ENERGY USE IN THE U.S. COMMERCIAL SECTOR – ENERGY INFORMATION ADMINISTRATION DATA, INFORMATION, AND ANALYSES

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ABSTRACT

The Energy Information Administration (EIA) is the independent statistical and analytical agency within the U.S. Department of Energy. As such, EIA has a wealth of energy data and analyses available for public use, including information about energy use in the buildings sectors.

This paper discusses the types of EIA energy information available, how the information can be accessed, and how it may be valuable in the quest to improve existing building energy usage.

BACKGROUND

The Energy Information Administration (EIA) is an autonomous statistical and analytical agency within the U.S. Department of Energy (DOE). EIA is charged with providing objective, timely, and relevant data, analysis and projections for use by DOE, other agencies, Congress, and the public. The data and analysis reports produced by EIA assist policy makers in their determination of energy policy. However, EIA does not take positions on policy issues, does not speak for DOE, or the Administration, and does not represent any particular point of view with respect to energy policy. EIA's baseline projections on energy trends are widely used by government agencies, the private sector, and academia for their own energy analyses.

The Office of Energy Information and Analysis, which later became EIA, was established within the Federal Energy Administration in 1976 under the Energy Conservation and Production Act (Public Law 94-385). This office was to operate a comprehensive National Energy Information System, possess expertise in energy analysis and forecasting, coordinate energy information activities with Federal agencies, promptly provide upon request any energy information to any duly established committee of Congress, and make periodic reports on the energy situation and trends to the Congress and the public. In 1977, the Department of Energy Organization Act (Public Law 95-91) established EIA as the single Federal Government authority for energy information. EIA was given independence from the rest of DOE with respect to data collection, and from the entire Government with respect to the content of EIA reports. The Energy Policy Act of 1992 (Public Law 102-486) required EIA to expand its data gathering and analysis in several areas, including energy consumption, alternative fuels and alternatively-fueled vehicles, greenhouse gas emissions, fossil fuel transportation rates and distribution patterns, electricity production from renewable energy sources, and foreign purchases and imports of uranium.

EIA's Internet site offers all EIA publications at no cost to the user. The EIA data, projections and reports discussed in this paper are all available for public use. Although this paper focuses on U.S. energy information, international energy data and projections are also available from EIA. The *International Energy Annual* and *International Petroleum Monthly* are examples of EIA publications featuring historical energy data, while the *International Energy Outlook* provides mid-term projections of worldwide energy consumption. Users can view and download selected pages or entire reports, search for information, and download EIA data and analysis applications. The EIA World Wide Web site may be found at http://www.eia.doe.gov. The FTP site for direct download of EIA information is ftp://ftp.eia.doe.gov.

HISTORICAL ENERGY INFORMATION

Energy Consumption and Prices. Historical data on energy consumption and energy prices are available from EIA's Web site. Annual data by energy source and demand sector are available for 1949 to the present with monthly data available for the most recent two years in both publication and database application format. Annual state-level data regarding energy consumption and energy prices and expenditures are available as part of the State Energy Data System (EIA, 2001b and EIA, 2000c). For many energy sources, monthly publications, such as *Natural Gas Monthly*, have state-level price and consumption data for the most recent two years.

Commercial Buildings Information. The U.S. Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey conducted by EIA that collects statistical information on the consumption and expenditures for energy in U.S commercial buildings, as well as collecting statistics on a wide range of energy-related building

characteristics. CBECS was first conducted in 1979 and then every three years between 1983 and 1995. Currently, the survey is conducted every four years with the most recent CBECS conducted in 1999.

The statistical information provided by CBECS is generally categorized by energy-related building characteristics and by the nine U.S. Census divisions, as represented in Figure 1. Information includes the total and average number of buildings and square feet; the total amount and cost of electricity, natural gas, fuel oil and district heat consumed in the survey year; and the average amount and cost of electricity, natural gas, fuel oil, and district heat per square foot, per building and per employee. Based on this information, EIA develops estimates of total energy consumption and energy end use intensities for space heating, space cooling, water heating, ventilation, refrigeration, cooking, lighting, office equipment, and miscellaneous use in the survey year (EIA, 1998).

