times the electric boiler was actually in operation were during scattered peak periods when it supplemented the other boiler, and during times when the gas/oil boiler was down for maintenance or repairs. Altogether, the two boilers consumed 27.5 billion Btu of fuel during 1985, providing steam to the plant through a single piping system.

None of the 6 million kWh of electricity consumed is switchable because, (a) there were no alternate fuels for lighting and running machinery, and (b) the gas/oil boiler, even though it had unused capacity during 1985, could not have been "turned up" to produce the steam generated by the electric boiler at the times when the electric boiler was operating.

The 15 million cubic feet of natural gas that were consumed in the gas/oil boiler could have been totally replaced by residual fuel oil. The other substitution possibility involves burning one-third less natural gas in the gas/oil boiler, and running the electric boiler at full operating capacity. Under both of these alternatives, total fuel consumption would have remained at 27.5 billion Btu.

The fuel switching capability of the residual fuel oil is derived in the same manner. All of the residual oil could have been replaced by natural gas and half (800 barrels) could have been replaced by purchased electricity.

### Example 2: Practical Limitations

Assume the same equipment configuration and fuel consumption as Example 1, with the following additional considerations:

- (1) The XYZ plant has entered into a binding contract to purchase 600 barrels of residual fuel oil at a negotiated price;
- (2) the gas/oil boiler is derated by 10 percent when oil is burned in place of natural gas;
- (3) 1 million of the 15 million cubic feet of natural gas was burned during a 2 week period when oil supplies were interrupted because of a strike by delivery personnel;
- (4) the price for additional electricity above the 6 million kWh level is 3 cents per kWh higher than the price for the first 6 million.

As in Example 1, none of the 6 million kWh of electricity is switchable. The residual fuel oil contract prevents 600 barrels from being switched; however, the remaining 1,000 barrels is switchable. Eight hundred barrels can be replaced by increased use of the electric boiler as before. Any increased use of electricity beyond the 6 million kWh may have been economically inadvisable because of the increased price, but this is not a constraint to switching capability. All 1,000 switchable barrels can be replaced with natural gas.

Finally, the capability of switching from natural gas to electricity is the same as in Example 1. However, the capability to switch from gas to oil in the gas/oil boiler is reduced from 15 million to 14 million cubic feet to account for the period when residual fuel oil deliveries were interrupted. All 14 million cubic feet can be switched by substituting residual fuel oil and running the boiler at a higher percentage of capacity to counteract the derating of the boiler.

### Example 3: Exclusions to Fuel-Switching Capability

The ABC Manufacturing Plant consumed four energy sources during 1985: purchased electricity, natural gas, coal, and waste packaging materials. The 6 million kWh of electricity consumption were used only for lighting and the running of machinery. All natural gas consumption (2 million cubic feet) was in a series of paint drying ovens, which were also equipped to burn distillate fuel oil. However, distillate fuel oil was not used to fire the ovens because it could change the tint of the pigments in the paint, rendering the products unsaleable. Two boilers supplied the plant with heat and process steam through a single piping system. One boiler was a "garbage gulper," which was fired intermittently throughout the year as sufficient waste packaging materials became available. The total energy consumption of this boiler during 1985 was 5 billion Btu. The other boiler was capable of burning either coal or residual fuel oil and could be switched from one fuel to the other in three days. However, the only input to this boiler during 1985 was 5,000 tons of coal. For economic reasons, no residual fuel oil was burned.

None of the 6 million kWh of electricity consumption is switchable because there were no alternate fuels for lighting and the running of machinery. Even though distillate fuel oil could have been substituted for natural gas in the drying ovens, this would not be reported as switching capability because of the resulting changes in tint (i.e., consistent color is a requirement of the manufacturing process). Thus, none of the natural gas consumption is switchable.

The consumption of waste packaging materials could have been replaced by increasing the output of the coal/residual fuel oil boiler (if that boiler had unused capacity). However, we are not interested in this capability, and there is no place in the fuel switching table to record it.

Under the equipment configuration and plant operations as described at the beginning of this example, all of the coal consumption could have been replaced by residual fuel oil in the coal/oil boiler. On the other hand, none of the coal could have been replaced by waste packaging materials, because the "garbage gulper" was being used to the maximum possible extent, given the plant operations during 1985. However, the definition of switching capability does allow a respondent some latitude in determining switching capability in these circumstances. This latitude is based upon the respondent's understanding of the availability of alternate fuels and the condition of energy-using equipment during 1985. If the respondent for the ABC Manufacturing Plant knew that residual fuel oil was not available to the plant during 1985, switching capability from coal to residual fuel oil should be recorded as zero, regardless of the capability of the equipment to accept residual fuel oil. Conversely, fuel switching from coal to waste materials could be nonzero if the respondent knew of additional supplies of waste that could have been hauled in and used to fuel the "garbage gulper" in an emergency.

## Appendix D

### **Forms and Specifications Used During the Editing Process of MECS**

## Appendix D

# Forms and Specifications Used During the Editing Process of MECS

- 1) Edit Specifications for the 1985 Manufacturing Energy Consumption Survey. (Technical Notes #13 and #22)
- 2) Specifications for Edits Between the 1985 Manufacturing Energy Consumption Survey and the 1984 Annual Survey of Manufactures. (Technical Note #14)
- 3) Edit Specifications for MECS Part II - Fuel Switching Survey. (Technical Note #15)

**Technical Note #13  
February 6, 1987  
(Revised January 13, 1988)**

**Edit Specifications for the 1985  
Manufacturing Energy Consumption Survey**

Jean Paananen

The following edit specifications apply to the 1985 Manufacturing Energy Consumption Survey (MECS). Part I of the specifications provides definitions and key codes for variables from the MECS and the Annual Survey of Manufactures (ASM) which are used in the edits. Part II tests the unit cost of energy sources and reasonableness.

Part I - Definitions and key codes.

MECS Section I Key Code      562 Quantity purchased by energy source  
   563 Expenditure by energy source  
   564 Quantity produced onsite by energy source  
   565 Quantity consumed onsite as a fuel by energy source  
   566 Quantity consumed onsite for nonfuel purposes by energy source  
   567 Design storage capacity by energy source

MECS Section II Part I - Electricity

Key Code      562 Quantity purchased  
   563 Expenditure  
   564 Quantity transferred in  
   565 Quantity generated onsite by cogeneration  
   566 Quantity generated by renewables  
   567 Quantity generated by other processes  
   568 Quantity sold  
   569 Quantity transferred out

MECS Section II Part II - Steam

Key Code      562 Quantity purchased  
   563 Expenditure  
   564 Quantity transferred in  
   565 Quantity generated onsite from renewables  
   566 Quantity sold/transferred out

ASM                      Key Code      320 Plant hours worked by production workers  
   330 1982 value of shipments

BFCON                  Total Btu of fuel consumed.  
Sum Section I (Key Code 565 X conversion factor  
by fuel code) + Section II, Part I ((Key Codes  
562 + 564 + 566 - 568 - 569) X 3412) +  
Section II, Part II (Key Codes 562 + 564  
+ 565 - 566)

BMOS                  Btu equivalent of MECS measure of size  
REGN                  Census region (transferred from ASM)  
SIC2                   2-digit SIC (transferred from ASM)  
SIC4                   4-digit SIC (transferred from ASM)

Conversion factors by fuel code

Fuel code	216	-	6.287	million Btu per barrel
	224	-	5.825	million Btu per barrel
	240	-	3.603	million Btu per barrel
	307	-	1.032	million Btu per 1000 cubic feet
	406	-	25.01	million Btu per short ton
	414	-	22.76	million Btu per short ton
	422	-	22.76	million Btu per short ton
	430	-	24.8	million Btu per short ton
	448	-	19.0	million Btu per short ton
Section II Part I -	3412			Btu per kwh

Part II - Unit price and reasonableness.

1) Unit cost of purchased fuels.

MECS Sections I and II Key Codes 563/Key Codes 562

Price ranges to use in edits of energy source prices are listed below. Multiply the unit price for each energy source by the first factor (1 in all cases), and test against the given range. If the price is outside the range, flag with ''' and multiply by the second factor. If the calculated price now falls within the stated range flag with '''. For all edits with a flag of ''', change the amounts in MECS Sections I and II Key Codes 562 and in Section I Key Codes 565, 566, and 567 to the result obtained when the reported figure is divided by the second multiplier. Flag the new amounts with the double '''' flag. Transfer to the output data set those responses flagged ''' or ''', including the calculated unit price and Key Code 562, 565, 566, and 567 amounts. Include a histogram of unit prices for each energy source in the output data set after Edit 1 is completed and any changes made.

