

DOE/EIA-0588
Distribution Category UC-98

Energy Consumption by End-Use Sector

**A Comparison of Measures
by Consumption and Supply Surveys**

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



Contacts

General information concerning the contents of the report may be obtained from Lynda T. Carlson, Director of the Energy End Use Division (202/586-1112). Specific information regarding the contents or preparation of the publication may be obtained from Nancy L. Leach, Chief of the Residential and Commercial Branch (202/586-1114). The Residential Energy Consumption Survey manager and a major contributor to this report is Wendel Thompson (202/586-1119). The report was written by Gerald Peabody (202/586-6160).



Preface

This report was prepared in response to a request from the Office of Policy Integration in the U.S. Department of Energy for an analysis of how Energy Information Administration data from its consumption surveys compares with data from its supply surveys. The consumption surveys provide valuable details about energy use by the consumers, while the supply surveys provide valuable detail on trends in total consumption. The Office of Policy Integration, and other users of EIA data, often need to rely on supply surveys to understand trends and on consumption surveys to understand market forces. This report highlights those areas where the two types of surveys overlap and reinforce each other and those areas where they have differences. This report is a first step in making both sets of EIA data more useful to policy analysts who use EIA data in their work.



Contents

Introduction	1
Comparison of Supply and Consumption Survey Methodologies	5
Overview of Surveys	5
Supply and Consumption	7
Sources of Uncertainty or Error	8
Sampling Techniques	10
Sector Coverage by Survey Type	11
Residential Sector	17
Sector Coverage by Survey Type	17
Energy Consumption by Fuel Type	19
Commercial Sector	23
Sector Coverage by Survey Type	23
Energy Consumption by Fuel Type	25
Industrial Sector	31
Sector Coverage by Survey Type	32
Energy Consumption by Fuel Type	33
Conclusion	39

Tables

1. Number of Commercial and Industrial Electric Accounts, 1966 - 1987	14
2. Residential Electricity Consumption and Supply	20
3. Residential Natural Gas Consumption and Supply	21
4. Residential Fuel Oil Consumption and Supply	22
5. Commercial Electricity Consumption and Supply	27
6. Commercial Natural Gas Consumption and Supply	28
7. Commercial Fuel Oil Consumption and Supply	29
8. Industrial Fuel Oil and Kerosene Consumption and Supply	35
9. Coal Consumption from MECS and Supply Survey for Manufacturing Industries	37



Introduction

Energy policy makers--be they industry executives, members of utility commissions, or government officials--require reliable data to make informed decisions. The need is particularly acute when the task is to forecast the future of energy markets. Making reasonable estimates of possible future prices, supply, and demand for energy requires accurate and detailed data about the current and historical situation of energy markets.

The Energy Information Administration (EIA) was mandated by Congress to be the agency within the Department of Energy that collects, analyzes and disseminates impartial, comprehensive data about energy--how much energy is produced, who uses it, and the purposes for which it is used. Energy data are also collected by a wide range of other groups; including other governmental agencies--Federal, State and local; individual utility companies; and members of the energy industry, including individual companies and industry associations, such as the Edison Electric Institute.

To forecast energy market behavior, it is useful to bring together as much data as possible about the supply and demand of energy. The integration of data on the same subject from different sources, however, usually entails some difficulty since data collected by different groups and/or by different means are seldom completely compatible. Some effort must therefore be undertaken to reconcile the differences in data sets before the combined data can be used in an analysis.

EIA collects data from two distinct sources that, in their entirety, provide a comprehensive picture of energy production, marketing and use in the United States. The first set of surveys--termed "supply" surveys in this report--are directed to the suppliers or marketers of specific fuels (including electricity). These surveys measure the quantity of the specific fuel produced and/or supplied to the market, along with other information related to the fuel's production and supply. Supply surveys are conducted for petroleum, natural gas, electricity, and coal. (The "supply" surveys for coal include surveys of consumers, which provide information on coal consumption; these surveys are discussed in the chapter on the industrial sector.)

The second group of surveys--termed "consumption" surveys in this report--collect data from samples of end-use consumers. These consumers use one, several, or all kinds of fuels. These surveys gather information on the types of fuels used by the consumer, the purposes for which each fuel is used, and the characteristics of the users. The end-use consumption surveys are conducted for the residential sector, commercial buildings, manufacturing establishments, and personal transportation.

Together, the data from the supply and consumption surveys provide a rich, detailed source of data on energy supply and use. The supply surveys have been conducted for many years, starting with predecessor agencies to EIA. The consumption surveys were started during the past decade under the auspices of EIA.



It is tempting to merge the time series data from the supply surveys with the detailed cross-sectional data from the consumption surveys. However, there are important differences between the supply and consumption surveys which need to be taken into account in any analysis that uses both data sources.

This report discusses the relationship of EIA data from the supply surveys and from the consumption surveys. This comparison is made for three major end-use sectors: residential, commercial, and industrial. The discussion of industry is limited because the consumption survey covers manufacturing industries while the supply surveys (with the exception of coal) cover the entire industrial sector. No discussion is given of the transportation sector because the end-use consumption survey collects data only for personal transportation, and there are no comparable supply data available. Estimates of energy supply and consumption in each sector are compared for electricity, natural gas, petroleum fuels, and (for manufacturing industries) coal.

There are three important differences between the supply-based and consumption-based surveys:

- The supply surveys measure product supplied at some point in the supply chain, while the consumption surveys measure the actual quantity of fuel consumed (except for petroleum fuels for which the quantity delivered to the consumer is measured). Since fuels (except electricity) can be stored, the amount of product supplied to a sector in a given period is not necessarily equal to the amount consumed.
- The consumption surveys are based on a sample of the consumers in each economic sector, so there is a sampling error associated with the data from these surveys in addition to the nonsampling errors that are common to both sample and census surveys. In many cases, the supply surveys are a census of suppliers and so have no sampling error.¹
- There are differences between the consumption and supply surveys in the coverage of each sector. The residential consumption survey, for example, does not cover the same set of residences as do the supply surveys. Further, there are differences among the various supply surveys in the coverage of each sector.

These differences are discussed further in the next chapter. It is important to note that the existence of differences between the two types of surveys does not mean that one or the other is incorrect or improperly conducted. In both types of survey, the decisions on the kinds of data to gather and the means to collect them have been based on sound statistical criteria and a full understanding of the types of data that could be collected without placing an undue burden on the respondent. For the most part, the differences between the two types of surveys reflect limitations imposed by efforts to minimize the burden of responding to the surveys and the need

¹The term census, or census survey, in this report is used to mean a survey that covers all the members of the population from which data is being collected. A sample survey, on the other hand, collects data from a portion (a small portion in the case of the consumption surveys) of the total population being surveyed.

to limit the costs of data collection.

The result of the comparison in this report shows that, taking into account their differences, the two types of surveys present a consistent picture of energy consumption in the United States. Neither type of survey alone provides a complete description of energy consumption by economic sector. A fuller understanding of energy use by sector can be obtained by using data from the two sources, allowing for their differences.

Before comparing the methodologies used in the supply and consumption surveys, the sources of data used in this report will be described briefly. For each energy consumption survey, there are associated publications with detailed tables of findings from the survey. For the most part, data in this report have been obtained from these publications. In a few cases in which consumption figures were revised after the associated publication was released, the revised figures were obtained from the *Annual Energy Review* (AER), a composite report containing annual time series of data on energy production, price, and consumption.

For the fuel supply surveys, there are several sources of supply estimates. Preliminary estimates are obtained and published from weekly or monthly surveys. There are also annual reports, which publish results either from a separate annual survey or from a compilation of data received in the monthly surveys. In addition to data on quantities supplied and prices, reports based on the supply surveys provide a wealth of information about other factors related to the supply of each fuel.

Annual data on supply, consumption and prices for all fuels are also published in two consolidating reports--the AER and the *State Energy Data Report* (SEDR). These two reports are generally the source of supply data quoted in this report, because they publish any revisions to the annual supply data that occurred after the associated annual report was published. The SEDR contains consumption and prices for a variety of fuels by economic sector for each State. In some cases, the data in SEDR may differ from that published for the supply surveys because of differences in the definitions of the end-use sectors. For this report, this difference is of importance primarily for commercial consumption of electricity, which will be discussed in more detail in the chapter on the commercial sector.

The next section compares the methodology of the supply and consumption surveys. Particular attention is paid to the three important differences between them noted above. Successive chapters discuss each end-use sector covered in this report (residential, commercial, and industrial), with separate sections for each fuel. The final chapter summarizes the report's findings.



Comparison of Supply and Consumption Survey Methodologies

The supply and consumption surveys conducted by EIA to measure energy use in the different economic sectors are based on different methods for collecting data, and they collect different kinds of data. This chapter gives a brief overview of each type of survey and discusses some of the important differences between the surveys that should be recognized in using the data from both types of survey to analyze energy demand or for other purposes.

Overview of Surveys

The consumption surveys collect information with a sample survey based on a relatively small number of users of energy in each sector. These surveys collect detailed information on the amounts of energy consumed, the purposes for which energy is used, and the characteristics of the users. The sample of consumers is selected using statistical techniques that allow the survey results to be generalized to the total population for the sector. These surveys are now conducted every three years.

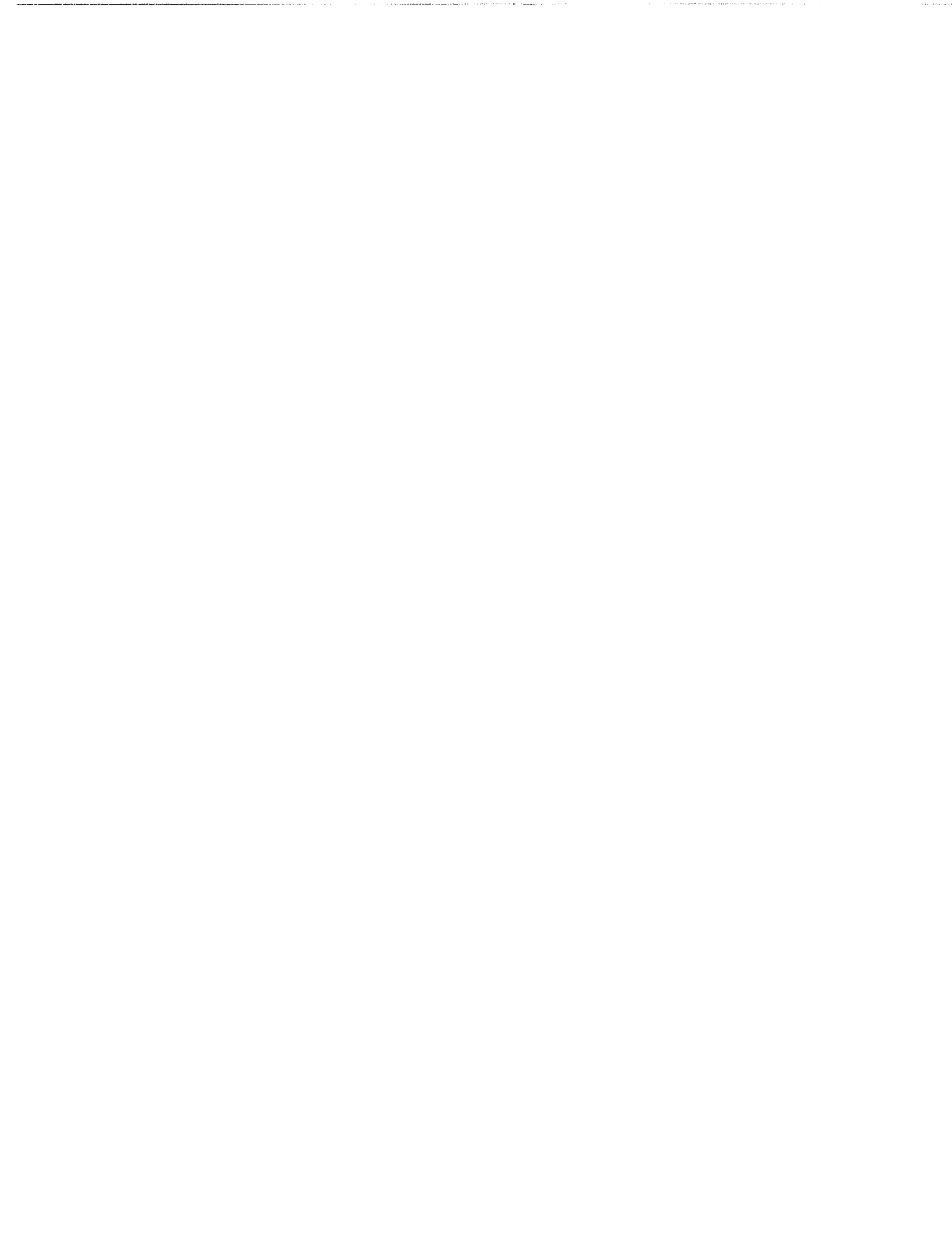
The supply surveys use both census and sample surveys to collect data. There are a number of supply surveys for each fuel that are conducted at different frequencies and collect different types of data. The supply data used in this report are based on census surveys for electricity and natural gas, while the petroleum fuels survey is a sample survey.²

Energy Supply Data

Statistical data on the production and sale of the principal sources of energy have been collected and published for many years. The producers and/or primary suppliers of a specific type of energy generally number in the hundreds to thousands. This number allows for data collections from all the major suppliers and a substantial portion, if not all, of the smaller ones.