The 1999 CBECS Public Use Data is expected to be available later this year (2001). Data, tables and reports related to CBECS, including reports on special topics such as "Trends in the Commercial Buildings Sector," are available at http://www.eia.doe.gov/emeu/cbecs.

Residential Households Information. Although the commercial sector is the focus of this paper, information is available to those interested in residential energy use, as well. EIA conducts a national sample survey of energy-related characteristics, energy usage and expenditures in U.S. households. The Residential Energy Consumption Survey (RECS) was conducted annually from 1978 through 1982, every three years between 1984 and 1993, and is currently conducted every four years. The latest available RECS data were collected in 1997 with data collection for 2001 currently in progress. RECS provides total household energy usage and expenditures; estimates of the amount of energy used and expenditures for space heating, air conditioning, water heating, refrigerators and other appliances; a comprehensive list of household appliances and energy usage indicators; and the ability to characterize energy usage and consumption by household demographics and housing characteristics. Data are available in summary data tables and micro data files at the nine Census divisions level and for the four most populous states:

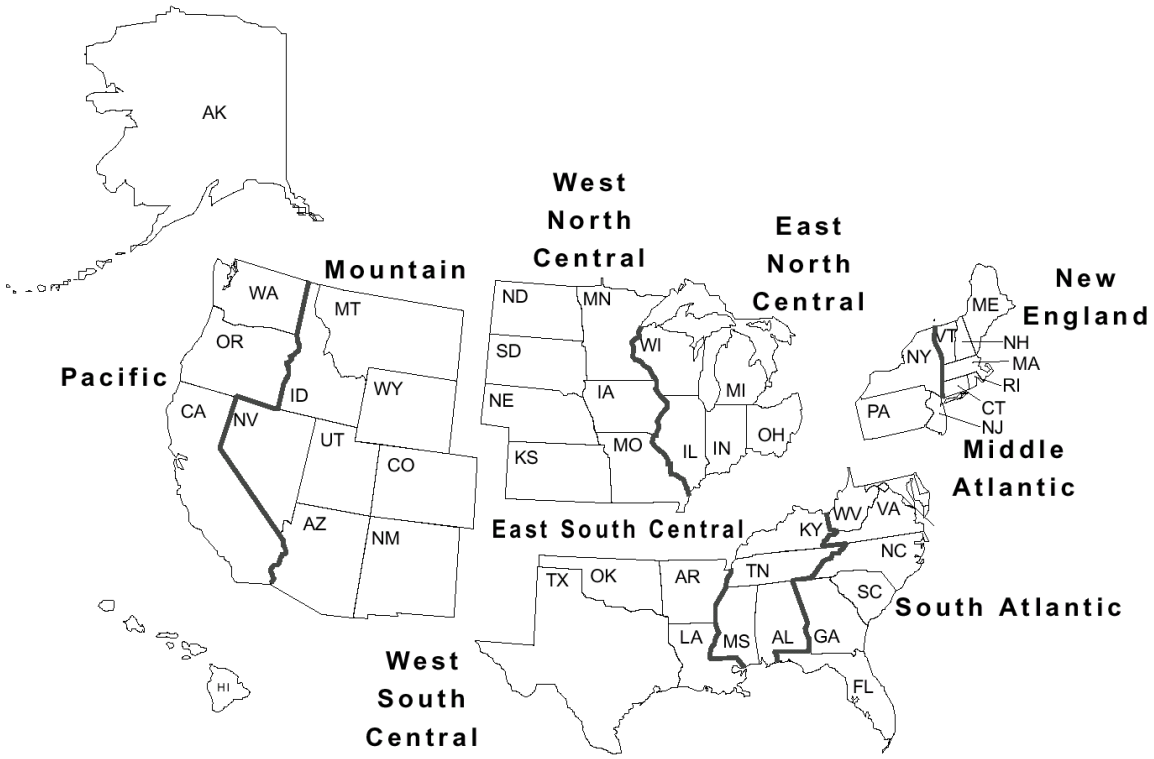

Figure 1. U.S. Census Divisions

California, Florida, New York, and Texas (EIA, 1999). RECS data are available on the Internet at http://www.eia.doe.gov/emeu/recs.