Fuel Type	Price Range (\$/unit)		Multiplier Code
	Lower	Upper	
216 Residual	20	60	1, 42
224 Distillate	20	60	1, 42
240 LPG	0.50	1.5	1, 0.222
307 Natural gas	2.50	7.5	1, 10.3
Electricity	0.02	0.16	1, 1EE-3

The next edits identify relationships between variables for each establishment. Any response which does not meet the relationship specified goes into the failed edit output data set. Perform Edit 3 on all SIC codes *except* 24, 26, 2869 and 3312. For those SIC codes, decrease the lower bound to 0.2 and perform Edit 3. Flag with the number of each edit any MECS response that does not have the energy measure of size, given in Btu, that falls within the specified range for that SIC code. Include the figure calculated in Edit 3 in the output data set if the edit fails. A histogram of responses for each edit is included in the output data set.

2) Btu equivalent of all combustible fuels consumed should be greater than the Btu equivalent of electricity generated onsite.

Sum of Section I (Key Code 565 X conversion factor by fuel code) should be greater than Section II, Part I Key Codes (565 + 567) X 3412.

3)  $0.5 \leq R \leq 2.0$

where R equals:

$$\text{BMOS} / [\text{sum of MECS Section I} (\min(\text{Key Code 562}, \text{Key Code 565})) + \text{MECS Section II, Part I} ((\text{Key Codes 562} + \text{564} + \text{566} - \text{568} - \text{569}) \times 3412) + \text{Part II} (\text{Key Codes 562} + \text{564} + \text{565} - \text{566})].$$

For each fuel code in Section I determine whether Key Code 562 or Key Code 565 contains the smaller value. Multiply the smaller figure by the conversion factor and sum. Use in Edit 3 along with the computed values for Section II, Parts I and II.

**MECS Technical Note #14**  
**March 30, 1987**

**Specifications for Edits Between the 1985 Manufacturing Energy  
Consumption Survey and the 1984 Annual Survey of Manufactures**

Jean Paananen

The following edit specifications apply to the 1985 Manufacturing Energy Consumption Survey (MECS) and the 1984 Annual Survey of Manufactures (ASM). Part I of the specifications provides definitions and key codes for variables from the ASM and the MECS which are used in the edits. Part II identifies edits of quantity, cost, and consistency. Part III identifies edits of reasonableness. 1984 ASM costs in Key Codes 321, 323, 324, and 330 are changed to 1985 dollars by multiplying by 1.036.

**Part I - Definitions and key codes**

**ASM Key Codes**

327	Quantity of purchased electricity
328	Quantity of electricity generated (gross generation less generating station use)
329	Quantity of electricity sold or transferred to other establishments
CMU	Cost of materials, parts, components, containers, etc., used Key Code 321 times 1.036
CFC	Cost of fuels consumed for heat or power Key Code 323 times 1.036
CPE	Cost of purchased electricity Key Code 324 times 1.036
VOS	1984 Value of shipments Key Code 330 times 1.036

**MECS Key Codes Section I Combustible Energy**

562	Quantity of combustible energy purchased, by energy source
563	Expenditure for combustible energy by energy source
565	Quantity of combustible energy consumed onsite as a fuel by energy source
CCEF	Cost of combustible energy consumed as a fuel, Section I Key Codes (563/562) X 565

**MECS Key Codes Section II Part I Electricity**

562	Quantity purchased
563	Expenditure
ECTO	Quantity of electricity sold or transferred out, Section II Part I Key Codes 568 + 569
QEGO	Quantity of electricity generated onsite, Section II Part I Key Codes 565 + 566 + 567

**Part II - Edits**

Match and merge ASM responses to MECS responses by Census File Number. ASM responses are on the left side of each equation with MECS responses on the right. If the ASM response has been imputed, flag the edit and do not compare the MECS response to the imputed ASM response.

For edits one through four, if the ASM and MECS responses differ by more than 5 percent, flag the edit with the number of the failed edit. If the ASM response in edit five is less than half of the MECS response, the edit fails. Flag each failed edit with the edit number(s) and transfer to an output data set of failed edits. Include the Census File Number, SIC code, company name, flag number(s) and the ASM and MECS figures for each failed edit. Include in the output data set a histogram of responses for each edit.

- 1) Cost of combustible energy consumed as a fuel.  $ASM\ CFC = MECS\ Section\ I\ CCEF$
- 2) Cost of purchased electricity.  $ASM\ CPE = MECS\ Section\ II,\ Part\ I\ Key\ Code\ 563$
- 3) Quantity of electricity purchased.  $Key\ Code\ 327 = MECS\ Section\ II,\ Part\ I\ Key\ Code\ 562$

- 4) Quantity of electricity sold or transferred out.  
Key Code 329 = MECS Section II Part I ECTO
- 5) Quantity of electricity generated onsite  
Key Code 328  $\geq$  .5 MECS Section II, Part I QEGO  
Key Code 328  $\leq$  2 MECS Section II, Part I QEGO

**Part III - Reasonableness**

For the final edits, group MECS responses by SIC codes into the nine categories as shown:

Category 1	SIC codes	20,22,24,26
2		21
3		23,25,27,31,38,39
4		28,30
5		29
6		32
7		33 (excluding 3334)
8		3334
9		34,35,36,37

Subdivide each category into quartiles based on the measure of size (MOS) of each respondent. Perform the following edits on each member within the 36 cells. Calculate the mean, variance and standard error for the MECS responses by cell. Flag any response two or more standard errors from the cell mean with the number of whatever edit(s) failed. Transfer all flagged edits to the output data set of failed edits. Include for all failed edits the Census File Number, SIC code, company name, flag number(s) and MECS responses of the failed edit. Include the standard error of the failed edit and the number of standard deviations the failed response differs from the cell mean, as well as a histogram of responses by quartile.

- 6) Cost of combustible energy consumed as a fuel divided by the cost of materials.  
MECS Section 1 CEF/ASM/ CMU
- 7) Cost of combustible energy consumed as a fuel divided by the value of shipments.  
MECS Section 1 CCEF/ASM VOS

Technical Note #15  
April 27, 1987

Edit Specifications for MECS Part II -  
Fuel-Switching Survey

Jean Paananen

Part I - Column Numbers, Key Codes, and Definitions

Manufacturing Energy Consumption Survey Part I - MECS

Column 2	Energy Source Code Identifier
	216 - Residual fuel oil
	224 - Distillate fuel oil
	307 - Natural gas
	406 - Anthracite
	414 - Bituminous & subbituminous coal
	422 - Lignite
	430 - Coal coke
	448 - Breeze
Key Code 562	Section II, Part I - Quantity of electricity purchased
Column 7	Quantity consumed onsite as a fuel, by energy source

Fuel-Switching Capability Survey - FS

Key Code 581	Energy Source Code Identifier
Column C	109 - Electricity
Column D	307 - Natural gas
Column E	224 - Distillate fuel oil
Column F	216 - Residual fuel oil
Column G	455 - Coal and coke
Line 1	Quantity consumed onsite as a fuel, Columns C through G
2	Nonsubstitutable quantity, Columns C through G
3	Substitutable quantity, Columns C through G
4	Potential quantity substitutable by purchased electricity, Columns D through G
5	Potential quantity substitutable by natural gas, Column C, Columns E through G
6	Potential quantity substitutable by distillate fuel oil, Columns C and D, Columns F and G
7	Potential quantity substitutable by residual fuel oil, Columns C through E, Column G
8	Potential quantity substitutable by coal and coke, Columns C through F
9	Potential quantity substitutable by LPG, Columns C through G
10	Potential quantity substitutable by other fuels not listed, Columns C through G
11	Time required to convert to alternative energy source, Columns C through G

Part II - Edits

The first edit compares the quantity of each energy source consumed by the respondent between the MECS and FS. The fuel codes listed on the left are from Line 1 of the FS, and codes listed on the right are from Column 7 of the MECS. If the FS value is not equal to the MECS value, the response fails the edit. Flag with the edit number and transfer to an output data set of failed responses which includes the Census File Number, SIC code, company name, FS and MECS reported figures.

1) Comparison of reported energy consumption

Fuel Switching

MECS

- Line 1, Column C = MECS Section II, Part I, Key Code  
D = Energy Source Code 307, Section I Column 7  
E = Energy Source Code 224, Section I Column 7  
F = Energy Source Code 216, Section I Column 7  
G = Sum of Section I Column 7 values for Energy  
Source Codes 406 + 414 + 422 + 430 + 448

In the following edits, all variables are from the FS. Any response that does not satisfy the relationship specified fails the edit. Flag with the number of whichever edit(s) fail, and transfer to the failed edit output data set. Include the number of the failed edit(s), the Census File Number, SIC code, and company name. For edit number two, and for each Column C through J that fails the edit, include in the output data set the value in each Line, 1 through 3. For edits three and four, for each Column C through J that fails the edit, include in the output data set the value in each Line, 4 through 10.