Data collected from suppliers provide a measure of the total amount of the specific type of energy supplied. These surveys also collect a range of other information related to the production and supply of each fuel. However, only the total quantity supplied to each end-use

²The petroleum data from the SEDR that are quoted here have, however, been benchmarked to total products supplied, figures calculated from census surveys.



sector is relevant to this report, so the other types of data will not be discussed. The supply surveys considered in this report are for electricity, natural gas, petroleum fuels (kerosene and distillate and residual fuel oils), and coal.³

The data used in this report are from one survey for each of the fuels. Annual electricity sales data are currently collected on Form EIA-861, "Annual Electric Utility Report," which is sent to all electric utilities in the United States. The findings are reported in the *Electric Power Annual*. Annual natural gas data are collected on Form EIA-176, "Annual Report of Natural and Supplemental Gas Supply and Disposition," which is mailed to all natural gas pipeline companies and other companies that deliver natural gas directly to consumers, with results reported in the *Natural Gas Annual*. Petroleum fuel sales to end-use sectors are collected in a sample survey using Form EIA-821, "Annual Fuel Oil and Kerosene Sales Report," and reported in the *Petroleum Marketing Annual*. The coal data used here are unique in that the "supply" data are from a survey of consumers rather than suppliers. Form EIA-3, "Quarterly Coal Consumption Report," is sent to all manufacturing plants that consume coal, and the findings are reported in the *Quarterly Coal Report*.

The production and sales data provide limited information about the users of energy. The supply data can be categorized into very broad groupings of types of customers (residential, industrial, and so on), generally based on rate classifications, and their location (state or region). These data provide no information on how the customers use the energy. For information about the purposes for which energy is used, data must be collected from the users themselves.

End-Use Consumption Data

Data collected from the final consumers of energy provide information about the amount of energy consumed by individual consumers and the purposes--end uses--for which it is used. Energy is needed for the services it can perform: heating homes or buildings, fueling vehicles, or powering a manufacturing process. End-use consumption data provide information about the ways energy is used to provide these services. End-use data for a home, for example, would provide information about the various types of energy used in the home, the purposes for which energy is used, and the amount of each fuel consumed. At the most detailed level, this information would specify how much fuel was used to perform a particular function--how much natural gas, for example, was used to heat a house.

To obtain consumption information at this level of detail, it is necessary to ask the consumers themselves what types of energy they use and the purposes for which they use it. The energy consumption surveys conducted by EIA are based on detailed information obtained from a sample of consumers in three major economic sectors--residential (including private vehicle use), commercial buildings, and manufacturing industries. Each of the consumption surveys are now conducted every three years. The Residential Energy Consumption Survey (RECS) is conducted

³Except for the industrial sector, the petroleum fuels are considered collectively in this report. RECS and NBECS do collect data on kerosene, as well as distillate and residual fuel oil, but for the purposes of this report it is sufficient to consider the petroleum fuels in total.



on a sample of full-time occupied residences, and has been conducted seven times starting in 1978. The survey of commercial buildings, the Nonresidential Buildings Energy Consumption Survey (NBECS), is conducted on a sample of buildings in which over one-half the floorspace is devoted to commercial activities.⁴ NBECS has been conducted three times starting with 1979. The Manufacturing Energy Consumption Survey (MECS) is based on a sample of manufacturing establishments and was first conducted in 1985.

For the RECS and NBECS, personal interviews are conducted with the home owner or building representative; for MECS, the survey questionnaire is mailed to the establishments. Data on the amount of fuels consumed are obtained from the companies that sell the fuels to the users for RECS and NBECS. The respondents list the quantities of fuel purchased and consumed in MECS.

The introduction noted three important differences between the supply and consumption surveys: the distinction between consumption and supply, sources of errors in the surveys, and the types of units covered within a sector by each survey. These differences are discussed in turn. In addition, the supply and consumption surveys use two different sampling techniques to draw samples for the surveys. RECS and NBECS are based on multistage area probability sampling techniques, while MECS and the petroleum supply survey, EIA-821 "Annual Fuel Oil and Kerosene Sales Report," use sampling from lists. These sampling techniques are also briefly described.

Supply and Consumption

A market is in balance when supply equals demand, or consumption. Consequently, the terms supply and consumption are sometimes used interchangeably in reports on energy use. For petroleum fuels, however, there are a number of steps in the chain of supply. It extends from the oil field where the crude oil is produced (or the receiving dock where the oil is imported), to the refinery where various fuels and other products are produced from the crude oil, and to the resellers and dealers who ultimately sell the fuels to the final consumer. Supply can be measured at several points along the supply chain, and these measures of supply will not necessarily be equal to measures of final end-use consumption.

Products held by a supplier need not be consumed in a given time period; they can be stored or exported. Further, a supplier may sell products from storage or products that have been imported. This is primarily true for petroleum fuels, where there are a number of products, storage at many points in the supply chain is common, and both crude oil and products can be imported and exported.

Natural gas is also stored and imported, but this does not affect the supply data cited here.

⁴The next commercial buildings survey, conducted for 1989, will be termed the Commercial Buildings Energy Consumption Survey (CBECS). The acronym NBECS will be used throughout this report since that is the name of the surveys reported on here.



The annual survey based on Form EIA-176 is sent to companies that deliver gas directly to consumers, so the measures of end-use sales from this survey should be compatible with end-use consumption data. For electricity, no storage is possible, so there is no distinction between supply and consumption.

Because the supply situation for petroleum fuels is complex, there are two types of surveys conducted in this area: supply surveys and marketing surveys. The supply surveys focus on field production of crude oil, refinery operations, and import/exports. The marketing surveys cover refiners, gas plant operators, suppliers, and resellers. The survey cited in this report is part of the petroleum marketing survey of retailers and resellers. The "Annual Fuel Oil and Kerosene Sales Report" (Form EIA-821) survey determines the quantity of product sold to end-use customers. Two types of findings are reported from this survey: the direct sales data are reported, along with data that have been adjusted to ensure that the PAD District total sales of distillate and residual fuel oils and kerosene equal the products supplied as published in the *Petroleum Supply Annual*. These adjusted figures are called supply and are the values used in SEDR for end-use consumption by sector. These figures are also used here to compare supply with consumption data.

In comparing the results from two different types of survey, it is important to account for errors in the data. The next section discusses the types of errors in the supply and consumption survey data.

Sources of Uncertainty or Error

Three sources of error--respondent error, processing error, and sampling frame error--are common to both types of surveys, census and sample. Another source of error, sampling error, is introduced when a sample of the target population is surveyed instead of the entire population.

Respondent, Processing, and Frame Errors

Respondent errors in survey data result from incorrect answers, or failure to answer a question, by the respondent. All the survey data quoted in this report are subject to this type of error. To minimize such errors, rigorous procedures have been developed and tested over time for each survey to screen responses for plausibility and to check with the respondent when an answer does not seem reasonable or when a question is not answered. Every effort is made to ensure that the answers provided are correct, to the extent that the respondent can answer the question. Nonetheless, not all errors will be corrected, so there remains an unknown level of respondent error in the survey data discussed in this report.

For the residential and commercial consumption surveys, data are obtained from the fuel supplier as well as from the householder or building representative, and respondent error by the

fuel supplier can have an important effect on the quality of the survey results. For natural gas and electricity, only one supplier is available to the customer and the utilities keep good records on the quantities supplied to their customers. The quality of consumption data for these fuels is very high.

For fuel oil, on the other hand, the consumer can receive deliveries from several suppliers. When responding to the survey, the respondent may fail to list all the fuel oil suppliers. In addition, many fuel oil dealers are relatively small businesses and may not keep records in a form that allow them to readily determine the total quantities delivered to a particular customer. They might overlook some deliveries and fail to report them when responding to the survey. Consequently, data on consumption of fuel oil for the residential and commercial surveys have higher uncertainty than do data on natural gas and electricity consumption. Also, the petroleum consumption data may be biased low. For MECS, all fuel consumption data in the survey are from the manufacturer's records of purchases and are expected to be of equal quality for all fuels.

Another source of error in survey data comes from mistakes in processing the data after they are received. The data must be coded and then entered into a computerized data base system, and mistakes can occur at each step of the data processing. All of the surveys have extensive edit checks and other procedures designed to minimize these types of errors so that the data base reflects as accurately as possible the data received from the respondents.

Frame errors can occur in both sample and census surveys. To conduct a census survey, it is necessary to have an accurate list of all the members of the population being surveyed, or have a method for conducting the survey that will ensure that the total population is covered. Since any population is always changing through the addition (a new business starts up or a person is born) and deletion (a corporation goes out of business or a person dies) of members, keeping track of the population to be surveyed is difficult. An incompleteness in the list of the population being surveyed results in frame error for the survey. Sample surveys have a complex sample frame that is used to select the sample. To the extent these procedures lead to the selection of a sample that is not representative of the entire population (by under or over sampling a particular types of units) there will be frame error.

Respondent, processing and frame errors are common to all surveys. It is difficult to quantify the magnitude of these errors, so in publishing its data, EIA does not present an estimate of the size of error from these sources. Since no estimate of their size is available, these errors aren't discussed further in comparisons of the results from the supply and consumption surveys. The magnitude of sampling errors, however, is quantifiable.

Sampling Error

All of the consumption surveys and the annual survey of fuel oil dealers based on Form EIA-621 are sample surveys. Sample surveys are used when the population of interest is so large that it is not feasible to conduct a census survey. For example, there were 90.5 million households in the United States in 1987, while the Residential Energy Consumption Survey



(RECS) was based on about 6,000 households.

The statistical procedures followed in selecting the sample are designed to make the sample representative of the entire population. These procedures also determine how to make estimates for the entire population from the sample data, and how to estimate the uncertainty in these estimates, which is termed the sampling error.

For 1987, the year of the latest RECS, total energy consumption was estimated to be 9.13 quadrillion Btu (quads) for the residential sector. The sampling error, one standard error, for this estimate is 0.19 quads, about 2 percent of the estimated value. The 95-percent confidence interval for the estimate is 9.13 +/-0.37 quads. Based on the sampling error, we can be 95-percent confident that the true value for total consumption lies within the range from 8.77 to 9.51 quads. (The 95-percent confidence interval is the estimated value +/- 1.96 times the standard error.) The relative sampling error (RSE) will be cited in this report as the measure of uncertainty in the consumption surveys. (The RSE is the ratio of the standard error to the estimate expressed in percent.)

The standard error increases with decreasing size of the sample upon which an estimate is based. Consequently, for the consumption surveys, the standard errors are lower for fuels that are used by a large portion of the population, such as electricity, and higher for fuels used by a minority of the population, such as fuel oil for residential and commercial consumers.

The petroleum supply survey of annual fuel oil and kerosene sales is based on a sample of retailers, and sampling errors have been calculated for the sales data. The supply data quoted in this report are the sales data adjusted so that total sales equal total product supplied. The adjustment process redistributes sales among the end-use sectors. Standard errors aren't available for these supply figures, so only the standard errors from the consumption surveys are used in this report for making comparisons.

Sampling Techniques

Two types of sampling techniques are used to select the samples for the consumption and supply surveys: multistage area probability sampling and list sampling. RECS and NBECS use multistage area probability sampling techniques. MECS is based on a list of manufacturing establishments maintained by the Census Bureau, and the petroleum supply survey for Form EIA-821 uses a sample from list of fuel oil retailers and resellers. The NBECS sample is supplemented with a sample drawn from lists of large buildings. Each type of sampling technique is discussed in turn.

Multistage Area Probability Sampling

The sample selection process begins with a list of all the counties in the United States. Information about the county relevant to the particular survey, such as population size,

geographic location, and main heating fuel for households, is used to select counties for the sample. The selection process is designed to make the sample representative of the various regions of the country and of other population characteristics. Within the selected counties, successively smaller areas are selected, until a very small geographic area is selected.

An interviewer is then sent to that area to list all the units to be surveyed (either housing units or commercial buildings). These small areas generally contain about 45 to 50 housing units for RECS, and about 100 commercial buildings for NBECS. The interviewer records the address of each unit and the characteristics that are relevant to the survey (building size and apparent usage for NBECS, for example). From this listing, a small number of units are selected to be included in the survey.

A representative for each unit selected from the sample is interviewed in person and a questionnaire is filled out that contains comprehensive information about the characteristics of the building, the energy-using equipment within the building, and the characteristics of the occupants (household characteristics for RECS and business activities for NBECS). The respondent is also asked to sign an authorization form that allows EIA to get information on the energy supplied to the building directly from the suppliers. Thus the energy consumption data are obtained from actual billing data maintained by the utilities supplying the buildings. The responses from the household or building interviews, combined with the energy use information from the energy suppliers, form the content of the energy consumption surveys.

List Sampling

The second method used by EIA to select a sample for surveys is sampling from a list of members of the population. The NBECS uses lists to supplement the sample drawn by the multistage area probability sampling technique, while the MECS sample is drawn entirely from a list of manufacturing establishments. For NBECS, lists of specialized buildings were used (hospitals, colleges and universities, schools, post offices, and Federal government buildings) as well as a list of large buildings in each metropolitan area. MECS is based upon a comprehensive list of manufactures that is maintained by the Census Bureau for its Annual Survey of Manufactures. The characteristics of the buildings or manufacturing establishments are used to draw a sample that is representative of all types of buildings or establishments. For example, for the MECS, the lists are stratified by industry groups and the drawing is made from within each manufacturing group to ensure that all manufacturers are represented. The annual survey of fuel oil dealers is a sample drawn from the list of dealers maintained for the sampling frame for the monthly petroleum marketing surveys. This list is also stratified by dealer characteristics so that the sample is representative of the universe of dealers.

Sector Coverage by Survey Type

The consumption surveys were designed to provide broad information about energy consumers

geographic location, and main heating fuel for households, is used to select counties for the sample. The selection process is designed to make the sample representative of the various regions of the country and of other population characteristics. Within the selected counties, successively smaller areas are selected, until a very small geographic area is selected.

An interviewer is then sent to that area to list all the units to be surveyed (either housing units or commercial buildings). These small areas generally contain about 45 to 50 housing units for RECS, and about 100 commercial buildings for NBECS. The interviewer records the address of each unit and the characteristics that are relevant to the survey (building size and apparent usage for NBECS, for example). From this listing, a small number of units are selected to be included in the survey.