Manufacturing Energy Use Information. EIA also conducts a national sample survey of energy use in manufacturing, the Manufacturing Energy Consumption Survey (MECS) (EIA, 1997). Information supplied by manufacturing establishments allows EIA to report energy use estimates by industry group. The first MECS reported data for 1985 with subsequent surveys every three years through 1994. The survey is now conducted every four years. Data for the 1998 MECS are available through EIA's Web site at http://www.eia.doe.gov/emeu/mecs/contents.html.

ENERGY PROJECTIONS AND ANALYSES

Short-term energy projections are published in EIA's *Short-Term Energy Outlook* (*STEO*), which is updated monthly and contains quarterly projections for the successive two calendar years, taking into account the latest developments in energy markets. Midterm forecasts are developed and published annually in the *Annual Energy Outlook* (*AEO*), which provides projections and analyses of domestic energy consumption, supply, prices, and energy-related carbon dioxide emissions through 2020. These projections are not meant to be exact predictions of the future, but represent a likely energy future, given technological and demographic trends, current laws and regulations, and consumer behavior as derived from known data.

EIA recognizes that projections of energy markets are highly uncertain, subject to many random events that cannot be foreseen, such as weather, political disruptions, strikes, and technological breakthroughs. In addition to these short-term phenomena, long-term trends in technology development, demographics, economic growth, and energy resources may evolve along a different path than assumed in the *AEO* reference case. Many of these uncertainties are explored through alternative cases in both the *STEO* and *AEO*. Analyses are also prepared in response to requests for special studies by the U.S. Congress, the DOE Office of Policy, other offices in DOE, and other government agencies. EIA's forecasts and analyses are provided at http://www.eia.doe.gov/oiaf/forecasting.html.

Short-Term Projections

Short-Term Energy Model. The Short-Term Energy Model is a set of equations, including estimated regression equations, that together form a system of interrelated forecasting equations. The model provides short-term energy supply, demand, and price projections using historical energy data that are regularly reported in the *Monthly Energy Review*, *Petroleum Supply Monthly*, and other EIA publications. These energy price and volume data are supplemented by data from outside sources, such as, *Employment and Earnings* from the Bureau of Labor Statistics, *Industrial Production* from the U.S. Federal Reserve System, *Survey of Current Business* from the Bureau of Economic Analysis, and *Monthly State, Regional, and National Heating/Cooling Degree-Days Weighted by Population* from the National Oceanic and Atmospheric Administration. Values for the current month and quarter are all preliminary EIA estimates or calculated from model simulations using the latest exogenous information available (for example, electricity sales and generation are simulated using actual weather data).

Short-Term Energy Outlook. The *STEO* presents national forecasts that are developed monthly for publication on the Internet (EIA, 2001a). Projections are provided for each quarter in the forecast period, which extends from the current month to the end of the following year, currently 2002. *STEO* projections focus on a mid world oil price case with 95% confidence intervals shown in graphics presenting price projections for crude oil, retail motor gasoline, and spot natural gas purchases. Each April the *STEO* includes a "Summer Motor Gasoline Outlook," and the October *STEO* contains a "Winter Fuels Outlook".

The forecast is driven by three sets of assumptions: estimates of key macroeconomic variables, world oil prices, and assumptions about the severity of weather. Macroeconomic estimates are produced by DRI/McGraw-Hill but are adjusted by EIA to reflect EIA assumptions about the world price of crude oil, energy product prices, and other assumptions that may affect the macroeconomic outlook.

In addition to the *STEO* publication, the Short-Term Energy Outlook Query System allows access to extensive monthly history for key variables from the database used to generate the *STEO* forecast.