- 2) Verification of substitutable quantities by energy source. For each Column C through G, Line 3 = Line 1 - Line 2.
- 3) Comparison of total substitutable quantity and individual alternatives, by energy source. For each Column C through G, the value in Line 3  $\geq$  the value in each Line, 4 through 10.
- 4) Comparison of quantity substitutable and the sum of identified alternatives. For each Column C through G, the value in Line  $\leq 3$  the *sum* of values in Lines 4 through 10.
- 5) Time required to substitute fuel. For each Column C through G,  $1 \leq$  Line 11  $\leq 3$ .

## Technical Note #22

### Addendum to Edit Specifications for the 1985 Manufacturing Energy Consumption Survey

Jean Paananen

The following edits are to be considered part of the Manufacturing Energy Consumption Survey (MECS) edit specifications mailed to Census on February 6, 1987, a copy of which is attached. For the first two edits, flag any response which has an entry in Section I, Column 8 (Key Code 566-Quantity Consumed On site for All Nonfuel Purposes) corresponding to energy source code 802-roundwood, or energy source code 810-wood waste. Transfer to the output data set the number of failed edit(s), the Census File Number, SIC code, Company name and amount reported in Column 8.

- 4) For energy source code 802 in MECS Section I, Key Code 566 = 0
- 5) For energy source code 810 in MECS Section I, Key Code 566 = 0

For the final edit, transfer to the output data set any response that does not meet the condition listed. Include the edit number, the Census File Number, SIC code, Company name and amounts in Key Codes 562, 563, 565, 566, and/or 567.

- 6) For each energy source code in MECS Section I, if Key Code 562 and/or Key Code 563 > 0, then the sum of Key Code 565 + Key Code 566 + Key Code 567 > 0.

## Appendix E

### **Details Concerning the Expected MECS Sample Size**

## Details Concerning the Expected MECS Sample Size

This appendix is intended as a supplement to Technical Paper 24, a methodological report on the ASM published by the Census Bureau. The subject of the technical paper, the ASM, is a one-stage probability sample, whereas the MECS is a two-stage probability sample. Because a Bernoulli sampling method is used to choose ASM samples and MECS subsamples, the number of establishments in a sample is a random variable rather than a fixed quantity. In Technical Paper 24 a proof is given that, for a one-stage sample such as the ASM, the expected value of the actual sample size is equal to the desired sample size. The proof of expected sample size is here extended to the case of a two-stage Bernoulli sample (the MECS sample design).

The proof for a one-stage sample proceeds as follows:

If  $a_j$  is defined as a count variable, where:

$$a_j = \begin{cases} 1 & \text{if establishment } j \text{ is in the sample, and} \\ 0 & \text{otherwise} \end{cases}$$

and  $Q_j$  is the probability that establishment  $j$  is selected for the ASM, the actual sample size can be written as:

$$n' = \sum_{j=1}^N a_j, \text{ and } E(n') = E \left[ \sum_{j=1}^N a_j \right] = \sum_{j=1}^N \left[ E(a_j) \right] \cdot$$

Because  $E(a_j) = (Q_j) \cdot 1 + (1-Q_j) \cdot 0 = Q_j$

$$E(n') = E \sum_{j=1}^N a_j = \sum_{j=1}^N E(a_j) = \sum_{j=1}^N Q_j \cdot \tag{1}$$

Because  $n'_1$  establishments are chosen into the sample with probability 1, (that is, they are in every possible sample), (1) can be rewritten as:

$$E(n') = \sum_{j=1}^{n'_1} 1 + \sum_{j=1}^{N-n'_1} Q_j = n'_1 + \sum_{j=1}^{N-n'_1} Q_j \cdot \tag{2}$$

For the ASM,  $Q_j$  for the  $(N - n'_1)$  noncertainty establishments is defined as:

$$Q_j = \frac{(n - n'_1) \cdot Z_j}{\sum_{j=1}^{N-n'_1} Z_j}$$

where  $n$  represents the desired sample size and  $Z$  is any arbitrary measure of establishment size.

The expected value of  $n'$  is now seen to be:

$$E(n') = n'_1 + \sum_{j=1}^{N-n'_1} \frac{(n' - n'_1) \cdot Z_j}{\sum_{j=1}^{(N-n'_1)} Z_j}$$

$$= n'_1 + \frac{(n' - n'_1)}{\sum_{j=1}^{N-n'_1} Z_j} \sum_{j=1}^{N-n'_1} Z_j = n'_1 + n - n'_1 = n \cdot$$

Using conditional expectations, it can also be proven that the expected value of the actual sample size of a two-stage sample, such as MECS, is equal to the desired sample size. This proof runs as follows:

The actual two-stage sample size,  $m'$ , is defined as:

$$m' = \sum_{j=1}^{n'} \infty_j = \sum_{j=1}^N a_j \cdot \infty_j,$$

where  $\infty_j = \begin{cases} 1 & \text{if establishment } j \text{ is in the MECS subsample, and} \\ 0 & \text{otherwise.} \end{cases}$

The expected value of the sample size is, therefore:

$$E(m') = E \left[ \sum_{j=1}^N a_j \cdot \infty_j \right].$$

Rewriting this equation in terms of conditional expectations, where  $E_m$  is the conditional expectation over all possible MECS samples within a given ASM sample, and  $E_a$  is the expectation over all ASM samples, the expected two-stage sample size is:

$$E(m') = E_a \left\{ E_m \left[ \sum_{j=1}^N a_j \cdot \infty_j \right] \right\}$$

$$= E_a \left\{ \sum_{j=1}^N a_j \cdot E_m(\infty_j) \right\} \cdot \quad (3)$$

But because  $E_m(\infty_j) = R_j \cdot 1 + (1 - R_j) \cdot 0 = R_j$ , the conditional probability that establishment  $j$  is selected into the MECS sample, given that it has already been selected into the ASM sample, (3) can be rewritten as:

$$E(m') = E_a \left\{ \sum_{j=1}^N a_j \cdot R_j \right\} \cdot \quad (4)$$

This sum can be separated into two components, the  $m'_1$  certainty establishments in the MECS (two-stage) sample, and the  $(N - m'_1)$  establishments that are not certainty establishments in the two-stage sample. The equation now looks like:

$$\begin{aligned} E(m') &= E_a \left\{ \sum_{j=1}^{m'_1} 1 \cdot 1 + \sum_{j=1}^{N-m'_1} a_j \cdot R_j \right\} \\ &= E_a(m'_1) + E_a \sum_{j=1}^{N-m'_1} a_j \cdot R_j \end{aligned}$$

Replacing  $R_j$  with the expression given for the MECS selection probability in the chapter on the Sampling Method,

$$E(m') = E_a(m'_1) + E_a \left\{ \sum_{j=1}^{N-m'_1} \frac{1}{Q_j} \frac{(m - m'_1) \cdot TBt_{uj}}{\sum_{j=1}^{n'-m'_1} (1/Q_j) \cdot TBt_{uj}} \cdot a_j \right\} \quad (5)$$

But note that  $\sum_{j=1}^{n'-m'_1} (1/Q_j) TBt_{uj} = \sum_{j=1}^{N-m'_1} (1/Q_j) \cdot TBt_{uj} \cdot a_j$ , because  $a_j = 1$

only for the  $n'$  establishments in the ASM sample. Equation (5) can, therefore, be rewritten as:

$$E(m') = E_a(m'_1) + E_a \left\{ \sum_{j=1}^{N-m'_1} \frac{1}{Q_j} \frac{(m - m'_1) TBt_{uj}}{\sum_{j=1}^{N-m'_1} (1/Q_j) \cdot TBt_{uj} \cdot a_j} \cdot a_j \right\}$$

$$E(m') = E_a(m'1) + E_a \left\{ (m - m'1) \cdot \frac{\sum_{j=1}^{N-m'1} (1/Q_j) TBt_{uj} a_j}{\sum_{j=1}^{N-m'1} (1/Q_j) TBt_{uj} a_j} \right\}$$

$$= E_a(m'1) + E_a(m - m'1) = E_a(m'1) + m - E_a(m'1) = m.$$

Thus,  $E(m') = m$ .

## Appendix F

### **Derivations of MECS Estimator**

## Derivations of MECS Estimators

Estimators used to obtain totals, and the variances of totals, were developed as an extension of earlier work on ASM estimators performed by the Census Bureau. This earlier work is described in detail in Technical Paper 24, "The Annual Survey of Manufactures: A Report on Methodology" published by the Bureau of the Census. EIA's work on these estimators for use in MECS consisted of extending the Census Bureau's derivations and proofs to a two-stage Bernoulli sample.

In addition, unlike the ASM, the MECS is designed to produce estimates of ratios of industry characteristics. EIA is currently conducting research on these estimators for both ratios and the variances of these ratios. This appendix will concentrate mostly on formulas for the relatively simple estimators used to produce totals. Work to date on ratio estimators will also be described. This work follows from discussions of ratio estimators presented in standard statistics texts.