A representative for each unit selected from the sample is interviewed in person and a questionnaire is filled out that contains comprehensive information about the characteristics of the building, the energy-using equipment within the building, and the characteristics of the occupants (household characteristics for RECS and business activities for NBECS). The respondent is also asked to sign an authorization form that allows EIA to get information on the energy supplied to the building directly from the suppliers. Thus the energy consumption data are obtained from actual billing data maintained by the utilities supplying the buildings. The responses from the household or building interviews, combined with the energy use information from the energy suppliers, form the content of the energy consumption surveys.

List Sampling

The second method used by EIA to select a sample for surveys is sampling from a list of members of the population. The NBECS uses lists to supplement the sample drawn by the multistage area probability sampling technique, while the MECS sample is drawn entirely from a list of manufacturing establishments. For NBECS, lists of specialized buildings were used (hospitals, colleges and universities, schools, post offices, and Federal government buildings) as well as a list of large buildings in each metropolitan area. MECS is based upon a comprehensive list of manufactures that is maintained by the Census Bureau for its Annual Survey of Manufactures. The characteristics of the buildings or manufacturing establishments are used to draw a sample that is representative of all types of buildings or establishments. For example, for the MECS, the lists are stratified by industry groups and the drawing is made from within each manufacturing group to ensure that all manufacturers are represented. The annual survey of fuel oil dealers is a sample drawn from the list of dealers maintained for the sampling frame for the monthly petroleum marketing surveys. This list is also stratified by dealer characteristics so that the sample is representative of the universe of dealers.

Sector Coverage by Survey Type

The consumption surveys were designed to provide broad information about energy consumers

in specific economic sectors. The design of the sampling frame determines what portion of the sector is included in the sample. The supply surveys, on the other hand, were designed to survey suppliers of specific fuels to provide information about the quantities of fuel supplied and at what price. The supply surveys weren't necessarily designed to obtain information about end-use sectors, and what information is obtained about deliveries of fuels to individual sectors is obtained from responses to the questions on the survey form. The coverage of each sector varies between the supply and consumption surveys, and among the various supply surveys. The following sections give an overview of some of these differences in coverage and the reasons for them. More detailed discussions are provided in the individual chapters for each sector.

Consumption Surveys

The RECS sample is designed to cover all occupied residential units, but it explicitly excludes summer homes and other homes that are only occupied for part of the year. Farm houses and single family houses on military bases are included, as are apartments. Group housing, such as school dormitories, military barracks, and nursing homes are not covered.

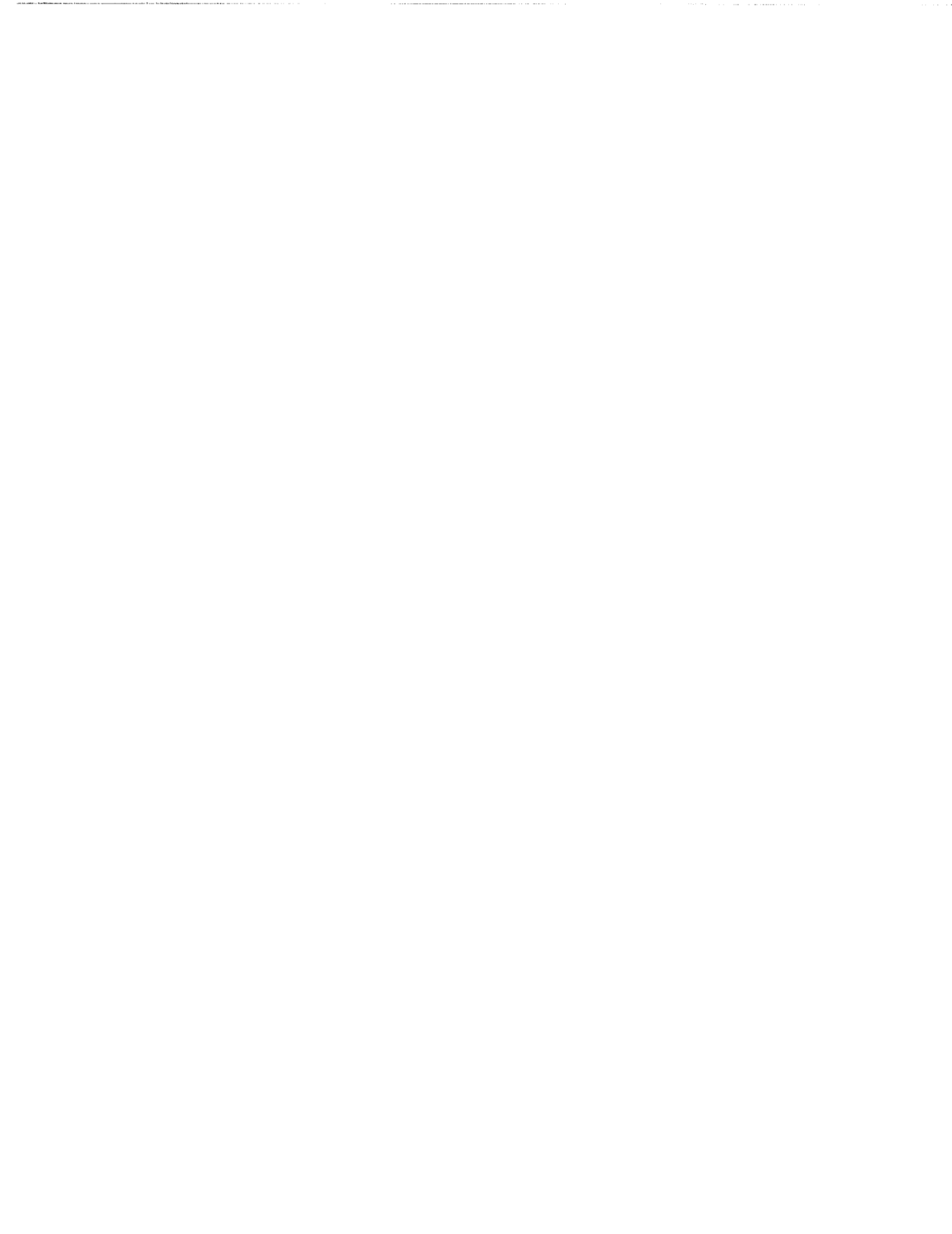
NBECS covers commercial activities that take place in buildings, but excludes the limited number of commercial sector activities that are not located in buildings (street lighting, for example). NBECS also picks up a small amount of consumption by residences or industrial establishments that are located in buildings that are primarily commercial, and it misses consumption by commercial establishments located in buildings that are primarily noncommercial.

The MECS is explicitly designed to cover manufacturing industries, and since it is based on a comprehensive list of manufacturing establishments, it provides complete coverage of the manufacturing sector. However, there is no consumption survey that covers the other segments of the industrial sector--construction, mining, and agriculture.

Supply Surveys

For each fuel, annual data are collected on sales or deliveries to end-use consumers. However, there is some variation among the surveys in the way the end-use sectors are defined. The quality of the data on end-use sector sales depends on the response to the question by the utility or supplier. In many cases, suppliers will classify their end-use sales by rate classification which may not be consistent with other definitions of the sectors.

Electric and natural gas utility companies have different rate structures for different categories of customers. They will typically have one rate schedule for residential customers, with relatively low consumption levels; a second rate schedule for commercial customers, with intermediate levels of consumption; and an industrial rate schedule for large consumers. The rates reflect any number of considerations that are important to the economic welfare of the company and may reflect other interests as well, such as life-line rates that provide economic service to low-income families.



The utility specifies how much fuel it supplied to residential, commercial, industrial, and other customers by totaling the quantity supplied under these rate classes. Utilities are not required to maintain records on the economic activities of their customers, so their rate structures may not correspond to economic definitions of the end-use sectors. To the extent there is not a one-to-one correspondence between the economic activity of the customers and the rate schedule at which they are billed, there will be a misclassification of end-use sector supply data.

The instructions for Form EIA-861, the EIA form for collecting annual supply information from electric utilities, specify that the utility should list sales to five categories of end users. These categories include the major end-use sectors (residential, commercial, and industrial) as well as two categories specific to the survey (street and highway lighting and other). The instructions for the form are intended to allow the utilities to use their preferred bases for categorizing consumers. Thus utilities are allowed to use discretion to determine which customers are classified in what end-use sector.

The form for the natural gas survey, Form EIA-176, provides definitions of the different sectors. A study of a small number of respondents found there is some misclassification in the natural gas data due to the way records are kept, but the misclassification is highly consistent over time.⁵ For example, a large master-metered apartment building may be classified as commercial if it is billed at commercial rates.

It is possible for a customer's classification--or rate schedule--to change over the course of the year as its consumption varies. For example, a very large commercial building may have a high electricity load in the summer when it runs its air-conditioning equipment and be billed at industrial rates. In the winter, if it is heated with gas, the building's electricity consumption might be substantially lower and be billed at commercial rates. This is most likely to be a concern for electric utilities, where consumption for summer months can increase markedly to air condition a building, and then be much lower in the fall and spring, when much less heating or air conditioning is required.

There are no data available that would enable EIA to determine how much misclassification there might be in end-use sector supply data supplied by the utilities. There are, though, some limited data that suggest that the problem is not negligible.⁶

The Edison Electric Institute (EEI) recognizes this situation and consequently combines commercial and industrial sales data when they make comparisons with EIA data. This is done to minimize changes that may be caused by changes in classification. Concerning the published

⁵An intensive study was conducted by EIA's Office of Oil & Gas on a small sample of respondents to Form EIA-176.

⁶In 1978, Southern California Gas had 8,000 customers they classified as industrial. Following a reclassification that was designed to have their classification conform to the standard industrial classification (SIC) codes, the number of industrial customers increased to 30,000. (Data quoted in a 1984 letter from Paul Schaffer, Senior Editor for Statistics, *Energy Daily News*, to Lynda Carlson, Director of the Energy End Use Division of EIA.)



counts of commercial and industrial customers, the EEI notes in the 1986 edition of its *Statistical Yearbook* (p. 53) that "commercial and industrial are not wholly comparable on a year-to-year basis due to changes from one classification to another."

Evidence that customers are not consistently classified from year to year appears in the historical trends of the number of accounts classified as commercial and industrial (Table 1). The EEI data indicate that commercial accounts have shown a steady increase every year from 1966 through 1987. The number of industrial accounts has shown more variation in their growth. In 1982, the number of industrial accounts reached a peak which has not been reached since.

Table 1. Number of Commercial and Industrial Electric Accounts, 1966 - 1987

Year	Commercial	Percent Change	Industrial	Percent Change
1966	7,536,066		316,098	
1967	7,579,626	+0.6	324,222	+2.6
1968	7,706,779	+1.7	333,650	+2.9
1969	7,744,851	+0.5	348,648	+4.5
1970	7,865,073	+1.6	352,993	+1.2
1971	8,002,572	+1.7	355,967	+0.8
1972	8,200,033	+2.5	369,952	+3.9
1973	8,361,847	+2.0	413,383	+11.7
1974	8,472,817	+1.3	422,736	+2.3
1975	8,591,108	+1.4	414,665	-1.9
1976	8,750,949	+1.9	427,403	+3.1
1977	8,943,732	+2.2	448,009	+4.8
1978	9,148,399	+2.3	464,637	+3.7
1979	9,386,572	+2.6	477,874	+2.8
1980	9,698,809	+3.3	484,652	+1.4
1981	9,847,260	+1.5	516,996	+6.7
1982	9,976,274	+1.3	533,635	+3.2
1983	10,266,449	+2.9	500,215	-6.3
1984	10,565,239	+2.9	525,692	+5.1
1985	10,920,861	+3.4	499,728	-4.9
1986	11,114,300	+1.8	498,254	-0.3
1987p	11,358,420	+2.2	494,545	-0.7

p: preliminary data

Source: Edison Electric Institute, *Statistical Yearbook of the Electric Utility Industry/1986*, Table 10; customer count is for December 31 of year indicated.

There are three aspects to the ways utilities are likely to classify consumption by sector that affect comparisons between consumption and supply data and studies of variations in supply data



over time. First, as has been discussed, some utilities use rate schedules for commercial, industrial, and other customers that do not provide a distinction between these customers that is consistent with the economic definitions of the sectors in which the customers are located.

Second, the rate schedules for different utilities are not necessarily the same, so it is likely that the characterization of customers will vary across utilities. This can be important for studies of regional differences in consumption that are based on supply data. To the extent that differences of energy supplied to a specific sector reflect differences in utilities' classification rather than actual differences in consumption, the analysis will be adversely affected.

Finally, within a utility the classification of customers may shift over time for two reasons. First, a company may change its consumption level over the course of time, or even over the course of one year, and therefore move between different rate classifications. Then the customers' consumption would be shifted back and forth between commercial and industrial categories, even though the business of the customer did not change. Secondly, a utility may change its rate structure and therefore change the distribution of its supply among the sectors even though the nature of the customers did not change.

For these reasons, the time series of supply-based consumption data do not present a clean time series of consumption by economic sector. There are unknown shifts of consumption among sectors that will occur because of changes in rate structures or movements between rate structures by firms that have changes in consumption. Since there are no data available that would enable EIA to determine to what extent these changes are taking place, the supply-based consumption data must be used with some caution in time series analyses of consumption by sector. Further, care must be taken in attempting to integrate supply-based data and consumption-based data. Since it is likely that these two sources of consumption data are not measuring consumption by the same population of consumers, care must be taken in any analysis that is based on the joint use of these data.

The situation for each end-use sector will be discussed in more detail in the following chapters. These chapters consider each sector individually, and discuss the degree of overlap of coverage in the consumption and supply surveys for each fuel. The discussion in these chapters should prove to be an aid to analysts who are studying energy demand through the joint use of supply and consumption data series.

over time. First, as has been discussed, some utilities use rate schedules for commercial, industrial, and other customers that do not provide a distinction between these customers that is consistent with the economic definitions of the sectors in which the customers are located.