Midterm Projections And Analyses

National Energy Modeling System. The National Energy Modeling System (NEMS) is a computer-based, energy-economy modeling system of U.S. energy markets for the midterm period through 2020. NEMS projects the production,

imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics.

NEMS is used by EIA to project the energy, economic, environmental, and security impacts on the United States under alternative assumptions about energy markets. Projections are made for each year from the present through 2020. This time period is one in which technology, demographics, and economic conditions are sufficiently understood to represent energy markets with a reasonable degree of confidence.

Energy resources and prices, the demand for specific energy services, and other characteristics of energy markets can vary widely across the United States. To address these differences, NEMS is a regional model. The basic regional structure is that of the nine Census divisions, represented in Figure 1.

The forecasts produced by NEMS are contingent on the key assumptions made about U.S. energy systems. Assumptions include, for example, the estimated size of the economically recoverable resource base of fossil fuels, changes in world energy supply and demand, the rates at which new energy technologies are developed and the rate and extent of their adoption and penetration, and existing or prospective government actions or policies.

An overview of the structure and methodology of NEMS, including the Commercial Sector Demand Module and its relationship to the other modules of NEMS, is provided in the EIA publication *National Energy Modeling System (NEMS): An Overview* (EIA, 2000b).

Annual Energy Outlook. Baseline forecasts through 2020 are developed with NEMS and published annually in the *Annual Energy Outlook*. In accordance with the requirement that EIA remain policy-neutral, the *Annual Energy Outlook* projections assume that all existing legislation, regulations, and policies remain unchanged.

The analyses in the *Annual Energy Outlook 2001* (*AEO2001)* focus primarily on a reference case and four other cases that assume higher and lower economic growth and higher and lower world oil prices than in the reference case. Alternative cases explore the impacts of varying key assumptions in NEMS – e.g., technology penetration (EIA, 2000a).

The *AEO2001* projections are based on Federal, State, and local laws and regulations in effect on July 1, 2000. Pending legislation and sections of existing legislation for which funds have not been appropriated are not reflected in the forecasts. Historical data used for the *AEO2001* projections were the most current available as of July 31, 2000, when most 1999 data but only partial 2000 data were available. The estimates for 2000 and 2001 incorporate the short-term projections from EIA's September 2000 *Short-Term Energy Outlook*.

Currently, most attention in energy markets is focused on near-term issues of world oil supply and prices, U.S. natural gas prices, and the transition to restructured electricity markets in several regions of the country. The *AEO2001* addresses the longer-term trends, such as electricity industry restructuring, fossil fuel supply and prices, and the impacts of economic growth on projected energy use and carbon dioxide emissions. It does not project short-term events, such as supply disruptions or severe weather.

The *AEO2001* projections assume a transition to full competitive pricing of electricity in states with specific deregulation plans – California, New York, New England, the Mid-Atlantic States, Illinois, Texas, Oklahoma, Michigan, Ohio, Arizona, New Mexico, and West Virginia. Other states are assumed to continue cost-of-service electricity pricing.

Commercial sector estimates published in the *AEO2001* and available through EIA's Web site include projections of commercial sector energy consumption by type of fuel, end-use service, building type, and Census division. Price projections are published at the National and Census division level for each of the energy sources considered to be a major fuel in the commercial sector. *AEO2001* projections of commercial floorspace provide estimates of new construction and surviving floorspace, as well as projections of commercial floorspace by building type. Floorspace and energy use estimates are combined to provide measures of projected energy consumption intensity (use per square foot) in terms of both energy delivered to the site and total energy use, including energy losses incurred in the generation, transmission, and distribution of electricity. Projections of commercial sector carbon dioxide emissions and the average efficiency of energy-using equipment are also published.