A simple inflation estimator of an aggregate characteristic Y based on ASM sampling probabilities is given by:

$$\hat{Y} = \sum_{j=1}^{n'} y_j (1/Q_j) \quad (1)$$

where  $n'$  = the number of ASM sample establishments and

$Q_j$  = the ASM probability of selection for establishment j.

This expression can be rewritten as:

$$\hat{Y} = \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot a_j \quad (2)$$

where the summation is over all establishments in the population, and  $a_j$  is a random variable defined as:

$$a_j = \begin{cases} 1 & \text{if establishment } j \text{ is in the ASM sample; and} \\ 0 & \text{otherwise.} \end{cases}$$

Expression (2) can be used to show that  $\hat{Y}$  is an unbiased estimator of Y.

PROOF:

$$E(\hat{Y}) = E \left[ \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot a_j \right], \quad (3)$$

where  $y_j$  and  $Q_j$  are fixed constants with respect to the sample selection process, and  $a_j$  is the variable representing the uncertainty of selection.

Since selection is independent from establishment to establishment:

$$E(\hat{Y}) = \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot E(a_j)$$

but  $E(a_j) = Q_j$ , so the formula simplifies to:

$$E(\hat{Y}) = \sum_{j=1}^N y_j = Y. \tag{5}$$

A subsample of the ASM is now desired for use as a sample to collect MECS data, and estimate energy-use parameters for the portion of the manufacturing sector covered by the ASM mail sample. Let  $m$  be the desired MECS sample size.

**CLAIM:** A set of well-defined subselection probabilities can be determined for the ASM establishments such that if an independent Bernoulli process is used on each establishment, the resulting MECS subsample will have the following properties:

- 1) Overall probabilities of selection (not subselection probabilities) will be, as closely as possible, proportional to a specified measure of energy consumption.
- 2) A simple inflation estimator applied to sample data from MECS will be unbiased for ASM frame totals.
- 3) The expected MECS sample size will be  $m$ .

The MECS basic inflation estimator for population totals can be written in either of two ways. Written in terms of MECS sample observations, it takes the form:

$$\hat{Y} = \sum_{j=1}^{m'} y_j \cdot (1/Q_j) \cdot (1/R_j) \tag{6}$$

Written in terms of the entire population, the estimator is:

$$\hat{Y} = \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot a_j \cdot (1/R_j) \cdot \infty_j \tag{7}$$

where  $\infty_j = \begin{cases} 1 & \text{if ASM establishment } j \text{ is selected into the MECS sample; and} \\ 0 & \text{Otherwise.} \end{cases}$

To show that  $\hat{Y}$  is an unbiased estimator of  $Y$ , consider

$$E(\hat{Y}) = E \left[ \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot a_j \cdot (1/R_j) \cdot \infty_j \right] \quad (8)$$

where the expectation will be carried out in two stages: conditional expectation over all MECS samples within a given ASM sample (denoted by  $E_m$ ), followed by the expectation over all possible ASM samples (denoted by  $E_a$ ). Note that  $y_j$  and  $Q_j$  are fixed with respect to all ASM samples and MECS subsamples;  $a_j$  and  $R_j$  are constant over all MECS subsamples within a given ASM sample, but vary among ASM samples; and  $\infty_j$  varies among MECS subsamples. Using this information, the formula for  $E(\hat{Y})$  can be rewritten as:

$$\begin{aligned} E(\hat{Y}) &= E_a \left\{ E_m \left[ \sum_{j=1}^N y_j (1/Q_j) a_j (1/R_j) \cdot \infty_j \right] \right\} \\ &= \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot E_a \left\{ a_j (1/R_j) \cdot [E_m(\infty_j)] \right\} \end{aligned}$$

Using elementary properties of the expectation operator, the above expression simplifies to

$$= \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot E_a [ a_j \cdot (1/R_j) \cdot P_j ] \quad (9)$$

because the expected value of a Bernoulli random variable is the probability that it takes on the value 1. The formula further simplifies to:

$$E(\hat{Y}) = \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot E_a(a_j) \cdot$$

But  $a_j$  is also a Bernoulli random variable with expected value  $Q_j$ . Therefore,

$$E(\hat{Y}) = \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot Q_j = \sum_{j=1}^N y_j = Y,$$

and  $\hat{Y}$  is thus unbiased.

The sampling variance of  $\hat{Y}$  can be derived from the definition of variance:

$$\begin{aligned}\sigma^2(\hat{Y}) &= E(\hat{Y} - E(\hat{Y}))^2 \\ &= E \left[ \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot a_j \cdot (1/R_j) \cdot \infty_j - Y \right]^2 \\ &= E \left[ \sum_{j=1}^N y_j \cdot (1/Q_j) \cdot a_j \cdot (1/R_j) \cdot \infty_j \right]^2 - Y^2\end{aligned}$$

Expanding the squared summation:

$$\begin{aligned}\sigma^2(\hat{Y}) &= E \left\{ \sum_{j=1}^N y_j^2 \cdot (1/Q_j^2) \cdot a_j^2 \cdot (1/R_j^2) \cdot \infty_j^2 \right. \\ &\quad \left. + 2 \sum_{j \neq k}^N [y_j (1/Q_j) \cdot a_j \cdot (1/R_j) \cdot \infty_j] \cdot \right. \\ &\quad \left. [y_k \cdot (1/Q_k) \cdot a_k \cdot (1/R_k) \cdot \infty_k] \right\} - Y^2\end{aligned}\tag{10}$$

The next step is to rearrange terms in the cross product, and proceed with the same two-stage expected value argument used to derive  $E(\hat{Y})$ . That is:

$$\begin{aligned}\sigma^2(\hat{Y}) &= E_a \left\{ E_m \left[ \sum_{j=1}^N y_j^2 \cdot (1/Q_j^2) \cdot a_j^2 \cdot (1/R_j^2) \cdot \infty_j^2 \right] \right\} \\ &\quad + E_a \left\{ E_m \left[ 2 \sum_{j \neq k}^N y_j \cdot y_k \cdot (1/Q_j) \cdot (1/Q_k) \cdot a_j \cdot a_k \right. \right. \\ &\quad \left. \left. \cdot (1/R_j) \cdot (1/R_k) \cdot \infty_j \cdot \infty_k \right] \right\} - Y^2.\end{aligned}$$

Using the previously-stated dependencies of the  $y$ ,  $Q$ ,  $a$ ,  $R$ , and  $\infty$  terms (which also apply to their squares), the preceding expression can be rewritten as:

$$\begin{aligned}\sigma^2(\hat{Y}) &= \sum_{j=1}^N y_j^2 \cdot (1/Q_j) \cdot E_a \left\{ a_j^2 (1/R_j^2) [E_m(\infty_j^2)] \right\} \\ &\quad + 2 \sum_{j \neq k}^N y_j \cdot y_k \cdot (1/Q_j) \cdot (1/Q_k) \cdot E_a \left\{ a_j \cdot a_k \cdot (1/R_j) \cdot \right. \\ &\quad \left. (1/R_k) \cdot E_m [\infty_j \cdot \infty_k] \right\} - Y^2\end{aligned}\tag{11}$$

Because the  $a$ 's and  $\infty$ 's are independent Bernoulli random variables,

$$E_a (a_j^2) = E_a (a_j) = Q_j ;$$

$$E_m (\infty_j^2) = E_m (\infty_j) = R_j ;$$

$$E_a (a_j) \cdot (a_k) = E_a (a_j) \cdot E_a (a_k) ; \text{ and}$$

$$E_m (\infty_j) \cdot (\infty_k) = E_m (\infty_j) \cdot E_m (\infty_k) ;$$

so that the first summation in (11) simplifies to:

$$\begin{aligned} & \sum_{j=1}^N y_j^2 \cdot (1/Q_j) \cdot E_a \left\{ a_j^2 (1/R_j^2) \cdot R_j \right\} \\ &= \sum_{j=1}^N y_j^2 \cdot (1/Q_j) \cdot E_a \left\{ a_j^2 \cdot (1/R_j) \right\} \end{aligned}$$

and the second summation simplifies to:

$$\begin{aligned} & 2 \sum_{j \neq k}^N y_j \cdot y_k \cdot (1/Q_j) \cdot (1/Q_k) \cdot E_a \left\{ a_j \cdot a_k \cdot (1/R_j) \cdot (1/R_k) \cdot \right. \\ & \quad \left. [E_m(\infty_j)] \cdot [E_m(\infty_k)] \right\} \\ &= 2 \sum_{j \neq k}^N y_j \cdot y_k \cdot (1/Q_j) \cdot (1/Q_k) \cdot [E_a(a_j)] \cdot [E_a(a_k)] \\ &= 2 \sum_{j \neq k}^N y_j \cdot y_k \end{aligned}$$