Second, the rate schedules for different utilities are not necessarily the same, so it is likely that the characterization of customers will vary across utilities. This can be important for studies of regional differences in consumption that are based on supply data. To the extent that differences of energy supplied to a specific sector reflect differences in utilities' classification rather than actual differences in consumption, the analysis will be adversely affected.

Finally, within a utility the classification of customers may shift over time for two reasons. First, a company may change its consumption level over the course of time, or even over the course of one year, and therefore move between different rate classifications. Then the customers' consumption would be shifted back and forth between commercial and industrial categories, even though the business of the customer did not change. Secondly, a utility may change its rate structure and therefore change the distribution of its supply among the sectors even though the nature of the customers did not change.

For these reasons, the time series of supply-based consumption data do not present a clean time series of consumption by economic sector. There are unknown shifts of consumption among sectors that will occur because of changes in rate structures or movements between rate structures by firms that have changes in consumption. Since there are no data available that would enable EIA to determine to what extent these changes are taking place, the supply-based consumption data must be used with some caution in time series analyses of consumption by sector. Further, care must be taken in attempting to integrate supply-based data and consumption-based data. Since it is likely that these two sources of consumption data are not measuring consumption by the same population of consumers, care must be taken in any analysis that is based on the joint use of these data.

The situation for each end-use sector will be discussed in more detail in the following chapters. These chapters consider each sector individually, and discuss the degree of overlap of coverage in the consumption and supply surveys for each fuel. The discussion in these chapters should prove to be an aid to analysts who are studying energy demand through the joint use of supply and consumption data series.

Residential Sector

There is no well-established definition of the residential sector as there is for the other sectors. The residential sector is generally considered to consist of all private residences, including single family homes (both owned and rented), multifamily housing units, apartments, and mobile homes. Secondary homes, such as summer homes, are also included. Institutional housing, such as school dormitories, hospitals and military barracks, are generally not included in the residential sector. Since there is no standardized definition of this sector, there will be variation in which dwelling units are included in it in different studies or data sources. Residential housing units consume energy for space heating, water heating, air conditioning, lighting, refrigeration, cooking, clothes drying, and other appliance operation.

The Residential Energy Consumption Survey (RECS) provides a direct measure of energy consumption in individual housing units, along with detailed information about the housing unit, its energy consuming equipment, and the characteristics of the unit residents. The various EIA supply surveys provide estimates of the total amount of individual fuels supplied to the residential sector in total. The consumption survey and the various supply surveys differ somewhat in the types of housing units that are included in their respective definitions of the residential sector, as will be discussed in the following section.

Sector Coverage by Survey Type

All surveys cover the major portion of the residential sector, private housing units. However, there are some significant differences in the way certain portions of the sector are handled. RECS covers occupied, primary residences, but does not include vacant and secondary housing units. These units tend to be covered by the supply surveys. On the other hand, the supply surveys vary in their coverage of apartments and farm houses.

Consumption Survey

The sampling frame for RECS is explicitly designed to cover all residential housing units that are primary residences. It excludes units that are vacant or that are secondary homes, such as vacation homes, as well as migratory housing. The sample includes apartment buildings, farm homes, and single family homes on military bases (but not housing in military barracks). Other forms of institutionalized housing, such as college dormitories and hospitals, are not included.

The impact of excluding migratory and secondary housing cannot be assessed without data on the levels of consumption in these units. Migratory housing may use little energy. However, vacation homes could have a full complement of appliances. Those homes that are used for a

Residential Sector

There is no well-established definition of the residential sector as there is for the other sectors. The residential sector is generally considered to consist of all private residences, including single family homes (both owned and rented), multifamily housing units, apartments, and mobile homes. Secondary homes, such as summer homes, are also included. Institutional housing, such as school dormitories, hospitals and military barracks, are generally not included in the residential sector. Since there is no standardized definition of this sector, there will be variation in which dwelling units are included in it in different studies or data sources. Residential housing units consume energy for space heating, water heating, air conditioning, lighting, refrigeration, cooking, clothes drying, and other appliance operation.

The Residential Energy Consumption Survey (RECS) provides a direct measure of energy consumption in individual housing units, along with detailed information about the housing unit, its energy consuming equipment, and the characteristics of the unit residents. The various EIA supply surveys provide estimates of the total amount of individual fuels supplied to the residential sector in total. The consumption survey and the various supply surveys differ somewhat in the types of housing units that are included in their respective definitions of the residential sector, as will be discussed in the following section.

Sector Coverage by Survey Type

All surveys cover the major portion of the residential sector, private housing units. However, there are some significant differences in the way certain portions of the sector are handled. RECS covers occupied, primary residences, but does not include vacant and secondary housing units. These units tend to be covered by the supply surveys. On the other hand, the supply surveys vary in their coverage of apartments and farm houses.

Consumption Survey

The sampling frame for RECS is explicitly designed to cover all residential housing units that are primary residences. It excludes units that are vacant or that are secondary homes, such as vacation homes, as well as migratory housing. The sample includes apartment buildings, farm homes, and single family homes on military bases (but not housing in military barracks). Other forms of institutionalized housing, such as college dormitories and hospitals, are not included.

The impact of excluding migratory and secondary housing cannot be assessed without data on the levels of consumption in these units. Migratory housing may use little energy. However, vacation homes could have a full complement of appliances. Those homes that are used for a

substantial length of time over the course of a year could be expected to have consumption levels that approach that of a full-time occupied housing unit.

Supply Surveys

The treatment of apartment buildings varies among the various supply surveys. Instructions for Form EIA-861, the current electricity survey form for collecting annual sales data, allows utilities some discretion in how they classify customers. Consequently, some utilities use rate schedules to determine sectoral sales and may therefore misclassify some residential consumption. In particular, large apartment buildings that are billed at commercial rates could be included under commercial sales.

Apartment buildings are listed as being part of the residential sector on Form EIA-176 for the natural gas survey. However, in some cases, natural gas utilities use the billing rate classification for determining consumption by sector. Gas delivered to large apartment buildings that are billed under commercial tariff schedules would then be classified as commercial rather than residential sales.

Apartment buildings are explicitly excluded from the residential sector in the petroleum surveys. The respondents are instructed to include apartment building consumption of fuel oil in the commercial sector.

Farm homes are a second type of housing unit that is difficult to handle properly in the supply surveys. The electricity survey in particular is likely to have difficulty with farms. The survey will measure all sales to farms, but sales for the farm house and for other farm operations will not be distinguished in all cases. On a farm, some energy is consumed in the farm house for household purposes, while other energy is consumed for farm operations. The later consumption should be counted in the agriculture sector (as part of industry) while the former is part of residential consumption.

A farm family that uses electricity for farm buildings and other farm operations, as well as for their house, may receive only one bill from the electric utility. The utility would not be able to separate out consumption that was for residential purposes from that for agricultural purposes. Therefore, the total amount of consumption for the farm is likely to be assigned either to residential or to industry, depending upon how the farm is listed in their accounts. Neither assignment will give the correct amount of residential consumption.

Sales to farms are included in a separate category on the fuel oil and kerosene forms. Because this category contains multisector consumption (farm home use--residential and farm operation use--industrial or agriculture), this separate category does not help in making the proper assignment of this consumption. However, because of the separate category, we can identify that the farm consumption is not assigned to the residential sector for the supply surveys.

RECS does not identify farm homes *per se*, but it does identify homes that use energy for some farm operations. With this information, it is possible to estimate what portion of the energy is

substantial length of time over the course of a year could be expected to have consumption levels that approach that of a full-time occupied housing unit.

Supply Surveys

The treatment of apartment buildings varies among the various supply surveys. Instructions for Form EIA-861, the current electricity survey form for collecting annual sales data, allows utilities some discretion in how they classify customers. Consequently, some utilities use rate schedules to determine sectoral sales and may therefore misclassify some residential consumption. In particular, large apartment buildings that are billed at commercial rates could be included under commercial sales.

Apartment buildings are listed as being part of the residential sector on Form EIA-176 for the natural gas survey. However, in some cases, natural gas utilities use the billing rate classification for determining consumption by sector. Gas delivered to large apartment buildings that are billed under commercial tariff schedules would then be classified as commercial rather than residential sales.

Apartment buildings are explicitly excluded from the residential sector in the petroleum surveys. The respondents are instructed to include apartment building consumption of fuel oil in the commercial sector.

Farm homes are a second type of housing unit that is difficult to handle properly in the supply surveys. The electricity survey in particular is likely to have difficulty with farms. The survey will measure all sales to farms, but sales for the farm house and for other farm operations will not be distinguished in all cases. On a farm, some energy is consumed in the farm house for household purposes, while other energy is consumed for farm operations. The latter consumption should be counted in the agriculture sector (as part of industry) while the former is part of residential consumption.

A farm family that uses electricity for farm buildings and other farm operations, as well as for their house, may receive only one bill from the electric utility. The utility would not be able to separate out consumption that was for residential purposes from that for agricultural purposes. Therefore, the total amount of consumption for the farm is likely to be assigned either to residential or to industry, depending upon how the farm is listed in their accounts. Neither assignment will give the correct amount of residential consumption.

Sales to farms are included in a separate category on the fuel oil and kerosene forms. Because this category contains multisector consumption (farm home use--residential and farm operation use--industrial or agriculture), this separate category does not help in making the proper assignment of this consumption. However, because of the separate category, we can identify that the farm consumption is not assigned to the residential sector for the supply surveys.

RECS does not identify farm homes *per se*, but it does identify homes that use energy for some farm operations. With this information, it is possible to estimate what portion of the energy is

used for residential purposes and how much for agricultural. RECS thus attempts to include only the consumption associated with farm homes that is for residential purposes. Based on the RECS, it appears that this issue is primarily a problem only for electricity.

Energy Consumption by Fuel Type

In the following sections, the total consumption of energy for each fuel type as measured by the consumption and supply surveys will be compared and discussed.

Electricity

The EIA supply survey for electricity includes vacant and second homes, which comprise about 8 percent of the housing stock. The supply survey also includes consumption from seasonal and migratory housing units. These differences between the supply and consumption surveys would, by themselves, lead to a higher consumption level in the supply survey.

On the other hand, RECS includes some residential consumption that is not included in the supply survey--consumption in farm homes, in private homes on military bases, and some large apartment buildings. Electricity consumption in farm houses may not be listed under residential consumption in all cases in the supply survey. Consumption on military bases is not included in the supply survey.

There is no *a priori* basis for determining whether the supply or consumption survey will give a higher estimate of electricity use for the residential sector. If the apartments that are included in RECS, but not the supply survey, have a higher total consumption than the second and migratory homes, which are included in the supply survey but not RECS, then RECS will show a higher use for electricity. RECS electricity consumption is less than the supply values after 1982 (with the differences for 1984 and 1987 being statistically significant at the 95-percent confidence level), but not for earlier years (Table 2). The differences between RECS and the supply survey are not statistically significant for 1978, 1980, and 1982.

The number of seasonal and migratory homes, and vacant and second homes, surged after 1982. The 1985 American Housing Survey estimates an increase of 72 percent in migratory and seasonal units, 50 percent in second homes, and 10 percent for vacant homes over the two-year period from 1983 to 1985.⁷ Consequently, these types of housing, which are the major difference between RECS and the supply survey were probably more significant for 1984 and 1987 than for earlier years.

⁷American Housing Survey for the United States in 1985, U.S. Department of Census, HS-150-85, (Washington, D.C., 1989)

used for residential purposes and how much for agricultural. RECS thus attempts to include only the consumption associated with farm homes that is for residential purposes. Based on the RECS, it appears that this issue is primarily a problem only for electricity.

Energy Consumption by Fuel Type

In the following sections, the total consumption of energy for each fuel type as measured by the consumption and supply surveys will be compared and discussed.

Electricity

The EIA supply survey for electricity includes vacant and second homes, which comprise about 8 percent of the housing stock. The supply survey also includes consumption from seasonal and migratory housing units. These differences between the supply and consumption surveys would, by themselves, lead to a higher consumption level in the supply survey.

On the other hand, RECS includes some residential consumption that is not included in the supply survey--consumption in farm homes, in private homes on military bases, and some large apartment buildings. Electricity consumption in farm houses may not be listed under residential consumption in all cases in the supply survey. Consumption on military bases is not included in the supply survey.

There is no *a priori* basis for determining whether the supply or consumption survey will give a higher estimate of electricity use for the residential sector. If the apartments that are included in RECS, but not the supply survey, have a higher total consumption than the second and migratory homes, which are included in the supply survey but not RECS, then RECS will show a higher use for electricity. RECS electricity consumption is less than the supply values after 1982 (with the differences for 1984 and 1987 being statistically significant at the 95-percent confidence level), but not for earlier years (Table 2). The differences between RECS and the supply survey are not statistically significant for 1978, 1980, and 1982.

The number of seasonal and migratory homes, and vacant and second homes, surged after 1982. The 1985 American Housing Survey estimates an increase of 72 percent in migratory and seasonal units, 50 percent in second homes, and 10 percent for vacant homes over the two-year period from 1983 to 1985.⁷ Consequently, these types of housing, which are the major difference between RECS and the supply survey were probably more significant for 1984 and 1987 than for earlier years.

⁷American Housing Survey for the United States in 1985, U.S. Department of Census, HS-150-85. (Washington, D.C., 1989)

Natural Gas

The types of homes that are not included in RECS--second homes and migratory housing--are less likely to be serviced by natural gas companies than are primary housing units. Vacation and migratory homes tend to be located in areas where there is no natural gas available. The housing units included in RECS that may not be fully counted in the supply survey include homes on military bases, farm homes, and some apartment buildings. Farm homes and houses on military bases add a very small amount to the RECS consumption; the approximate number of farm homes using natural gas is 0.3 million.