Detailed estimates and indicators underlie the commercial projections presented in the *AEO2001*. Projections of commercial floorspace by Census

division, end-use technology market shares, and the average efficiency of purchased equipment are examples of estimates that are more detailed than can be provided in *AEO2001*, but may be of interest in analyzing commercial building energy use. Projections for distributed generation and combined heat and power technologies, such as generating capacity, electricity generation and fuel consumption, may also be useful. While not available directly from EIA's Web site, more detailed projections may be available by special request.

USE OF EIA DATA AND PROJECTIONS IN ANALYSES OF POTENTIAL IMPROVEMENTS

Engineers and energy managers concerned with energy use at a specific building or facility may be most interested in data and projections for commercial energy consumption and fuel prices related to that building type in a particular area of the country. Those whose interests may have a broader focus, such as State agency energy managers and scientists, may also be interested in projections of commercial floorspace growth and carbon dioxide emissions. Both groups may find use for the projections developed with alternative assumptions for economic growth, world oil prices, or technological development while weighing options for improving building energy consumption. Although data needs vary with the scope of a project, the following examples illustrate areas where EIA data, projections, and analyses may prove useful.

Baseline Energy Use. An estimate of baseline energy use is required to measure relative changes in consumption caused by the implementation of an improvement option. For individual buildings this can often be accomplished by comparing weather-adjusted billing records before and after an improvement has been implemented. The potential for unrelated changes in energy use should be considered when measuring the effects of implementation by this method. EIA regional data and projections of commercial energy use can provide a baseline, or alternative baselines, for estimating the effects of an area-wide program aimed at improving commercial building energy usage.

Figure 2 illustrates an example of a regional baseline (South Atlantic Census division), using historical energy consumption data and a range of projected energy consumption estimates for the commercial sector, based on the *AEO2001* reference case and high and low economic growth cases. The assumed rate of economic growth has a strong impact on projections of energy consumption.

The high economic growth case assumptions include higher projected growth in population, the labor force, and labor productivity than in the

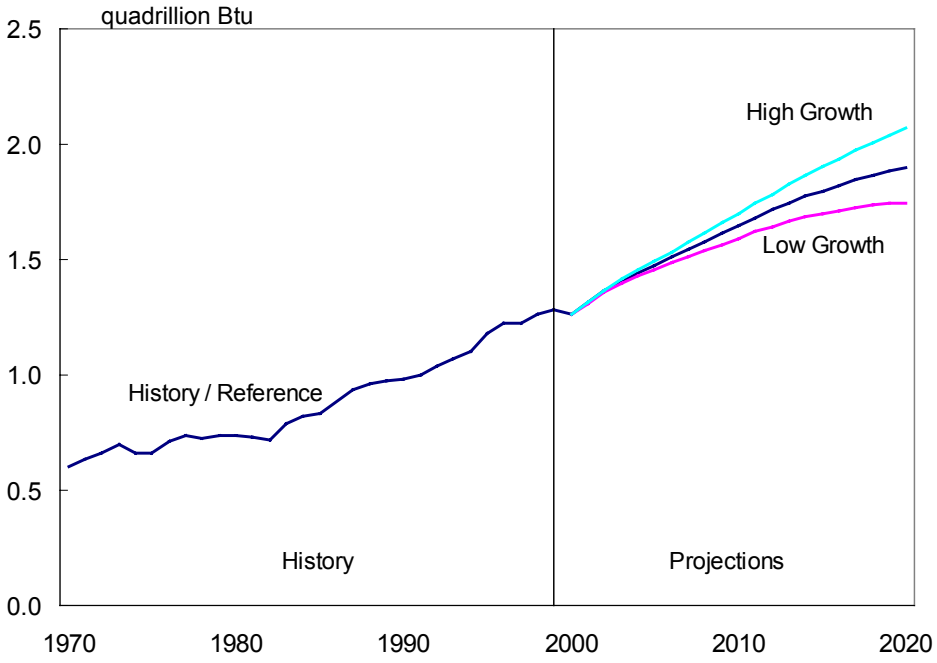

Figure 2. Commercial delivered energy use in the South Atlantic Census division, 1970-2020 (quadrillion Btu)
Sources: History: EIA, *State Energy Data Report 1999*. Projections: EIA, *Annual Energy Outlook 2001*.

reference case, leading to higher industrial output, lower inflation, and lower interest rates. Higher projected economic growth yields higher growth in commercial floorspace, the primary driver of commercial energy use in *AEO2001*. In the South Atlantic Census division, these assumptions result in over 2.0 quadrillion Btu in projected commercial delivered energy use by 2020, an average annual increase of 2.5 percent from 2000 through 2020, compared to an average projected increase of 2.0 percent per year in the reference case for the same time period.