The variance formula is now reduced to:

$$\begin{aligned} \sigma^2(\hat{Y}) &= \sum_{j=1}^N y_j^2 \cdot (1/Q_j^2) \cdot E_a \left[ a_j^2 \cdot (1/R_j) \right] \\ &+ 2 \sum_{j \neq k}^N y_j \cdot y_k - Y^2 \end{aligned} \tag{12}$$

Next, note that the probability of selecting an individual establishment into the ASM is independent of the probability of selecting that establishment into a MECS subsample, given a fixed ASM sample including it. Thus,  $E_a(a_j) \cdot (1/R_j) = E_a(a_j) \cdot E_a(1/R_j)$ , and the first summation in (12) becomes:

$$\begin{aligned}
& \sum_{j=1}^N y_j^2 \cdot (1/Q_j^2) \cdot E_a(a_j^2) \cdot E_a(1/R_j) \\
&= \sum_{j=1}^N y_j^2 \cdot (1/Q_j^2) \cdot Q_j \cdot E_a(1/R_j) \\
&= \sum_{j=1}^N y_j^2 \cdot (1/Q_j) \cdot E_a(1/R_j) ,
\end{aligned}$$

and the complete variance formula is now:

$$\sigma^2(\hat{Y}) = \sum_{j=1}^N y_j^2 \cdot (1/Q_j) \cdot E_a(1/R_j) + 2 \sum_{j \neq k}^N y_j \cdot y_k - Y^2 \quad (13)$$

Next, note that

$$Y^2 = \left[ \sum_{j=1}^N y_j \right]^2 = \sum_{j=1}^N y_j^2 + 2 \sum_{j \neq k}^N y_j \cdot y_k$$

so that (13) can be rewritten:

$$\begin{aligned}
\sigma^2(\hat{Y}) &= \sum_{j=1}^N y_j^2 \cdot (1/Q_j) \cdot E_a(1/R_j) + 2 \sum_{j \neq k}^N y_j \cdot y_k \\
&\quad - \sum_{j=1}^N y_j^2 - 2 \sum_{j \neq k}^N y_j \cdot y_k \\
&= \sum_{j=1}^N y_j^2 \left[ (1/Q_j) \cdot E_a(1/R_j) - 1 \right] \quad (14)
\end{aligned}$$

$$\begin{aligned}
&= \sum_{j=1}^N y_j^2 \cdot E_a \left[ (1/Q_j) \cdot (1/R_j) - 1 \right] \\
&= \sum_{j=1}^N y_j^2 \cdot E_a \left[ \frac{(1 - Q_j \cdot R_j)}{Q_j \cdot R_j} \right] \quad (15)
\end{aligned}$$

The corresponding estimate of  $\sigma^2(\hat{Y})$ , based on the MECS, is:

$$S^2(\hat{Y}) = \sum_{j=1}^{m'} y_j^2 \left[ \frac{(1 - Q_j \cdot R_j)}{Q_j^2 \cdot R_j^2} \right] \quad (16)$$

$S^2(\hat{Y})$  can be shown to be unbiased for  $\sigma^2(\hat{Y})$  by rewriting (16) as:

$$S^2(\hat{Y}) = \sum_{j=1}^N y_j^2 \cdot \frac{(1 - Q_j \cdot R_j)}{Q_j^2 \cdot R_j^2} \cdot a_j \cdot \infty_j$$

and using previously-invoked independence arguments to proceed as follows:

$$\begin{aligned} E[S^2(\hat{Y})] &= E_a \left\{ E_m \left[ \sum_{j=1}^N y_j^2 \frac{(1 - Q_j \cdot R_j)}{Q_j^2 \cdot R_j^2} \cdot a_j \cdot \infty_j \right] \right\} \\ &= \sum_{j=1}^N y_j^2 \cdot E_a \left[ \frac{(1 - Q_j \cdot R_j)}{Q_j^2 \cdot R_j^2} a_j \right] \cdot E_m(\infty_j) \\ &= \sum_{j=1}^N y_j^2 \cdot E_a \left[ \frac{(1 - Q_j \cdot R_j)}{Q_j^2 \cdot R_j^2} \right] \cdot E_a(a_j) \cdot R_j \\ &= \sum_{j=1}^N y_j^2 \cdot E_a \left[ \frac{(1 - Q_j \cdot R_j)}{Q_j \cdot R_j} \right] \\ &= \sigma^2(\hat{Y}), \text{ as given in (15).} \end{aligned}$$

The same line of argument can be used to prove that an unbiased estimator of the covariance of totals for two variables X and Y is:

$$\text{Cov}(\hat{X}, \hat{Y}) = \sum_{j=1}^N x_j \cdot y_j \left[ \frac{(1 - Q_j \cdot R_j)}{Q_j^2 \cdot R_j^2} \right] \cdot$$

One observation at this point will help to simplify later algebra: the bracketed expression

$$\begin{aligned}
 \frac{1 - Q_j \cdot R_j}{Q_j^2 \cdot R_j^2} &= \frac{1}{(Q_j \cdot R_j)^2} - \frac{1}{Q_j \cdot R_j} \\
 &= \left[ \frac{1}{Q_j \cdot R_j} \right]^2 - \frac{1}{Q_j \cdot R_j} \\
 &= T_j^2 - T_j \\
 &= T_j(T_j - 1)
 \end{aligned}$$

Where  $T_j = 1/Q_j \cdot R_j$  is the overall inflation weight associated with MECS sample establishment  $j$ .

The preceding formulas can be combined to give an approximate estimator for the mean square error (MSE) of ratio estimates produced for MECS.

For a MECS ratio estimator  $\hat{R} = (\hat{Y}/\hat{X})$ , of population ratio  $R = (Y/X)$ :

$$\hat{R} - R = (\hat{Y}/\hat{X}) - R = (\hat{Y}/\hat{X}) - (RX/\hat{X}) = (\hat{Y} - RX)/\hat{X}. \quad (17)$$

For sample sizes large enough so that  $\hat{X}$  is sufficiently close to  $X$ , (17) is approximately:

$$\hat{R} - R \doteq (1/X) (\hat{Y} - RX)$$

By the definition of MSE:

$$\text{MSE}(\hat{R}) = E(\hat{R} - R)^2.$$

Given the approximation of  $X$  for  $\hat{X}$ , and adding and subtracting  $Y$  from the difference factor  $(\hat{R} - R)$ ,

$$\begin{aligned}
 \text{MSE}(\hat{R}) &= (1/X^2) E [ (\hat{Y} - Y) - (R\hat{X} - Y) ]^2 \\
 &= (1/X^2) E [ (\hat{Y} - Y) - R(\hat{X} - X) ]^2 \\
 &= (1/X^2) \left\{ E(\hat{Y} - Y)^2 + R^2 E(\hat{X} - X)^2 - 2R [ E(\hat{Y} - Y)(\hat{X} - X) ] \right\} \\
 &= (1/X^2) [ \sigma^2(\hat{Y}) + R^2 \sigma^2(\hat{X}) - 2R\sigma(\hat{X}, \hat{Y}) ]
 \end{aligned} \quad (18)$$

Substituting into (18), term by term, the unbiased estimators of variance and covariance for aggregate statistics based on MECS, yields the MSE estimator:

$$\begin{aligned}
 \widehat{MSE}(R) &= (1/X^2) \left[ \sum_{j=1}^{m'} y_j^2 \cdot T_j \cdot (T_j - 1) + R^2 \sum_{j=1}^{m'} x_j^2 \cdot T_j \cdot (T_j - 1) \right. \\
 &\quad \left. - 2R \sum_{j=1}^{m'} y_j \cdot x_j \cdot T_j \cdot (T_j - 1) \right] \\
 &= (1/X^2) \sum_{j=1}^{m'} (y_j^2 - 2R \cdot y_j \cdot x_j + R^2 \cdot x_j^2) \cdot (T_j) \cdot (T_j - 1) \\
 &= (1/X^2) \sum_{j=1}^{m'} (y_j - R \cdot x_j)^2 \cdot T_j \cdot (T_j - 1). \tag{19}
 \end{aligned}$$

However,  $\widehat{MSE}(R)$  contains two population parameters that must be estimated. A corresponding biased estimator of  $\widehat{MSE}(R)$ , based totally on MECS sample data, is:

$$\widehat{MSE}(\widehat{R}) = (1/\widehat{X}^2) \sum_{j=1}^{m'} (y_j - \widehat{R} \cdot x_j)^2 \cdot T_j \cdot (T_j - 1) \tag{20}$$