Table 2. Residential Electricity Consumption and Supply

	1978	1980	1982	1984	1987
RECS Consumption (million kilowatthours)	724	721	710	728	808
billion ↗ ↘ EIA Supply Data (million kilowatthours)	674	717	730	778	850
Supply data as Percent of RECS	93.1%	99.4%	102.8%	106.9%*	105.2%*
One RSE (RECS sampling error)	4.3%	1.9%	2.9%	2.6%	1.7%

*Statistically different from 100% using 2 standard errors.

Source: *Residential Energy Consumption Survey: Consumption and Expenditures*, DOE/EIA-0321/1, various years. Supply data: *State Energy Data Report, Consumption Estimates 1960-1987*, DOE/EIA-0214(87). The data for 1978 through 1982 were collected on Form EIA-826, and data for 1984 and 1987 were collected on Form EIA-861.

Based on the known differences in the coverage of the two surveys, the difference between the natural gas use estimates from the supply and consumption surveys will depend on the number of apartments not included in the supply survey. An examination of the results from the two surveys shows that RECS has higher consumption estimates than does the EIA supply survey in all years (Table 3). However, the differences are statistically significant at the 95-percent confidence level only for 1978 and 1987.

An EIA study has compared the two sets of data and concluded that much of the difference can be attributed to the exclusion of large apartment buildings from the EIA supply data; a

Natural Gas

The types of homes that are not included in RECS--second homes and migratory housing--are less likely to be serviced by natural gas companies than are primary housing units. Vacation and migratory homes tend to be located in areas where there is no natural gas available. The housing units included in RECS that may not be fully counted in the supply survey include homes on military bases, farm homes, and some apartment buildings. Farm homes and houses on military bases add a very small amount to the RECS consumption; the approximate number of farm homes using natural gas is 0.3 million.

Table 2. Residential Electricity Consumption and Supply

	1978	1980	1982	1984	1987
RECS Consumption (million kilowatthours)	724	721	710	728	808
b1) 110% ↗ ↘ EIA Supply Data (million kilowatthours)	674	717	730	778	850
Supply data as Percent of RECS	93.1%	99.4%	102.8%	106.9%*	105.2%*
One RSE (RECS sampling error)	4.3%	1.9%	2.9%	2.6%	1.7%

*Statistically different from 100% using 2 standard errors.

Source: *Residential Energy Consumption Survey: Consumption and Expenditures*, DOE/EIA-0321/1, various years. Supply data: *State Energy Data Report, Consumption Estimates 1960-1987*, DOE/EIA-0214(87). The data for 1978 through 1982 were collected on Form EIA-826, and data for 1984 and 1987 were collected on Form EIA-861.

Based on the known differences in the coverage of the two surveys, the difference between the natural gas use estimates from the supply and consumption surveys will depend on the number of apartments not included in the supply survey. An examination of the results from the two surveys shows that RECS has higher consumption estimates than does the EIA supply survey in all years (Table 3). However, the differences are statistically significant at the 95-percent confidence level only for 1978 and 1987.

An EIA study has compared the two sets of data and concluded that much of the difference can be attributed to the exclusion of large apartment buildings from the EIA supply data; a

small part of the difference could also be attributed to a difference in the months covered.⁸ (The supply survey is based on a calendar year, while RECS up through 1984 has been based on a 12-month period spanning a full winter--April 1 of the first year through the end of March for the next year; for 1987, the RECS is based on the calendar year.)

Table 3. Residential Natural Gas Consumption and Supply

	1978	1980	1982	1984	1987
RECS Consumption (billion cubic feet)	5,461	4,840	4,680	4,830	4,687
EIA Supply Data (billion cubic feet)	4,903	4,752	4,633	4,555	4,315
Supply Data as a Percent of RECS	89.8%*	98.2%	99.0%	94.3%	92.1%*
One RSE (RECS sampling error)	5.5%	3.8%	3.9%	3.3%	3.4%

*Statistically different from 100% using 2 standard errors.
 Source: Residential Energy Consumption Survey: Consumption and Expenditures, DOE/EIA-0321/1, various years. Supply data: State Energy Data Report, Consumption Estimates 1960-1987, DOE/EIA-0214(87). The supply data are collected on Form EIA-176.

Fuel Oil

The biggest difference between RECS and the petroleum supply survey is the exclusion of apartment buildings and farm homes from the residential sector from the supply survey. These units comprise about 16 percent of the total housing stock. The secondary and migratory homes, which are excluded from RECS, comprise a smaller portion of the total housing stock.

Since the petroleum survey covers a smaller portion of the residential sector, it would be expected to have lower consumption estimates than RECS. This expectation is weakly supported in the data (Table 4). (The expectation is more strongly supported when the data are analyzed at the Census Division level.) In all but one year, the RECS estimate of total consumption is higher than the supply survey data. However, the difference is statistically

⁸An Assessment of the Quality of Selected EIA Data Series: Energy Consumption Data, DOE-EIA-0292(85), April 1986, pp. 63-72.

small part of the difference could also be attributed to a difference in the months covered.⁸ (The supply survey is based on a calendar year, while RECS up through 1984 has been based on a 12-month period spanning a full winter--April 1 of the first year through the end of March for the next year; for 1987, the RECS is based on the calendar year.)

Table 3. Residential Natural Gas Consumption and Supply

	1978	1980	1982	1984	1987
RECS Consumption (billion cubic feet)	5,461	4,840	4,680	4,830	4,687
EIA Supply Data (billion cubic feet)	4,903	4,752	4,633	4,555	4,315
Supply Data as a Percent of RECS	89.8%*	98.2%	99.0%	94.3%	92.1%*
One RSE (RECS sampling error)	5.5%	3.8%	3.9%	3.3%	3.4%

*Statistically different from 100% using 2 standard errors.

Source: *Residential Energy Consumption Survey: Consumption and Expenditures*, DOE/EIA-0321/1, various years. Supply data: *State Energy Data Report, Consumption Estimates 1960-1987*, DOE/EIA-0214(87). The supply data are collected on Form EIA-176.

Fuel Oil

The biggest difference between RECS and the petroleum supply survey is the exclusion of apartment buildings and farm homes from the residential sector from the supply survey. These units comprise about 16 percent of the total housing stock. The secondary and migratory homes, which are excluded from RECS, comprise a smaller portion of the total housing stock.

Since the petroleum survey covers a smaller portion of the residential sector, it would be expected to have lower consumption estimates than RECS. This expectation is weakly supported in the data (Table 4). (The expectation is more strongly supported when the data are analyzed at the Census Division level.) In all but one year, the RECS estimate of total consumption is higher than the supply survey data. However, the difference is statistically

⁸*An Assessment of the Quality of Selected EIA Data Series: Energy Consumption Data*, DOE-EIA-0292(85) April 1986, pp. 63-72.

significant only for 1984 at the 95-percent confidence level. (If the standard error associated with the petroleum supply survey were included in the standard error for the comparison in Table 4, the standard error for the comparison would be somewhat larger and none of the differences would be statistically significant at the 95-percent confidence level.)

Table 4. Residential Fuel Oil Consumption and Supply

	1978	1980	1982	1984	1987
RECS Consumption (million gallons)	15,802	11,220	8,230	9,080	8,850
EIA Supply Data (million gallons)	15,204	10,290	8,274	7,602	8,106
Supply Data as a Percent of RECS	96.2%	91.7%	100.5%	83.7%*	91.6%
One RSE (RECS Sampling Error)	7.6%	5.7%	5.8%	5.4%	5.4%

*Statistically different from 100% using 2 standard errors (based only on RECS sampling error; the sampling error from the petroleum survey has not been included).
 Source: *Residential Energy Consumption Survey: Consumption and Expenditures*, DOE/EIA-0321/1, various years. Supply data: *State Energy Data Report, Consumption Estimates 1960-1987*, DOE/EIA-0214(87); data from Form EIA-821.

Considering the 1987 data, if the supply data from EIA-821 were increased by 16 percent (the number of households in apartments as measured by RECS) and the RECS data increased by 8 percent (cited above as the proportion of secondary housing) to account for the missing "housing stock," the supply data as a percent of RECS would be 98.4 percent--very close agreement.

significant only for 1984 at the 95-percent confidence level. (If the standard error associated with the petroleum supply survey were included in the standard error for the comparison in Table 4, the standard error for the comparison would be somewhat larger and none of the differences would be statistically significant at the 95-percent confidence level.)

Table 4. Residential Fuel Oil Consumption and Supply

	1978	1980	1982	1984	1987
RECS Consumption (million gallons)	15,802	11,220	8,230	9,080	8,850
EIA Supply Data (million gallons)	15,204	10,290	8,274	7,602	8,106
Supply Data as a Percent of RECS	96.2%	91.7%	100.5%	83.7%*	91.6%
One RSE (RECS Sampling Error)	7.6%	5.7%	5.8%	5.4%	5.4%

*Statistically different from 100% using 2 standard errors (based only on RECS sampling error; the sampling error from the petroleum survey has not been included).

Source: *Residential Energy Consumption Survey: Consumption and Expenditures*, DOE/EIA-0321/1, various years. Supply data: *State Energy Data Report, Consumption Estimates 1960-1987*, DOE/EIA-0214(87); data from Form EIA-821.

Considering the 1987 data, if the supply data from EIA-821 were increased by 16 percent (the number of households in apartments as measured by RECS) and the RECS data increased by 3 percent (cited above as the proportion of secondary housing) to account for the missing "housing stock," the supply data as a percent of RECS would be 98.4 percent--very close agreement.

Commercial Sector

The commercial sector, as defined economically, consists of business establishments that are not engaged in manufacturing or other type of industrial activity (agriculture, mining or construction).⁹ These establishments include hotels, motels, restaurants, wholesale businesses, retail stores, laundries, and other service enterprises; office buildings; religious and nonprofit organizations; health, social, and educational institutions; and Federal, State, and local governments. Street lights, pumps, bridges, and public services are also included. Energy in the commercial sector is generally used for the same purposes as in the residential sector: space heating and cooling, cooking, water heating, and electrical equipment and appliance operation including lighting. However, the relative amounts of energy used for these purposes can vary substantially from use in the residential sector, depending on the specific activities of the commercial consumer.

The consumption survey, the Nonresidential Buildings Energy Consumption Survey (NBECS), and the various supply surveys produce measures of energy consumed by commercial customers. But the types of activities included as being in the commercial sector by these surveys vary, and no survey covers precisely the commercial sector as defined economically.

Sector Coverage by Survey Type

Consumption Survey

The NBECS estimates the energy consumed in buildings in which the activities are predominantly (i.e., using over one-half the floorspace) commercial. The survey measures only energy consumption that takes place in buildings. Commercial activities that do not take place in buildings, such as street lights, bridge operations, and lights in parking lots, are not included in the NBECS consumption data. The NBECS sample frame includes all buildings in which over half the floorspace is devoted to commercial activities and (for the most recent 1986 survey) that have floorspace greater than 1,000 square feet.

The NBECS is based on a sample of such buildings. The sample includes buildings that are occupied by industrial establishments that use the building primarily for commercial activities. For example, a building occupied by a manufacturing company that uses it as an office building

⁹This definition is based on the Standard Industrial Classification (SIC), which is a comprehensive set of categories developed by the Office of Management and Budget for classifying business establishments. For the commercial sector, the term business is used broadly to include government agencies, religious organizations and other nonprofit corporations. The SIC categories are described in Office of Management and Budget, "Standard Industrial Classification Manual, 1987" (Washington, D.C.).

Commercial Sector

The commercial sector, as defined economically, consists of business establishments that are not engaged in manufacturing or other type of industrial activity (agriculture, mining or construction).⁹ These establishments include hotels, motels, restaurants, wholesale businesses, retail stores, laundries, and other service enterprises; office buildings; religious and nonprofit organizations; health, social, and educational institutions; and Federal, State, and local governments. Street lights, pumps, bridges, and public services are also included. Energy in the commercial sector is generally used for the same purposes as in the residential sector: space heating and cooling, cooking, water heating, and electrical equipment and appliance operation including lighting. However, the relative amounts of energy used for these purposes can vary substantially from use in the residential sector, depending on the specific activities of the commercial consumer.

The consumption survey, the Nonresidential Buildings Energy Consumption Survey (NBECS), and the various supply surveys produce measures of energy consumed by commercial customers. But the types of activities included as being in the commercial sector by these surveys vary, and no survey covers precisely the commercial sector as defined economically.

Sector Coverage by Survey Type

Consumption Survey

The NBECS estimates the energy consumed in buildings in which the activities are predominantly (i.e., using over one-half the floorspace) commercial. The survey measures only energy consumption that takes place in buildings. Commercial activities that do not take place in buildings, such as street lights, bridge operations, and lights in parking lots, are not included in the NBECS consumption data. The NBECS sample frame includes all buildings in which over half the floorspace is devoted to commercial activities and (for the most recent 1986 survey) that have floorspace greater than 1,000 square feet.

The NBECS is based on a sample of such buildings. The sample includes buildings that are occupied by industrial establishments that use the building primarily for commercial activities. For example, a building occupied by a manufacturing company that uses it as an office building

⁹This definition is based on the Standard Industrial Classification (SIC), which is a comprehensive set of categories developed by the Office of Management and Budget for classifying business establishments. For the commercial sector, the term business is used broadly to include government agencies, religious organizations and other nonprofit corporations. The SIC categories are described in Office of Management and Budget, "Standard Industrial Classification Manual, 1987" (Washington, D.C.).

for managerial staff would be included in the NBECS sample.

A small amount of industrial consumption for manufacturing activities is included in NBECS, along with some residential consumption. A manufacturing establishment can be located in a building classified as commercial for the purposes of NBECS. The energy used by that company for manufacturing will be included in the NBECS consumption. Similarly, a building that is predominantly commercial but that also has some residential units will have the residential consumption included in the NBECS data. There are no data available on how much industrial and residential consumption are included in the NBECS figures.