In the low economic growth case, assumptions of lower projected growth in population, the labor force and labor productivity result in fewer expected additions to commercial floorspace. Commercial delivered energy consumption is projected to increase just 1.6 percent per year in the South Atlantic Census division in this case, to 1.7 quadrillion Btu in 2020.

Fuel Prices: Historical Trends and Projections. The cost effectiveness of an energy conservation measure depends on both the investment required (i.e., capital and fixed operating and maintenance costs) and the energy expenditure savings realized by putting the conservation measure in place. EIA information on energy prices may facilitate the cost analysis of an energy conservation measure by providing insight into the potential for cost savings.

State-level historical price data from the last few years can indicate the possible level of savings under the assumption that future fuel and electricity prices will be close to current prices. An alternative assumption would be that future prices will continue to follow the long-term trend that regional prices have shown for the last few decades. Projections for energy prices, and consequently cost savings, could be based on extending a trend evident in the historical annual time-series for State-level prices. As illustrated for commercial electricity prices in Texas (Figure 3), the projections obtained by extending a simple linear trend depend on the time period chosen as a base for the trend. Electricity prices in Texas rose steeply between 1974 and 1984, a time marked by volatile energy markets and rapid growth in commercial electricity use. After 1984, the

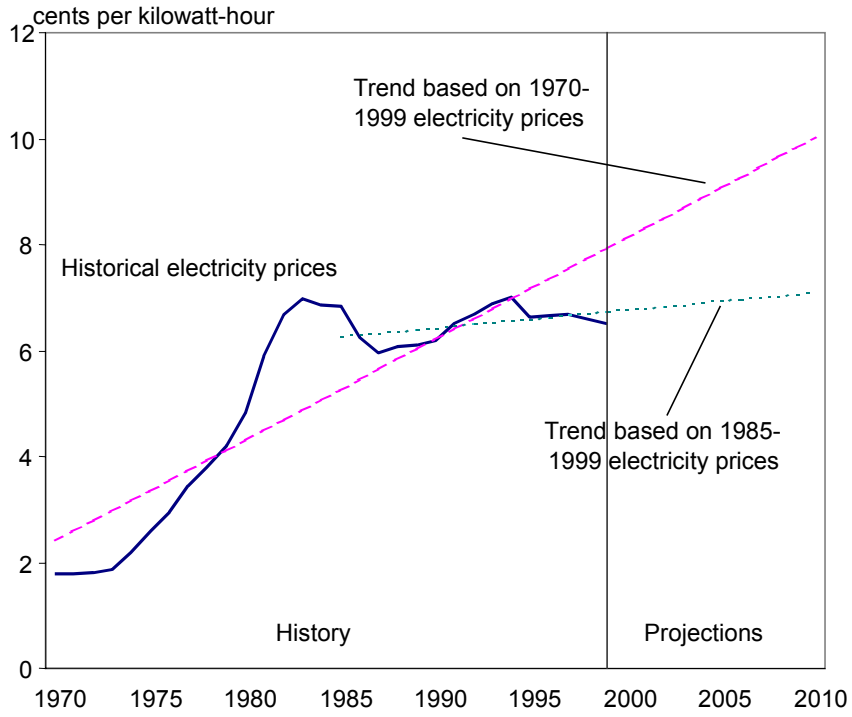

Figure 3. Texas Commercial Electricity Prices – History and Potential Trends, 1970-2010 (cents per kilowatt-hour)
Sources: EIA, *State Energy Price and Expenditure Report 1997*, EIA, "Retail Sales of Electricity, Revenue, and Average Revenue per Kilowatthour (and RSEs) by U.S. Electric Utilities to Ultimate Consumers by Census Division, and State, 1999 and 1998 – Commercial.

stabilization of fuel supplies and prices, and slower growth in electricity demand, resulted in fairly steady prices for electricity sold to commercial consumers in Texas. Including the 1974-1984 period of volatility in the development of a price trend leads to higher projections for future electricity prices than a trend that only considers prices subsequent to that time.