$\widehat{MSE}(\widehat{R})$  is a biased estimator of  $\widehat{MSE}(R)$  because  $\widehat{R}$  is a biased estimator of the population parameter  $R$ .  $\widehat{MSE}(\widehat{R})$  can be shown to be a consistent estimator of  $\widehat{MSE}(R)$ , however, as follows:

$$\begin{aligned}
 \widehat{MSE}(\widehat{R}) - \widehat{MSE}(R) &= (1/\widehat{X}^2) \sum_{j=1}^{m'} (y_j - \widehat{R} \cdot x_j)^2 \cdot T_j \cdot (T_j - 1) \\
 &\quad - (1/X^2) \sum_{j=1}^{m'} (y_j - R \cdot x_j)^2 \cdot T_j \cdot (T_j - 1) \\
 &= \sum_{j=1}^{m'} \left[ (1/\widehat{X}^2) \cdot (y_j - \widehat{R} \cdot x_j)^2 - (1/X^2) \cdot (y_j - R \cdot x_j)^2 \right] \cdot T_j \cdot (T_j - 1) \tag{21}
 \end{aligned}$$

It is clear that as the sample size approaches the number of establishments in the population,  $T_j$  goes to 1.0 and the rightmost term in (21) goes to zero for all terms in the summation. Therefore, the difference between the estimator  $\widehat{MSE}(\widehat{R})$ , based on sample estimates, and  $\widehat{MSE}(R)$  based on the population parameters  $X$  and  $R$ , goes to zero as the sample size approaches the population size. Thus,  $\widehat{MSE}(\widehat{R})$  is a biased but consistent estimator of  $\widehat{MSE}(R)$ .

Appendix G

**Suggestions for Working  
with Aggregated Data**

## Suggestions for Working with Aggregated Data

All publicly-available data produced from the MECS are in the aggregate form. Establishment-level data are not published to protect the privacy of the respondents. The Bernoulli sampling method used for the MECS results in estimators that have properties that alleviate some of the difficulties normally associated with working with aggregated data, however.

In particular, the estimators used to produce variances for MECS are additive, that is, the variance of an aggregate total produced from any complete group of subtotals is equal to the sum of the variances of the subtotals, as long as no establishments are represented in more than one subtotal.

The reason for this is that the basic MECS variance estimator consists of the sum of the weighted squared data values, with no subtracted constant preceding the summation. That is:

$$S^2(\hat{Y}) = \sum_g \sum_{j=1}^{m'_{gr}} y^2_{gj} \cdot (W_{gj}) \cdot (W_{gj} - 1)$$

$S^2(\hat{Y})$  is the same expression derived in the chapter on MECS Estimators. However, instead of being summed over weight adjustment cells, the expression is written as a summation over any set of subgroups  $g$  that partition the population. The subtotal for subgroup  $g$  is the variance estimator for that subgroup and the sum of the subtotals estimates the variance of  $\hat{Y}$ . In other words,

$$\begin{aligned} S^2(\hat{Y}) &= \sum_g \left\{ \sum_{j=1}^{m'_{gr}} y^2_{gj} \cdot (W_{gj}) \cdot (W_{gj} - 1) \right\} \\ &= \sum_g S^2(\hat{Y}_g) \end{aligned}$$

The same relationship holds for estimates of covariances:

$$S(\hat{Y}, \hat{X}) = \sum_g \sum_{j=1}^{m'_{gr}} y_{gj} \cdot x_{gj} \cdot W_{gj} \cdot (W_{gj} - 1)$$

In this relationship, the sum of the covariances of any arbitrarily defined subgroups of establishments equals the covariance of totals for  $Y$  and  $X$  added over the same set of subgroups.

The additive property of variance and covariance estimates from MECS, can easily be shown to carry over to variance estimates for ratios of totals:

$$\begin{aligned}
 S^2(\hat{R}) &= S^2(\hat{X}/\hat{Y}) \\
 &= \text{Var}(\hat{Y}) + R^2 \text{Var}(\hat{X}) - 2R \text{Cov}(\hat{Y}, \hat{X}) \\
 &= \sum_g \text{Var}(\hat{Y}_g) + R^2 \sum_g \text{Var}(\hat{X}_g) - 2R \sum_g \text{Cov}(\hat{Y}_g, \hat{X}_g)
 \end{aligned}$$

Thus, published MECS estimates of aggregate table cell totals, variances of totals, and covariances of totals, can be used to produce variance estimates for totals and ratios for any population subgroup that is an aggregation of published subgroups.

Appendix H

**A Useful Upper Bound for Errors of Proportions Based on MECS Data**

## A Useful Upper Bound for Errors of Proportions Based on MECS Data

Often in Government statistics systems, error estimates are computed for aggregate statistics but data are also presented and/or analyzed in the form of proportions, with no directly-computed error measures available for them. A proportion is a ratio statistic that can be written in the form

$$\hat{R} = \frac{\hat{Y}}{\hat{X}}$$

or its equivalent percentage form

$$\hat{R} = \frac{\hat{Y}}{\hat{X}} \cdot 100$$

where  $\hat{Y}$  and  $\hat{X}$  are survey-based estimates of aggregate parameters, and characteristic X "encompasses" characteristic Y. That is, each population element that contributes to the total for Y also contributes to the total for X, and the value of X for each element is  $\geq$  the value of Y. An example of a proportion statistic is the percent of total energy consumption in manufacturing that is accounted for by natural gas.

Proportions represent one specific class of the general ratio estimator

$$\hat{R} = \frac{\hat{Y}}{\hat{X}} \cdot$$

The error in  $\hat{R}$ , if it is not computed directly, can be approximated using the formula

$$V_{\hat{R}}^2 = V_{\hat{Y}}^2 + V_{\hat{X}}^2 - 2V_{\hat{Y}\hat{X}} \quad [1]$$

where

$V_{\hat{R}}^2$  denotes the estimated relative variance of  $\hat{R}$

$V_{\hat{Y}}^2$  denotes the estimated relative variance of  $\hat{Y}$ , given by  $S_{\hat{Y}}^2 / (\hat{Y})^2$

$V_{\hat{X}}^2$  denotes the estimated relative variance of  $\hat{X}$ , given by  $S_{\hat{X}}^2 / (\hat{X})^2$

$V_{\hat{Y},\hat{X}}$  denotes the estimated relative covariance of  $\hat{Y}$  and  $\hat{X}$ , given by  $\frac{\text{Cov}(\hat{Y},\hat{X})}{\hat{Y} \cdot \hat{X}}$

Expression [1] can be simplified for proportions which are based on attributes (where population elements are assigned the value 1 if they have an attribute, 0 if they do not) and which are estimated from a simple random sample. For this special case  $V_{\hat{Y},\hat{X}}$  can be shown to equal  $V_{\hat{X}}^2$  so that the relvariance estimator of the proportion simplifies to

$$V_{\hat{R}}^2 = V_{\hat{Y}}^2 - V_{\hat{X}}^2$$

This simple formula is very appealing, and fully takes into account the variance-reducing effect of the positive correlation between the numerator and denominator of a proportion. Because of its appeal, the formula has been applied to derive approximate errors of proportions for many types of complex survey designs. However, the validity of the approximation is uncertain, because  $V_{\hat{Y},\hat{X}}$  cannot be shown to be equal to  $V_{\hat{X}}^2$  for all survey designs, or for proportions based on nonattribute variables. One alternative way of approximating variances of proportions would be to assume  $V_{\hat{Y},\hat{X}} = 0$  and estimate errors by

$$V_{\hat{R}}^2 = V_{\hat{Y}}^2 + V_{\hat{X}}^2 \quad [2]$$

Such an upper bound is very conservative when  $\hat{Y}$  and  $\hat{X}$  are highly correlated and, thus, suggests a much higher level of uncertainty in survey estimates than is actually the case. However, a smaller, more useful upper bound can be derived, specific to the sample design for the Manufacturing Energy Consumption Survey (MECS).

As stated in the chapter on MECS Estimators, the aggregate parameter estimator for the MECS is given by

$$\hat{Y} = \sum_{j=1}^{m'r} y_j \cdot W_j$$

where  $y_j$  = the value of characteristic Y for establishment j in the MECS sample.

$W_j$  = the reciprocal of the probability of selection of sample establishment j, adjusted to account for nonresponse and undercoverage

$m'r$  = the number of MECS respondents.