On the other hand, NBECS will not capture the energy consumption of commercial establishments that are located in buildings not classified as commercial for the purposes of NBECS. Shops on the ground floor of an apartment building, or in a building that is primarily industrial, will not be covered in the NBECS sampling frame.

NBECS does not cover a small amount of consumption for other activities that are properly considered to be part of the commercial sector. Any activity that does not take place in a building, such as street or parking lot lighting or pumps and bridge operation, is not included. (One small study estimated this consumption in the neighborhood of three percent of total commercial consumption.)¹⁰ The exclusion of buildings under 1,001 square feet in size eliminates some additional commercial consumption (estimated to be in the neighborhood of 2 percent of the total).¹¹

Because NBECS is based on a sample of buildings, it includes some residential and industrial consumption and fails to measure some commercial consumption. Alternative approaches to designing a sample for NBECS were considered, but none proved to be feasible. One possibility explored was to survey commercial establishments directly, but no list of commercial establishments could be located that had the information needed to draw a sample for energy consumption purposes. Further, a commercial establishment itself does not necessarily purchase energy (since the cost of energy may be included in the rent the establishment pays for leasing floorspace), so sampling establishments would not necessarily provide useful energy consumption data. A sample based on buildings has the advantage that a building is a natural unit for determining energy consumption. The building's characteristics and the purposes for which it is used are major determinants of the energy consumed in the building.

The initial NBECS was designed to cover all buildings that were not almost entirely residential. Since the first survey, the type of building covered by the survey has gradually changed. After the report on the 1979 building characteristics was issued, industrial buildings were dropped from the sample base for the 1979 reports on consumption and expenditures. Further restrictions were imposed on the 1986 sample by removing buildings that (1) had commercial activity in them but were primarily (more than 50 percent of floorspace) residential or industrial,

¹⁰Based on a study of a few utilities in the Northwest Region. See Energy Information Administration, "Nonresidential/Commercial Buildings Energy Consumption Survey Feasibility Study," Vol I, 1982.

¹¹Eugene M Burns, "The Edge of NBECS, Part 1: Little Buildings," NBECS Technical Note, Number 65, April 5, 1988.

for managerial staff would be included in the NBECS sample.

A small amount of industrial consumption for manufacturing activities is included in NBECS, along with some residential consumption. A manufacturing establishment can be located in a building classified as commercial for the purposes of NBECS. The energy used by that company for manufacturing will be included in the NBECS consumption. Similarly, a building that is predominantly commercial but that also has some residential units will have the residential consumption included in the NBECS data. There are no data available on how much industrial and residential consumption are included in the NBECS figures.

On the other hand, NBECS will not capture the energy consumption of commercial establishments that are located in buildings not classified as commercial for the purposes of NBECS. Shops on the ground floor of an apartment building, or in a building that is primarily industrial, will not be covered in the NBECS sampling frame.

NBECS does not cover a small amount of consumption for other activities that are properly considered to be part of the commercial sector. Any activity that does not take place in a building, such as street or parking lot lighting or pumps and bridge operation, is not included. (One small study estimated this consumption in the neighborhood of three percent of total commercial consumption.)¹⁰ The exclusion of buildings under 1,001 square feet in size eliminates some additional commercial consumption (estimated to be in the neighborhood of 2 percent of the total).¹¹

Because NBECS is based on a sample of buildings, it includes some residential and industrial consumption and fails to measure some commercial consumption. Alternative approaches to designing a sample for NBECS were considered, but none proved to be feasible. One possibility explored was to survey commercial establishments directly, but no list of commercial establishments could be located that had the information needed to draw a sample for energy consumption purposes. Further, a commercial establishment itself does not necessarily purchase energy (since the cost of energy may be included in the rent the establishment pays for leasing floorspace), so sampling establishments would not necessarily provide useful energy consumption data. A sample based on buildings has the advantage that a building is a natural unit for determining energy consumption. The building's characteristics and the purposes for which it is used are major determinants of the energy consumed in the building.

The initial NBECS was designed to cover all buildings that were not almost entirely residential. Since the first survey, the type of building covered by the survey has gradually changed. After the report on the 1979 building characteristics was issued, industrial buildings were dropped from the sample base for the 1979 reports on consumption and expenditures. Further restrictions were imposed on the 1986 sample by removing buildings that (1) had commercial activity in them but were primarily (more than 50 percent of floorspace) residential or industrial.

¹⁰Based on a study of a few utilities in the Northwest Region. See Energy Information Administration, "Nonresidential/Commercial Buildings Energy Consumption Survey Feasibility Study," Vol I, 1982.

¹¹Eugene M Burns, "The Edge of NBECS, Part 1: Little Buildings," NBECS Technical Note, Number 65, April 5, 1988.

or (2) had less than 1,001 square feet of floorspace.

Supply Surveys

For the supply surveys, the activities that are included in the commercial sector vary by the type of fuel. The situation for electricity is complicated because there are three categories that include commercial sales. One of these categories, "other," includes sales to transportation and possibly other end-use sectors as well as commercial. Another of the three categories is "commercial sales," which is likely to include consumption for some sales billed at commercial rates by customers in other sectors.

For natural gas, the supply survey provides an explicit definition of the commercial sector, which is slightly broader in scope than the economic definition. Natural gas utilities are asked to include the consumption of agriculture, fishery, and forestry establishments as part of commercial consumption. Some apartment building and industrial consumption is also included because these customers are billed at commercial rates. The fuel oil supply survey includes apartment buildings in the commercial sector.

It is likely that some portion of the energy measured in NBECS that is consumed by industrial establishments engaged in commercial-related activities in buildings may also be included in the various supply surveys. In many cases, this consumption takes place in buildings that are leased by the industrial companies and may appear as commercial accounts to the utilities. This consumption would then also be included as commercial consumption by the supply survey. There are no data that would enable us to determine how much overlap there might be in these cases.

Energy Consumption by Fuel Type

The amount of each fuel measured by the consumption and supply surveys for the commercial sector is discussed in the following sections. Differences between the two surveys are discussed in light of the preceding discussion of differences in the universe of coverage.

Electricity

The current form for collecting annual electricity sales, Form EIA-861, contains five categories for listing end-use sales. Of these five, three include sales to the commercial sector as defined above: commercial sales, public street and highway lighting, and "other." (The remaining categories are residential sales and industrial sales.) The "other" category includes sales to railroads and railways, interdepartmental utility use, and sales under special contracts to municipalities or divisions and agencies of Federal or State governments. Some of the "other" category is clearly commercial--a substantial portion of the sales to government is likely to be

or (2) had less than 1,001 square feet of floorspace.

Supply Surveys

For the supply surveys, the activities that are included in the commercial sector vary by the type of fuel. The situation for electricity is complicated because there are three categories that include commercial sales. One of these categories, "other," includes sales to transportation and possibly other end-use sectors as well as commercial. Another of the three categories is "commercial sales," which is likely to include consumption for some sales billed at commercial rates by customers in other sectors.

For natural gas, the supply survey provides an explicit definition of the commercial sector, which is slightly broader in scope than the economic definition. Natural gas utilities are asked to include the consumption of agriculture, fishery, and forestry establishments as part of commercial consumption. Some apartment building and industrial consumption is also included because these customers are billed at commercial rates. The fuel oil supply survey includes apartment buildings in the commercial sector.

It is likely that some portion of the energy measured in NBECS that is consumed by industrial establishments engaged in commercial-related activities in buildings may also be included in the various supply surveys. In many cases, this consumption takes place in buildings that are leased by the industrial companies and may appear as commercial accounts to the utilities. This consumption would then also be included as commercial consumption by the supply survey. There are no data that would enable us to determine how much overlap there might be in these cases.

Energy Consumption by Fuel Type

The amount of each fuel measured by the consumption and supply surveys for the commercial sector is discussed in the following sections. Differences between the two surveys are discussed in light of the preceding discussion of differences in the universe of coverage.

Electricity

The current form for collecting annual electricity sales, Form EIA-861, contains five categories for listing end-use sales. Of these five, three include sales to the commercial sector as defined above: commercial sales, public street and highway lighting, and "other." (The remaining categories are residential sales and industrial sales.) The "other" category includes sales to railroads and railways, interdepartmental utility use, and sales under special contracts to municipalities or divisions and agencies of Federal or State governments. Some of the "other" category is clearly commercial--a substantial portion of the sales to government is likely to be

commercial--while other is transportation, and some can't be categorized without further information. The "commercial sales" category is likely to include most sales at commercial rates not included in the "other" or "lighting" categories.

The "public street and highway lighting" category is a commercial use of electricity that is included in the supply survey but not included in NBECS. The "commercial sales" category is likely to consist of commercial accounts that would have a high degree of overlap with NBECS coverage, apart from misclassifications of high consumption apartment buildings and relatively low-consuming industrial establishment which are billed at commercial rates. The "other" category will include consumption by governments that takes place in buildings, which will also be included in NBECS. However, the remaining portion of the "other" category will not be included in NBECS, and not all of it is commercial. There are no data available that can be used to distinguish government, other commercial, and the remainder.

Because of the complexity of the data, it is difficult to compare the supply data with NBECS. There are alternative combinations of the data from the supply survey that can be compared to NBECS. Two variations of the supply data are compared here with NBECS. The first is the value for commercial consumption obtained from the *State Energy Data Report* (SEDR). SEDR sums electric sales for public street and highway lighting, commercial sales, and other less an estimated amount of sales to the transportation sector. This number for consumption might be expected to be higher than the NBECS value, since it includes street and highway lighting that aren't included in NBECS. However, the inclusion of misclassified residential and industrial customers, and the omission of commercial customers billed at noncommercial rates, will have an unknown effect on the comparison.

The SEDR commercial consumption estimate is slightly lower than the NBECS estimate for 1979 and 1983, and slightly higher for 1986 (Table 5). The relative drop in NBECS consumption in 1986 is consistent with the reduced number of buildings covered by NBECS in 1986. None of the differences are statistically significant at the 95-percent confidence level, so these two measures are not statistically different.

A second comparison is with the commercial sales figures alone from the supply survey with NBECS (Table 5). In this case, the supply figure is substantially lower than NBECS, with the difference being statistically significant for 1979 and 1983. It would appear that enough government building consumption is included in the "other" sales category so that the "commercial sales" category for the supply survey is not comparable with NBECS.

Natural Gas

The delivery data for natural gas cover more economic units of activity than does NBECS: agriculture, fishery, and forestry establishments are included in the supply survey but not in NBECS. The NBECS estimates of commercial natural gas consumption are lower than the supply estimates collected on Form EIA-176 for the three years the NBECS has been conducted (Table 6). The differences are statistically significant at the 95-percent confidence level for 1979 and 1986. The difference between the two was larger in 1986 when the NBECS

commercial--while other is transportation, and some can't be categorized without further information. The "commercial sales" category is likely to include most sales at commercial rates not included in the "other" or "lighting" categories.

The "public street and highway lighting" category is a commercial use of electricity that is included in the supply survey but not included in NBECS. The "commercial sales" category is likely to consist of commercial accounts that would have a high degree of overlap with NBECS coverage, apart from misclassifications of high consumption apartment buildings and relatively low-consuming industrial establishment which are billed at commercial rates. The "other" category will include consumption by governments that takes place in buildings, which will also be included in NBECS. However, the remaining portion of the "other" category will not be included in NBECS, and not all of it is commercial. There are no data available that can be used to distinguish government, other commercial, and the remainder.

Because of the complexity of the data, it is difficult to compare the supply data with NBECS. There are alternative combinations of the data from the supply survey that can be compared to NBECS. Two variations of the supply data are compared here with NBECS. The first is the value for commercial consumption obtained from the *State Energy Data Report* (SEDR). SEDR sums electric sales for public street and highway lighting, commercial sales, and other less an estimated amount of sales to the transportation sector. This number for consumption might be expected to be higher than the NBECS value, since it includes street and highway lighting that aren't included in NBECS. However, the inclusion of misclassified residential and industrial customers, and the omission of commercial customers billed at noncommercial rates, will have an unknown effect on the comparison.

The SEDR commercial consumption estimate is slightly lower than the NBECS estimate for 1979 and 1983, and slightly higher for 1986 (Table 5). The relative drop in NBECS consumption in 1986 is consistent with the reduced number of buildings covered by NBECS in 1986. None of the differences are statistically significant at the 95-percent confidence level, so these two measures are not statistically different.

A second comparison is with the commercial sales figures alone from the supply survey with NBECS (Table 5). In this case, the supply figure is substantially lower than NBECS, with the difference being statistically significant for 1979 and 1983. It would appear that enough government building consumption is included in the "other" sales category so that the "commercial sales" category for the supply survey is not comparable with NBECS.

Natural Gas

The delivery data for natural gas cover more economic units of activity than does NBECS: agriculture, fishery, and forestry establishments are included in the supply survey but not in NBECS. The NBECS estimates of commercial natural gas consumption are lower than the supply estimates collected on Form EIA-176 for the three years the NBECS has been conducted (Table 6). The differences are statistically significant at the 95-percent confidence level for 1979 and 1986. The difference between the two was larger in 1986 when the NBECS

estimate no longer included some apartment buildings and some small buildings (smaller than 1,001 square feet).¹²

Table 5. Commercial Electricity Consumption and Supply

	1979	1983	1986
NBECS Consumption (billion kilowatthours)	589	656	701
SEDR Commercial Consumption (billion kilowatthours)	543	621	721
SEDR as Percent of NBECS	92.2%	94.7%	102.9%
Commercial Sales from Supply Survey (billion kilowatthours)	473	544	641
Commercial Sales as Percent of NBECS	80.3%*	82.9%*	91.4%
One RSE (based on NBECS sample variance)	7.0%	8.3%	5.4%

Note: The 1979 and 1983 NBECS included some smaller buildings (less than 1,001 square feet) and some apartment buildings that were not included in 1986.