EIA fuel price projections may also be used in estimating the cost savings potential of an energy conservation measure. The nature of the energy saving option under consideration determines whether short-term or mid-term projections are most suited to the analysis. If the analysis focuses on the effects on energy use and costs over the next few years, the *STEO* projections that incorporate short-term fluctuations on a quarterly basis may provide a better estimate. In this case, national level price projections for the commercial sector would be used in the analysis to obtain a general estimate of cost savings as a result of implementation. For conservation options that are expected to provide many years of energy expenditure savings, mid-term projections that incorporate likely technological and demographic trends and longer-term effects of current legislation and regulations may give a better representation of future energy prices. Census division level commercial energy price projections from the *AEO2001* reference case and alternative cases reflect regional price effects that may not be evident in the national level projections.

Alternative Paths of Technological Progress. Energy market projections are subject to many uncertainties, such as the availability and market penetration of new, more efficient technologies. The *AEO2001* reference case incorporates efficiency improvements for both commercial equipment and building shells. In order to address uncertainties about the pace of technological progress, *AEO2001* presents a range of alternative cases that vary assumptions about technology improvements and penetration. The 2001 technology case assumes that future equipment and building shells will be no more efficient than those available in 2001. Experts in technology engineering were consulted to derive high technology assumptions, considering the potential impacts of increased research and development for more advanced technologies. The revised assumptions include earlier years of introduction, lower costs, and higher efficiencies than assumed in the reference case.

Examining the alternative technology cases in *AEO2001* may offer insight into the potential energy savings of programs fostering enhanced technology development and, conversely, the potential increased energy consumption brought on by the lack of future technology development. The alternative technology cases include the effects of the relative turnover of the capital stock. In the high technology case, the rate of capital stock turnover may slow the rate of adoption for new, advanced technologies. However, in the 2001 technology case, this turnover allows continued improvement in aggregate efficiency as new equipment replaces older stock and the capital stock expands. In addition, no change in consumer behavior is assumed; that is, consumers value efficiency equally in each of the cases. Although more advanced technologies may reduce energy consumption, in general they are more expensive when initially introduced. In order to provide energy savings, advanced technologies must be purchased by consumers. However, many potential purchasers may not be willing to buy more expensive equipment that has a long period for recovering the additional cost through energy savings, and many may value other attributes over energy efficiency.

Figure 4 presents changes in projected U.S. commercial energy consumption in the *AEO2001* 2001 technology and high technology cases relative to the reference case. The cases include alternative technology assumptions for all end-use demand sectors and the electricity generation sector, representing the possible synergistic or dampening effects that would not be captured if alternative rates of technological progress were considered for a single sector in isolation. Commercial primary energy use in the 2001 technology case is projected to be 530 trillion Btu (2.6 percent) higher in 2020 than the reference case forecast. Projected commercial sector energy savings using high technology assumptions reach 800 trillion Btu (3.9 percent) in 2020, relative to reference case assumptions about technological progress, including energy savings from improved efficiencies in the generation and distribution of electricity to the commercial sector.