The independent Bernoulli processes used to select the MECS sample result in the relatively simple unbiased variance expression

$$S_{\hat{Y}}^2 = \sum_{j=1}^{m'r} (y_j)^2 \cdot (W_j) \cdot (W_j - 1)$$

which accounts for sampling error and a part of nonsampling error caused by random effects of the loss of information due to nonresponse and undercoverage. A corresponding expression for covariance can be shown to be

$$S_{\hat{Y},\hat{X}} = \sum_{j=1}^{m'r} (y_j) \cdot (x_j) \cdot (W_j) \cdot (W_j - 1)$$

### An Upper Bound for $V_{\hat{R}}^2$

Expression [1] given earlier can be rewritten as

$$\begin{aligned} V_{\hat{R}}^2 &= V_{\hat{Y}}^2 + V_{\hat{X}}^2 - 2V_{\hat{Y},\hat{X}} \\ &= V_{\hat{Y}}^2 + V_{\hat{X}}^2 - 2 \frac{\sum_{j=1}^{m'r} (y_j) \cdot (x_j) \cdot (W_j) \cdot (W_j - 1)}{\hat{X} \cdot \hat{Y}} \end{aligned} \quad [3]$$

The strategy at this point is to replace the quotient in the rightmost term of [3] with something simpler, such that the revised term is smaller than the existing one, and the resulting expression will be an upper bound for  $V_{\hat{R}}^2$ . The way to create a revised term that is smaller is to replace the numerator with a smaller expression, or replace the denominator with a larger expression. We know that for purposes of the MECS, X and Y values represent consumption and related measures. If characteristic X encompasses characteristic Y, the observed value  $x_j$  for any sample establishment must by definition be  $\geq$  the corresponding  $y_j$ .

Therefore, by substitution

$$\sum_{j=1}^{m'r} (y_j) (x_j) (W_j) (W_j - 1) \geq \sum_{j=1}^{m'r} (y_j) (y_j) (W_j) (W_j - 1) = S_{\hat{Y}}^2$$

Substituting back into [3]

$$V_{\hat{R}}^2 \leq V_{\hat{Y}}^2 + V_{\hat{X}}^2 - 2 \frac{S_{\hat{Y}}^2}{\hat{X} \cdot \hat{Y}} \quad [4]$$

The right-hand term of [4] may be small relative to the first two terms if  $\hat{Y} \ll \hat{X}$ . However, in that case, it is likely that  $V_{\hat{Y}}^2$  will dominate  $V_{\hat{X}}^2$  also, so that  $V_{\hat{R}}^2 \approx V_{\hat{Y}}^2$  regardless of the approximation that is used.

An alternative computational form of [4] can be derived as follows:

$$\begin{aligned}
 V_{\hat{R}}^2 &= V_{\hat{Y}}^2 + V_{\hat{X}}^2 - 2 \frac{S_{\hat{Y}}^2}{\hat{X} \cdot \hat{Y}} \\
 &= V_{\hat{Y}}^2 + V_{\hat{X}}^2 - \frac{2(V_{\hat{Y}}^2) \cdot (\hat{Y})^2}{\hat{X} \cdot \hat{Y}} \\
 &= V_{\hat{Y}}^2 + V_{\hat{X}}^2 - 2(\hat{R}) \cdot V_{\hat{Y}}^2 \\
 &= V_{\hat{Y}}^2 \cdot [1-2(\hat{R})] + V_{\hat{X}}^2
 \end{aligned} \tag{5}$$

Expression [5] can be expressed in terms of variances rather than relative variances by writing

$$V_{\hat{R}}^2 = \frac{S_{\hat{R}}^2}{\hat{R}^2} \leq \frac{S_{\hat{Y}}^2}{\hat{Y}^2} \cdot [1-2\hat{R}] + \frac{S_{\hat{X}}^2}{\hat{X}^2}$$

so that

$$\begin{aligned}
 S_{\hat{R}}^2 &\leq \hat{R}^2 \left[ \frac{S_{\hat{Y}}^2}{\hat{Y}^2} (1-2\hat{R}) + \frac{S_{\hat{X}}^2}{\hat{X}^2} \right] \\
 &= \frac{\hat{Y}^2}{\hat{X}^2} \left[ \frac{S_{\hat{Y}}^2}{\hat{Y}^2} \cdot (1-2\hat{R}) + \frac{S_{\hat{X}}^2}{\hat{X}^2} \right] \\
 &= \frac{1}{\hat{X}^2} \left[ S_{\hat{Y}}^2 (1-2\hat{R}) + S_{\hat{X}}^2 \cdot (\hat{R}^2) \right]
 \end{aligned} \tag{6}$$

As an example of the effect of the upper bound, consider a 30 percent statistic, that is,  $\hat{Y} = 0.3\hat{X}$ , for which  $V\hat{Y} = 2V\hat{X}$  (an eminently reasonable circumstance). The conservative upper bound in [2] yields

$$\begin{aligned} V_{\hat{R}}^2 &= V_{\hat{Y}}^2 + V_{\hat{X}}^2 \\ &= (2V_{\hat{X}})^2 + V_{\hat{X}}^2 \\ &= 5V_{\hat{X}}^2 \end{aligned}$$

and the upper bound in [5] yields

$$\begin{aligned} V_{\hat{R}}^2 &= V_{\hat{Y}}^2 \cdot (1-2R) + V_{\hat{X}}^2 \\ &= (2V_{\hat{X}})^2 \cdot (1-2(.3)) + V_{\hat{X}}^2 \\ &= 4V_{\hat{X}}^2 (1-.6) + V_{\hat{X}}^2 \\ &= 1.6 V_{\hat{X}}^2 + V_{\hat{X}}^2 \\ &= 2.6 V_{\hat{X}}^2 \end{aligned}$$

a reduction of almost one half.

## Glossary

# Glossary

**ASM:** Annual Survey of Manufactures. An annual survey of the manufacturing sector conducted by the Bureau of the Census. The ASM surveys a panel of approximately 56,000 manufacturing establishments annually about their economic activity in the previous year. The panel is updated yearly from Social Security Administration lists of new manufacturing establishments.

**ASM Mail Frame:** The population of manufacturing establishments from which the ASM mail sample is chosen. The frame is updated every fifth year using data collected on the Census of Manufactures, and includes all manufacturing establishments above a fixed payroll cutoff. The cutoff is determined for each industry so that, at the time of updating, 98 percent of the total value of shipments in an industry is represented in the mail frame. This lower bound corresponds to a cutoff between 5 and 9 employees per establishment for most industries, but ranges as high as 19 employees per establishment.

**ASM Mail Sample:** A probability sample of approximately 56,000 establishments chosen from the ASM frame. A new ASM sample is selected every fifth year subsequent to the updating of the ASM frame. The ASM sample is then updated each year using respondent data and IRS records, until collection of the next Census of Manufactures.

**Census of Manufactures:** A complete census of the approximately 350,000 establishments in the manufacturing sector. The Bureau of the Census administers this census once every 5 years (in years ending in 2 or 7). The census collects more detailed economic data than the ASM, and serves as the frame for creating a new ASM panel every 5 years.

**Energy Source:** A substance used as a fuel or feedstock.

**Establishment:** An establishment is an economic unit, generally at a single physical location, where business is conducted or industrial operations are performed. An establishment is not necessarily identical with a company, which may consist of one or more establishments.

**Feedstock:** A fuel-like substance used as a raw material, additive, or ingredient to manufactured products.

**Frame:** A set of elements that are, or can be linked in some way with, the observational units of the target population. The MECS frame is a list of manufacturing establishments (the frame elements) that can be linked to the target population (all establishments in the manufacturing sector) through the ASM sample design and through supplementary information about the "births" and "deaths" of manufacturing establishments.

**Fuel:** A material consumed to produce heat, steam, power, or generated electricity.

**Industry:** The 1972 edition of the SIC Manual defines industry as the 4-digit level of classification of establishments. A narrower definition of industry is used in publications produced by EIA, which defines industry as SIC Major Groups 01 through 39, consisting of establishments in agriculture, forestry, fishing, mining, and construction, as well as in manufacturing.

**Manufacturing:** Manufacturing consists of establishments 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 characteristically use power-driven machines and materials-handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered to be manufacturers if the new product is neither a structure nor other fixed improvement. Also included is the blending of materials such as lubricating oils, plastics, resins, or liquors. Manufacturing is defined as activities covered by SIC Major Groups 20 through 39.

**Manufacturing Sector:** The total population of U.S. manufacturing establishments.

**MECS Frame:** The ASM mail sample.

**SIC:** Standard Industrial Classification. A hierarchical classification system grouping establishments according to their primary economic activities. The SIC Manual defines three levels of classifying manufacturing industries:

- **Major Industry Groups:** Twenty broad, 2-digit categories such as Food and Kindred Products, and Chemicals and Allied Products.
- **Industry Groups:** Intermediate, 3-digit categories within the Major Industry Groups. Examples of Industry Groups include Meat Products, Drugs, and Household Appliances.
- **Industries:** Four-digit categories within Industry Groups. Examples of Industries include Creamery Butter, Alkalies and Chlorine, and Motors and Generators.

The standard reference for SIC codes is the 1972 *Standard Industrial Classification Manual* published by the Office of Management and Budget.