*Statistically different from 100% using 2 standard errors.

Sources: NBECS: *Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA-0318(86); 1979 and 1983 data are from *Annual Energy Review 1986*, DOE/EIA-0394-(86), Table 30. NBECS data for 1979 in the AER are revised from the data originally published. Supply Data: *State Energy Data Report 1960-1987*, DOE/EIA-0214(87) for SEDR commercial consumption; *Annual Energy Review 1988*, DOE/EIA-0384(88), Table 89 for Commercial Sales. Supply data for 1986 are from Form EIA-861, and earlier years from Form EIA-826

Presumably, an important factor in the difference between NBECS and the natural gas supply survey is the inclusion of agricultural consumption in the supply survey. However, there are no independent measures of natural gas consumption in this industry to check whether the differences between the supply and consumption survey estimates correspond to consumption in this industry.

¹²In the early NBECS, the coverage of small buildings was probably not complete so the term "some small buildings" has been used. See Eugene M. Burns, "The Edge of NBECS, Part 1: Little Buildings," NBECS Technical Note 65, April 5, 1988.

estimate no longer included some apartment buildings and some small buildings (smaller than 1,001 square feet).¹²

Table 5. Commercial Electricity Consumption and Supply

	1979	1983	1986
NBECS Consumption (billion kilowatthours)	589	656	701
SEDR Commercial Consumption (billion kilowatthours)	543	621	721
SEDR as Percent of NBECS	92.2%	94.7%	102.9%
Commercial Sales from Supply Survey (billion kilowatthours)	473	544	641
Commercial Sales as Percent of NBECS	80.3%*	82.9%*	91.4%
One RSE (based on NBECS sample variance)	7.0%	8.3%	5.4%

Note: The 1979 and 1983 NBECS included some smaller buildings (less than 1,001 square feet) and some apartment buildings that were not included in 1986.

*Statistically different from 100% using 2 standard errors.

Sources: NBECS: *Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA-0318(86); 1979 and 1983 data are from *Annual Energy Review 1986*, DOE/EIA-0394-(86), Table 30. NBECS data for 1979 in the AER are revised from the data originally published. Supply Data: *State Energy Data Report 1960-1987*, DOE/EIA-0214(87) for SEDR commercial consumption; *Annual Energy Review 1988*, DOE/EIA-0384(88), Table 89 for Commercial Sales. Supply data for 1986 are from Form EIA-861, and earlier years from Form EIA-826

Presumably, an important factor in the difference between NBECS and the natural gas supply survey is the inclusion of agricultural consumption in the supply survey. However, there are no independent measures of natural gas consumption in this industry to check whether the differences between the supply and consumption survey estimates correspond to consumption in this industry.

¹²In the early NBECS, the coverage of small buildings was probably not complete so the term "some small buildings" has been used. See Eugene M. Burns, "The Edge of NBECS, Part 1: Little Buildings," NBECS Technical Note 65, April 5, 1988.

Table 6. Commercial Natural Gas Consumption and Supply

	1979	1983	1986
NBECS Consumption (billion cubic feet)	2,270	2,160	1,674
EIA Supply Data (billion cubic feet)	2,786	2,433	2,318
Supply Data as a Percent of NBECS	122.7%*	112.6%	138.0%*
One RSE (based on NBECS sampling variance)	7.9%	8.2%	5.6%

Note: The 1979 and 1983 NBECS included buildings smaller than 1,001 square feet and some apartments that were not included in 1986.

*Statistically different from 100% using 2 standard errors.

Source: NBECS: *Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA-0318(86); 1979 and 1983 data are from *Annual Energy Review 1986*, DOE/EIA-0394-(86), Table 30. NBECS data for 1979 in the AER are revised from the data originally published. The 1979 data in the AER were converted to physical units using 1,109 Btu per cubic foot. Supply Data: *State Energy Data Report 1960-1987*, DOE/EIA-0214(87), Table 14, (data from Form EIA-176).

Fuel Oil

As noted in the second chapter, fuel oil is the fuel most difficult to measure either by the supply or consumption approach. The EIA supply data include fuel oil delivered to apartment buildings that is not included in NBECS.

Total commercial fuel oil deliveries measured by NBECS are substantially lower than the values from the supply survey (Table 7). Indeed, the quantities measured in NBECS are about one-half those measured by the supply survey.

The fuel oil supply data are so much larger than the consumption estimates that some reason not yet considered must be affecting the comparison between these data sources. One factor that may account for some part of the difference is that power plants located on campus type facilities are typically not included in NBECS because they are not considered to be commercial buildings. This consumption is likely to be included in the supply surveys as commercial. NBECS would measure the steam or electricity delivered to the NBECS buildings, but would

Table 6. Commercial Natural Gas Consumption and Supply

	1979	1983	1986
NBECS Consumption (billion cubic feet)	2,270	2,160	1,674
EIA Supply Data (billion cubic feet)	2,786	2,433	2,318
Supply Data as a Percent of NBECS	122.7%*	112.6%	138.0%*
One RSE (based on NBECS sampling variance)	7.9%	8.2%	5.6%

Note: The 1979 and 1983 NBECS included buildings smaller than 1,001 square feet and some apartments that were not included in 1986.

*Statistically different from 100% using 2 standard errors.

Source: NBECS: *Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA-0318(86); 1979 and 1983 data are from *Annual Energy Review 1986*, DOE/EIA-0394-(86), Table 30. NBECS data for 1979 in the AER are revised from the data originally published. The 1979 data in the AER were converted to physical units using 1,109 Btu per cubic foot. Supply Data: *State Energy Data Report 1960-1987*, DOE/EIA-0214(87), Table 14, (data from Form EIA-176).

Fuel Oil

As noted in the second chapter, fuel oil is the fuel most difficult to measure either by the supply or consumption approach. The EIA supply data include fuel oil delivered to apartment buildings that is not included in NBECS.

Total commercial fuel oil deliveries measured by NBECS are substantially lower than the values from the supply survey (Table 7). Indeed, the quantities measured in NBECS are about one-half those measured by the supply survey.

The fuel oil supply data are so much larger than the consumption estimates that some reason not yet considered must be affecting the comparison between these data sources. One factor that may account for some part of the difference is that power plants located on campus type facilities are typically not included in NBECS because they are not considered to be commercial buildings. This consumption is likely to be included in the supply surveys as commercial. NBECS would measure the steam or electricity delivered to the NBECS buildings, but would

not count the fuel used to produce the steam or electricity.¹³

Table 7. Commercial Fuel Oil Consumption and Supply

	1979	1983	1986
NBECS Consumption (million gallons)	5,465	2,526	3,168
EIA Supply Data (million gallons)	8,148	6,930	6,216
Supply Data as a Percent of NBECS	149.1%*	274.3%*	196.2%*
One RSE (based on NBECS Sampling Variance)	8.9%	13.7%	8.6%

Note: The 1979 and 1983 NBECS included some smaller buildings (less than 1,001 square feet) and some apartment buildings that were not included in 1986. Fuel oil includes distillate fuel oil, residual fuel oil and kerosene.

*Statistically different from 100% using 2 standard errors (based only on NBECS sampling error; the sampling error from the petroleum survey has not been included).

Source: NBECS data for 1986, *NBECS: Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA-0318(86), 1979 and 1983 data are from "Annual Energy Review 1986," DOE/EIA-0394-(86), Table 30. NBECS data for 1979 in the AER are revised from the data originally published. The 1979 data in the AER were converted to physical units using 140.898 Btu per gallon. Supply Data: *State Energy Data Report 1960-1987*, DOE/EIA-0214(87).

About 75 percent of the district heat counted in the 1986 NBECS was produced onsite by power plants that were part of a company facility. If we assume that this nonpurchased district heat was produced at 60 percent efficiency through the use of fuel oil, that would represent 3,849 million gallons of fuel oil--an amount more than large enough to explain the difference between NBECS and the supply survey. Of course, other fuels such as coal and natural gas are also used to produce district heat, and there are no data available that can be used to determine how much of it is produced by fuel oil.

There are other reasons why NBECS could be short in its measurement of fuel oil consumption.

¹³A pilot study is being conducted as part of the 1989 CBECS to see how well such central plant consumption can be measured, and to try to quantify how much such consumption contributes to the difference between supply-side and demand-side estimates. For multibuilding facilities that have central plants, consumption and production data by fuel type are being collected from the plants.

not count the fuel used to produce the steam or electricity.¹³

Table 7. Commercial Fuel Oil Consumption and Supply

	1979	1983	1986
NBECS Consumption (million gallons)	5,465	2,526	3,168
EIA Supply Data (million gallons)	8,148	6,930	6,216
Supply Data as a Percent of NBECS	149.1%*	274.3%*	196.2%*
One RSE (based on NBECS Sampling Variance)	8.9%	13.7%	8.6%

Note: The 1979 and 1983 NBECS included some smaller buildings (less than 1,001 square feet) and some apartment buildings that were not included in 1986. Fuel oil includes distillate fuel oil, residual fuel oil and kerosene.

*Statistically different from 100% using 2 standard errors (based only on NBECS sampling error; the sampling error from the petroleum survey has not been included).

Source: NBECS data for 1986, *NBECS: Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA-0318(86), 1979 and 1983 data are from "Annual Energy Review 1986," DOE/EIA-0394-(86), Table 30. NBECS data for 1979 in the AER are revised from the data originally published. The 1979 data in the AER were converted to physical units using 140.898 Btu per gallon. Supply Data: *State Energy Data Report 1960-1987*, DOE/EIA-0214(87).

About 75 percent of the district heat counted in the 1986 NBECS was produced onsite by power plants that were part of a company facility. If we assume that this nonpurchased district heat was produced at 60 percent efficiency through the use of fuel oil, that would represent 3,849 million gallons of fuel oil—an amount more than large enough to explain the difference between NBECS and the supply survey. Of course, other fuels such as coal and natural gas are also used to produce district heat, and there are no data available that can be used to determine how much of it is produced by fuel oil.

There are other reasons why NBECS could be short in its measurement of fuel oil consumption.

¹³A pilot study is being conducted as part of the 1989 CBECS to see how well such central plant consumption can be measured, and to try to quantify how much such consumption contributes to the difference between supply-side and demand-side estimates. For multibuilding facilities that have central plants, consumption and production data by fuel type are being collected from the plants.

The building representative who is interviewed for the survey may fail to list all the fuel oil suppliers in response to the survey questions. Also, a fuel oil dealer may not list all the deliveries to the building.

The building representative who is interviewed for the survey may fail to list all the fuel oil suppliers in response to the survey questions. Also, a fuel oil dealer may not list all the deliveries to the building.

Industrial Sector

The industrial sector is much more diverse, and more complex in its energy use, than either the residential or commercial sector. It comprises manufacturing industries--which make up the largest part of the sector--along with mining, construction, agriculture, fisheries, and forestry. Establishments in the sector range from a steel mill, to a small farm, to a company assembling electronic components.

The principal uses for energy in this sector are powering manufacturing processes and carrying out other types of industrial activities. The energy used to space condition buildings (heating or cooling them), a major component of energy use in the residential and commercial sectors, is relatively unimportant for industry. Energy is used for a wide range of industrial processes, which use a large number of different types of equipment. Because of this diversity, it is difficult to measure the end uses of energy for industry.

It is even complex to determine how much energy is "consumed" by a manufacturing plant.¹⁴ During the course of an industrial process, byproducts can be produced which are usable as a fuel. A boiler used in manufacturing can also cogenerate electricity which can either be consumed at the plant or sold back to a utility. Some energy sources are also used as raw material--or feedstock--input to a production process; the output of the process may be a fuel of another form or may no longer be usable as a fuel.

Comparing industrial energy consumption estimates from a survey of industrial users with data on energy supplied to industrial customers, must be done with these complexities of industrial energy use taken into consideration. The measure of energy consumption from a consumption survey that would most closely correspond with data from a supply survey would be total fuels purchased. However, care should also be taken to make sure that both types of survey are dealing in the same way with fuels purchased as feedstocks.

Only one consumption survey is conducted for the industrial sector, the Manufacturing Energy Consumption Survey (MECS), which covers manufacturing. There is no end-use survey of mining, construction, or agriculture. The supply surveys vary in their coverage of the industrial sector, so each survey will be discussed individually in the next section.

The industrial sector provides an additional element for consideration. Coal is an important fuel for the industrial sector, where only scant amounts of it are consumed in the residential and commercial sectors. Therefore, coal is added to the list of fuels discussed in this chapter.

¹⁴See *Manufacturing Energy Consumption Survey: Consumption of Energy 1985*, DOE/EIA-0512(85) for a discussion of different measures of energy consumption in the manufacturing industries sector.



Sector Coverage by Survey Type

Consumption Survey

MECS is based on a sample of manufacturing establishments, selected from a complete list of manufacturers maintained by the Census Bureau for its Annual Survey of Manufactures. MECS is designed to provide complete coverage of the manufacturing sector. The sample of establishments is stratified so that each industry is covered, and those industries with high energy consumption levels are selected at a higher sampling rate to ensure the data will be reliable for industries with high energy consumption.

Very small establishments are the only exclusion from the survey. The consumption of the small establishments excluded from MECS is estimated to be about 3 percent of the total consumption of the manufacturing sector.¹⁵

The sample element for MECS is similar to that for RECS and NBECS--it is the unit in which energy is consumed. For MECS, that unit is an establishment--a site where manufacturing occurs. The site has geographical boundaries and may encompass several buildings, be one building or part of a building, or not be located in a building at all. Energy collection from establishments is feasible because companies manage energy on an establishment level, data are maintained at the establishment level rather than for individual buildings within an establishment, and supplementary economic data are available for establishments.