SUMMARY

The Energy Information Administration, as an independent statistical and analytical agency within the U.S. Department of Energy, has a wealth of energy data and analyses available for public use via the EIA Web site at http://www.eia.doe.gov. Historical data on energy consumption and energy prices are available at both the national and state levels. Statistical information on commercial and residential energy-related building characteristics, consumption, and expenditures is also available. EIA

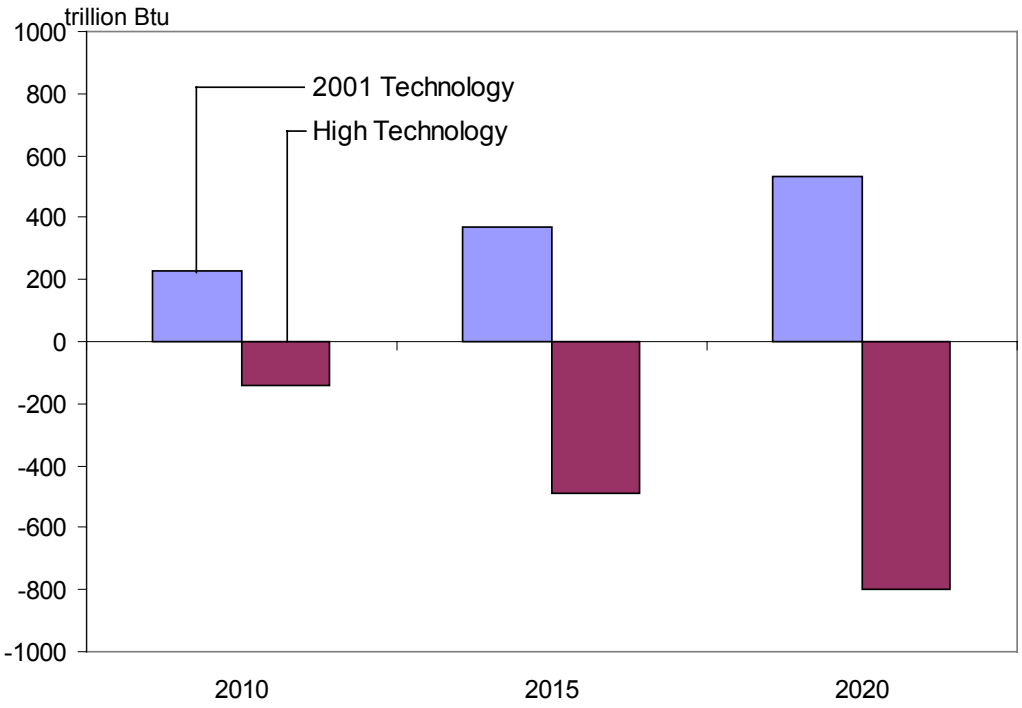

Figure 4. Projected variation from reference case commercial primary energy use in two alternative cases, 2010, 2015, and 2020 (trillion Btu)
Source: EIA, *Annual Energy Outlook 2001*.

produces short-term and midterm forecasts of U.S. energy markets that provide projections and analyses of domestic energy consumption, supply, prices, and energy-related carbon dioxide emissions. Analyses that focus on specific energy-related issues are also prepared in response to requests by the U.S. Congress, DOE, and other government agencies. This paper has explored areas where EIA data, projections, and analyses may be valuable when investigating options for improving energy use in commercial buildings.

REFERENCES

Energy Information Administration (EIA). 1997. *Manufacturing Consumption of Energy 1994*. Washington, D.C.: Energy Information Administration.

EIA. 1998. *A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures*. Washington, D.C.: Energy Information Administration.

EIA. 1999. *A Look at Residential Energy Consumption in 1997*. Washington, D.C.: Energy Information Administration.

EIA. 2000a. *Annual Energy Outlook 2001, with Projections to 2020*. Washington, D.C.: Energy Information Administration.

EIA. 2000b. *National Energy Modeling System: An Overview 2000*. Washington, D.C.: Energy Information Administration.

EIA. 2000c. *State Energy Price and Expenditure Report 1997*. Washington, D.C.: Energy Information Administration.

EIA. 2001a. *Short-Term Energy Outlook*. Washington, D.C.: Energy Information Administration (June).

EIA. 2001b. *State Energy Data Report 1999, Consumption Estimates*. Washington, D.C.: Energy Information Administration.