**Target Population:** The population intended to be represented by the MECS sample.

## Statistical Notation

This section is divided into five groups of symbols. The first four groups are used to identify various parameters, data items, statistical operators, statistical measures and size indicators that are manipulated in the algebraic explanations and derivations in this document. The last group consists of subscripts, which are used to define or limit the scope of application of the first four sets of symbols to specified population subgroups or time periods. The subscript definitions identify the types of symbols in Groups I - IV with which the subscripts are used.

### I. Survey Data Parameters and Reported Values

- C: Total cost of purchased fuels as reported on the ASM.
- E: Total purchased electricity consumption as reported on the ASM.
- F: Total fuel consumption as reported on the ASM.
- M: Total employment as reported on the ASM.
- X,Y: Unspecified aggregate parameters for the establishment population.
- x,y: Values of the population characteristics represented by X and Y, for an individual establishment.
- R: A ratio of two aggregate parameters.

### II. Selection Probabilities, Weights, and Weight Adjustments

- $\pi$ : Theoretical exact probability of selection into the MECS sample based on energy consumption as a measure of size.

- P: Computed probability of selection into the MECS sample. It is equal to the probability of selection into the ASM mail sample (Q) multiplied by its conditional probability of subselection into the MECS sample (R).
- Q: Probability of selecting an establishment from the mail file to be in the ASM sample.
- R: Conditional probability of selecting an establishment for the MECS sample, given that it is in the ASM sample.
- T: The inflation weight associated with the overall sampling probabilities for the MECS by the relationship

$$T = \frac{1}{P} = \frac{1}{Q \cdot R}$$

- A: Weight Adjustment factor, used to adjust MECS inflation weights to account for nonresponse and undercoverage in the MECS survey.
- W: The final MECS weight, equal to the inflation weight T multiplied by the weight adjustment factor A.

### III. Counts and Count Variables

- N: Number of establishments in the list from which the ASM sample is drawn.
- n: Target (desired) number of cases in the ASM sample.
- n': Actual size of the ASM sample.
- m: Target (desired) number of MECS sample cases.
- m': Actual size of the MECS sample.
- a: A random variable which takes on the value 1 for establishments that are selected for the ASM; 0 otherwise.
- $\infty$ : A random variable which takes on the value 1 for establishments in the ASM sample that are selected for the MECS; 0 otherwise.

### IV. Statistical Operators and Variability Measures

- $E_a$ : Expected value over all possible ASM samples from the establishment population.
- $E_m$ : Expected value over all possible MECS subsamples of a fixed ASM sample.
- $\sigma^2$ : True variance of a survey estimator.
- $S^2$ : Estimated variance of a survey estimator.
- U: Estimated level of undercoverage of consumption in the target population by the MECS sample.

U: Estimated level of undercoverage of consumption in the target population by the MECS sample.  
U(rel): Estimated relative level of undercoverage of consumption in the target population by the MECS sample, defined as the absolute level of undercoverage U divided by the MECS consumption estimate.

$V^2$ : Estimated relative variance of a survey estimator.

#### V. Subscripts Delineating Population Subgroups and Collection Times

- b: Subscript denoting the set of establishment births during 1984; used with establishment counts.
  - c: Subscript denoting an establishment size class based on overall probability of selection for the MECS; used with various parameters, reported values, probabilities, weights, weight adjustments, counts, and count variables.
  - d: Subscript denoting the set of establishment deaths during 1985; used with establishment counts.
  - g: Subscript denoting an unspecified subgroup of the manufacturing sector; used with various data parameters, reported values, weights, and establishment counts.
  - h: Subscript denoting the set of establishments in the ASM mail file; used with various data parameters.
  - i: Subscript denoting the set of establishments in the ASM nonmail file; used with various data parameters.
  - j,k: Subscripts denoting unspecified individual establishments; used with various parameters, reported values, probabilities, weights, weight adjustments, and count variables.
  - r: Subscript denoting the set of establishments that responded to the MECS; used with various counts.
  - s: Subscript denoting a Standard Industrial Classification (SIC) category; used with various data parameters, reported values, probabilities, weights, weight adjustments, counts, and variability measures.
  - t: Subscript denoting the set of establishments in the total manufacturing establishment file (the mail file + the nonmail file); used with various data parameters.
- 81,84: Subscripts denoting values for calendar years 1981 and 1984; used with various data parameters.

Symbols from Groups I - IV are combined with subscripts from Group V to describe all of the specific measures referred to in this document. For example,  $m'_{scr}$  represents the number of responding (r) MECS sample establishments ( $m'$ ) in SIC s and size class c. Similarly,  $E_{84j}$  represents the purchased electricity consumption for establishment j, as reported on the 1984 ASM.



# Get the facts!

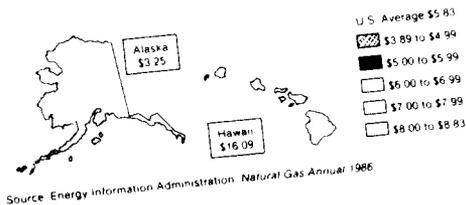
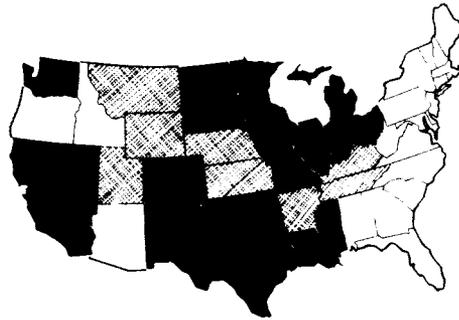
A quick reference to U.S. and international oil, gas, coal, electricity, and nuclear energy data.

## U.S. Natural Gas Consumption (Trillion Cubic Feet)

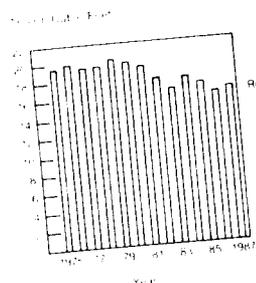
Year	Residential	Commercial	Industrial	Electric Utilities	Transportation	Total
1974	4.92	2.51	8.36	3.16	0.58	19.54
1975	5.05	2.67	8.60	3.08	.53	19.52
1976	4.92	2.60	8.47	3.19	.53	19.63
1977	4.90	2.60	8.40	3.49	.60	20.24
1978	4.97	2.79	8.40	3.68	.63	19.88
1979	4.75	2.51	8.20	3.64	.64	19.40
1980	4.75	2.52	8.06	3.23	.60	18.00
1981	4.63	2.81	6.94	2.91	.49	16.83
1982	4.63	2.41	6.62	3.11	.53	17.28
1983	4.38	2.52	7.23	3.04	.50	16.22
1984	4.46	2.43	6.50	2.60	.49	16.62
1985	4.43	2.32	6.50	2.60	.50	16.62
1986	4.37	2.29	6.68	2.84		
1987P	4.37	2.29	6.68	2.84		

P: Preliminary data.  
Note: Total may not equal sum of components due to independent rounding.  
Source: Energy Information Administration, Annual Energy Review 1987.

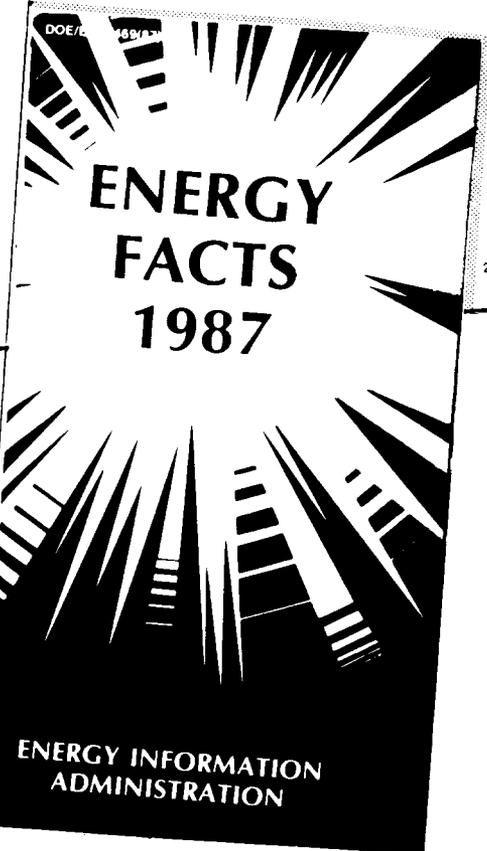
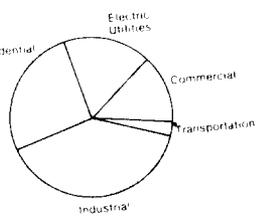
## Average Price of Natural Gas to Residential Consumers in 1986 (Dollars per Thousand Cubic Feet)



## Total Consumption



## 1987 Consumption



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