MECS is conducted by a mail questionnaire sent to each establishment selected for the survey. The questionnaire asks detailed questions about each type of fuel consumed by the establishment. The data on energy consumption is based on the records of fuel purchases maintained by the establishment.

From these responses, several measures of consumption of each type of fuel have been developed. These measures distinguish purchased energy, energy used as feedstocks, and total energy consumption, which includes the use of fuels produced onsite as a byproduct of the industrial process.

Supply Surveys

The electricity supply surveys, conducted with EIA Form-861, includes the entire industrial sector in its industry category. There is a likelihood that some industrial establishments with low consumption are billed at commercial rates by electric and/or natural gas utilities and their consumption consequently counted as commercial. Similarly, some large commercial accounts

¹⁵Energy Information Administration, *Manufacturing Energy Consumption Survey: Methodological Report 1985*, DOE/EIA-0514(85), November 1988, pp. 7-11.

could be billed at industrial rates and included in industrial consumption. There are no data available with which the effect of this kind of misclassification can be measured. There is no basis for estimating whether the net effect would be positive or negative, let alone estimating its magnitude.

As noted earlier in this report, agriculture, fisheries, and forestry are included in the commercial sector in the natural gas survey, Form EIA-176. Mining and construction are included in the industrial sector, along with manufacturing industries.

For petroleum products, the situation is a bit more complex. One reason petroleum fuels are more difficult to track in industrial consumption is that the petroleum and chemical industries use substantial amounts of petroleum fuels as inputs to their production process. The output of the process may be another fuel, as is the case for refineries, or another product that is not an energy source.

With both the MECS and the petroleum supply data, it is possible to separate petroleum establishments from other manufacturers. The balance of the petroleum supply data are principally for manufacturers, although some mining operations are included in the data. This situation will be discussed in more detail in the section on petroleum fuels.

The coal supply survey provides data on products supplied to specific industry categories. Therefore, it is possible to compare directly the coal supply data with the MECS consumption data for specific industries.

Energy Consumption by Fuel Type

For electricity and natural gas, the supply surveys cover a broader range of the industrial sector than just manufacturers, the subject of the consumption survey. For these fuels, then, we expect the supply figures to be larger than those from MECS, and that is what the data show. For petroleum and coal, the coverage of the two surveys is closer to being the same. However, as we shall see, there are still apparently differences of coverage in some cases so that a direct comparison cannot be made.

Electricity

As expected, the MECS figure for electricity consumption is substantially lower than the supply figure for 1985:¹⁶

¹⁶MECS distinguishes electricity "consumption," which includes electricity generated and consumed on site, from "purchased electricity," which is comparable to data collected in the supply survey. The MECS data are from *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, and the supply data are from *Annual Energy Review 1988*, DOE/EIA-0384(88), May 1989, Table 89; data from Form EIA-861.



MECS Purchased Electricity	654	billion kilowatthours
Industrial Sales of Electricity	825	billion kilowatthours
Supply as a Percent of MECS	128	percent
One RSE (MECS Sampling Error)	4	percent

There are no independent measures of electricity consumption in the agriculture, mining or construction industries to use to determine whether the difference between the MECS and supply figures is a reasonable estimate for the consumption in these industries.

Natural Gas

As with electricity, the supply measure of natural gas consumption for industry is larger than from MECS:¹⁷

MECS	5,012	billion cubic feet
Supply Survey (EIA-176)	5,901	billion cubic feet
Supply as Percent of MECS	118	percent
One RSE (MECS Sampling Error)	1	percent

The larger value for supply is expected because the supply survey includes mining and construction in addition to manufacturing industries. There are no independent estimates of natural gas consumption in these industries to determine whether or not the difference between MECS and the supply measure can be reasonably attributed to them.

Fuel Oil and Kerosene

The supply data on sales of fuel oil and kerosene to manufacturing industries are contained in two categories--sales for industrial use and sales for oil company use. Industrial use as defined in the supply form, EIA-821, includes manufacturing industries and some mining operations, but excludes oil company use. On the supply form, sales to oil companies includes sales to drilling companies, pipelines, other related oil companies not engaged in the selling of petroleum products, and fuel used by the reporting oil company for refinery operations.

In the MECS data, it is possible to separate consumption by oil companies themselves from other manufacturers. The MECS data for oil companies do not include consumption by pipelines and drilling companies, so it covers a slightly smaller range of companies than does the supply survey. Both the supply and MECS data can be further broken into type of fuel oil

¹⁷Data Sources: *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA--0514(85), November 1988; for the supply data, *Natural Gas Annual 1986*, DOE/EIA-0131(86)/1 October 1987, Table 27. The EIA supply data do not include 966 billion cubic feet of lease and plant fuel which are used by the natural gas companies and are not included in MECS.



consumed, distillate (including kerosene), and residual.

Since the MECS includes slightly fewer categories of companies for both industrial use (mining included in supply) and oil company use (drilling companies and pipeline included in supply), the MECS consumption figures are expected to be less than the supply figures. Both the supply survey and MECS collect data on deliveries rather than consumption of the products, so the two surveys are consistent in what they measure.

The MECS figures are lower, but the differences are far larger than would be expected on the basis of the differences in coverage of the two surveys (Table 8).

Table 8. Industrial Fuel Oil and Kerosene Consumption and Supply

	Distillate Fuel Oil and Kerosene		Residual Fuel Oil	
	Oil Comp- panies	Other Man- ufactures	Oil Comp- panies	Other Man- ufactures
MECS Consumption (thousand barrels)	752	34,987	15,731	71,277
EIA Supply Data (thousand barrels)	20,869	67,790	18,477	95,509
Supply as Percent of MECS	2,775%*	194%*	117%*	134%*
One RSE (MECS Sampling Error)	12%	6%	7%	3%

Note: Supply data for oil company use includes drilling and own company refining.
 * Statistically different from 100% using 2 standard errors (based only on NBECS sampling error; the sampling error from the petroleum survey has not been included).
 Source: *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*.
 Supply data: *Petroleum Marketing Monthly June 1988*, DOE/EIA-0380(88/06). pp.200-201; Data based on Form EIA-821.

Apart from residual fuel oil consumption for oil company use, where the MECS and supply data are fairly close (though not quite in agreement at a 95-percent confidence level), the supply estimates are substantially larger than the consumption estimates. The differences are so large as to suggest that the supply data are measuring something different than is being measured by



MECS.¹⁸ For example, the distillate fuel oil use by oil companies is so much larger than the MECS estimate that the supply data may be including some sales for refinery charging stocks rather than consumption. The instructions for Form EIA-821 request that oil companies exclude sales for use as refinery charging stocks, but the seller may not always know what use will be made of the product sold and so will not be able to respond accurately to the survey. Without further data, it is not possible to determine what factors underlie these extreme differences between MECS and the petroleum supply data.

Coal

The EIA coal "supply" survey and MECS both cover manufacturing industries, so the two can be compared more directly than is possible for other industrial fuel consumption. The "supply" survey, based on Form EIA-3, is a census of all plants using coal and measures consumption in a manner very similar to MECS. The MECS sample is drawn from a list maintained by the Census Bureau of manufacturing establishments, and it is a sample of manufacturers based on SIC classifications. The coal survey is a census of coal consuming companies, and the companies themselves specify the nature of their business on the survey form. The supply survey respondents may not classify their business consistently with the SIC categories, so it is possible there are some differences between the two surveys in the industrial classifications of the companies surveyed.

Since the coal survey is a census, it is not subject to sampling error as is MECS. Both surveys provide consumption estimates for specific industries, collect information about the same four types of coal, and ask how much coal is consumed, not just purchased or delivered. The supply survey is conducted quarterly, so the results from the four quarters of 1985 have been summed for these comparisons with MECS.

Total coal consumption measured by the supply survey is 12 percent higher than measured by MECS (Table 9). Much of the difference is believed to be a result of differences in coverage by the two surveys. Specifically, the supply survey includes some coal consumption by companies which are not included in MECS because their SIC code is not included in the codes for manufacturing industries. The industries most affected by this difference in coverage are Primary Metal and Petroleum.

Comparing the consumption estimates from the two surveys for individual industries shows a large number of differences (Table 9). Of the 15 manufacturing industries where comparisons could be made, the consumption estimates for 11 were different and 4 had the same consumption levels (at a 95-percent confidence level).

For primary metals, the MECS estimate is lower than the supply estimate by 6,504 thousand short tons. Up to half of this difference could be due to the exclusion of "auxiliary"

¹⁸See the article by Kelly and Wier, "A Comparison of Selected EIA-782 Data With Other Sources," *Petroleum Marketing Monthly*, DOE/EIA-0380(89/08), August, 1989, pp 5-17 for a discussion of some of the issues involved in measuring petroleum supply.



establishments from the MECS sampling frame, which are probably included in the supply survey. In some cases, an auxiliary establishment will provide electric power to the establishment it supports. In this situation, the auxiliary establishment will transfer in, rather than sell, the electricity to the establishment with which they are connected.

Table 9. Industrial Coal Consumption from MECS and Supply Survey for Manufacturing Industries

Industry	MECS (1,000 short tons)	Supply	Difference (S - M) (1,000 short tons)	Supply/ MECS	RSE
(Industries where differences are statistically significant)					
Primary Metal	41,676	48,180	6,504	116%	5%
Petroleum	339	5,875	5,536	1733%	9%
Paper	14,015	11,808	-2,207	84%	5%
Chemicals	14,957	15,966	1,009	107%	3%
Food	5,571	4,948	-623	89%	5%
Rubber	328	553	225	169%	7%
Transportation	1,860	2,041	181	110%	4%
Fabricated Metal	329	508	179	154%	6%
Furniture	89	240	151	270%	15%
Machinery	741	670	-71	90%	5%
Electric	373	426	53	114%	5%
(Industries where differences are not statistically significant)					
Stone	14,635	15,152	517	104%	5%
Tobacco	407	463	56	114%	8%
Textile	1,631	1,687	56	103%	7%
Leather	32	26	-6	81%	33%
All Manufacturers	97,981	109,526	11,545	112%	3%

Note: Data for Primary Metal include 41,056 thousand short tons consumed by coke plants which is collected on Form EIA-5. The total for all manufacturers includes consumption for industries not listed.

Source: *Manufacturing Energy Consumption Survey: Consumption of Energy, 1985*, DOE/EIA-0512(85); Supply Data: *Quarterly Coal Report October-December 1986*, DOE/EIA-0121(86/4Q), p.55 (Form EIA-3).

The MECS data indicate that 5,990 million kWh of electricity were transferred in by primary metal manufactures. If all this electricity were produced by coal, it would represent 3 thousand short tons of coal. Adding this quantity of coal to the MECS total would mean there is no

longer a statistically significant difference between the supply and consumption survey estimates. Not all of the electricity that is transferred in is necessarily produced by coal, of course, but a substantial amount of it is. This difference between the two surveys is an important reason for the differences in their findings for primary metals industries.

For the petroleum industry, the MECS consumption estimate is lower than the supply estimate by almost a factor of 20. The difference of 5,536 short tons is probably due to the inclusion of coal gasification plants in this category in the EIA-3 sample frame. These plants account for about 5,000 short tons of coal consumption. These plants are not considered manufacturing plants in the SIC classification, which is the basis for the MECS sample frame.

For the paper and allied products industries, the difference between the consumption survey and supply survey estimates is 2,207 short tons. There is no difference in coverage of establishments that we are aware of that could account for this difference. There is currently no explanation for the difference.

For chemicals, the MECS estimate is 1,009 short tons lower than from the supply survey. MECS does not include government owned and government operated plants. Nuclear processing plants are part of this industry and would be included in the supply survey but not MECS. There may also be auxiliary establishments that supply electricity generated from coal that are included in the supply survey but not MECS. There were 1,983 million kWh of electricity transferred in to chemical establishments, which is equivalent to about 1 thousand short tons. So this explanation could account for the discrepancy.

For the remaining industries, Food, Rubber, Transportation, Fabricated Metal, Furniture, Machinery and Electric, the consumption levels are lower, as are the magnitudes of the differences. There are no explanations for the differences, although there could be differences between the two surveys in the coverage of establishments included in the surveys, as was noted above for industries with higher consumption levels.



Conclusion

A typical analyst studying energy demand sees the combination of the rich cross-section detail in the consumption data and the longtime series of historical data available from the supply surveys as a valuable source of data for analysis. The data, however, don't fit quite so tightly together as we might hope. In some cases, the differences are relatively small, while in others the coverage of the two data sources is sufficiently different that they effectively cannot be used together. Further research and data collections will be required to reconcile the differences.

The two data sources do provide a consistent picture of energy use in the end-use sectors where both types of data have been collected. For the most part, though, the consumption and supply surveys are covering either slightly different, or substantially different, groups of energy consumers. Combining the two types of data in any analysis therefore requires that allowance be made for the differences of coverage.

Residential Sector

The supply and consumption surveys come closest to covering the same set of consumers in the residential sector. The Residential Energy Consumption Survey (RECS) does not cover second homes and unoccupied housing. The electric and natural gas supply surveys have some misclassification resulting from utilities using rate classes rather than the economic activity of the consumer to allocate sales in response to the survey. Apartment buildings are explicitly excluded from the fuel oil supply survey. The effect of these factors was difficult to observe in the data. For most of the years that RECS has been conducted, there was no statistically significant difference between the RECS estimate for electricity consumption and the residential supply figures. The natural gas and fuel oil figures were also not statistically significantly different for most years. Consequently, the effects of differences in coverage between the surveys are smaller than the standard error due to sampling variance in the consumption survey.

From the results of the comparison then, we can conclude that the two types of survey appear to be measuring close to the same thing. The standard error in the RECS data is sufficiently large that it is not possible from these data to estimate the likely size of the differences in consumption resulting from the differences in coverage of the two types of surveys.

