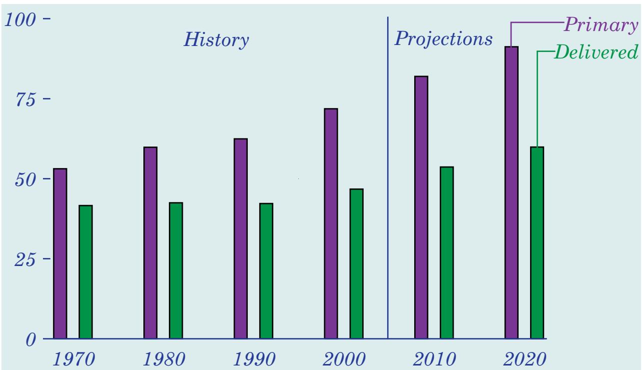
Annual Growth in Energy Use Is Projected To Continue

Figure 23. Primary and delivered energy consumption, excluding transportation use, 1970-2020 (quadrillion Btu)



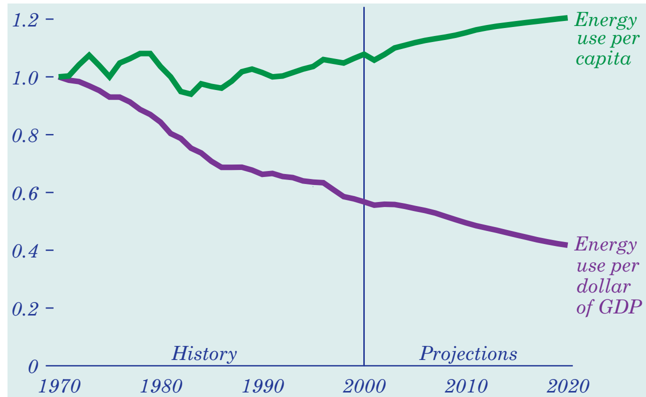
Net energy delivered to consumers represents only a part of total primary energy consumption. Primary consumption includes energy losses associated with the generation, transmission, and distribution of electricity, which are allocated to the end-use sectors (residential, commercial, and industrial) in proportion to each sector's share of electricity use [*77*].

How energy consumption is measured has become more important over time, as reliance on electricity has expanded. In 1970, electricity accounted for only 12 percent of energy delivered to the end-use sectors, excluding transportation. Since then, the growth in electricity use for applications such as space conditioning, consumer appliances, telecommunication equipment, and industrial machinery has resulted in greater divergence between primary and delivered energy consumption (Figure 23). This trend is expected to stabilize in the forecast, as more efficient generating technologies offset increased demand for electricity. Projected primary energy consumption and delivered energy consumption both grow by 1.2 percent per year, excluding transportation use.

At the end-use sectoral level, tracking of primary energy consumption is necessary to link specific policies with overall goals. Carbon dioxide emissions, for example, are closely correlated with total energy consumption. In the development of carbon dioxide stabilization policies, growth rates for primary energy consumption may be more important than those for delivered energy.

Average Energy Use per Person Increases Slightly in the Forecast

Figure 24. Energy use per capita and per dollar of gross domestic product, 1970-2020 (index, 1970 = 1)

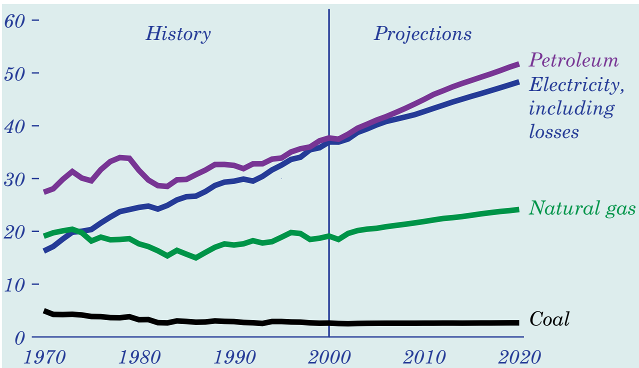


Energy intensity, both as measured by primary energy consumption per dollar of GDP and as measured on a per capita basis, declined between 1970 and the mid-1980s (Figure 24). Although the overall GDP-based energy intensity of the economy is projected to continue declining between 2000 and 2020, the decline is not expected to be as rapid as it was in the earlier period. GDP is estimated to increase by almost 80 percent between 2000 and 2020, compared with a 32-percent increase in primary energy use. Relatively stable energy prices are expected to slow the decline in energy intensity, as is increased use of electricity-based energy services. When electricity claims a greater share of energy use, consumption of primary energy per dollar of GDP declines at a slower rate, because electricity use contributes both end-use consumption and energy losses to total energy consumption.

In the *AEO2002* forecast, the demand for energy services is projected to increase markedly over 2000 levels. The average home in 2020 is expected to be 6.5 percent larger and to use electricity more intensively. Annual personal highway travel and air travel per capita in 2020 are expected to be 31 percent and 68 percent higher, respectively, than in 2000. With the growth in demand for energy services, primary energy intensity on a per capita basis is projected to increase by 0.6 percent per year through 2020, with efficiency improvements in many end-use energy applications making it possible to provide higher levels of service without significant increases in total energy use per capita.

Petroleum Products Lead Growth in Energy Consumption

Figure 25. Delivered energy use by fossil fuel and primary energy use for electricity generation, 1970-2020 (quadrillion Btu)



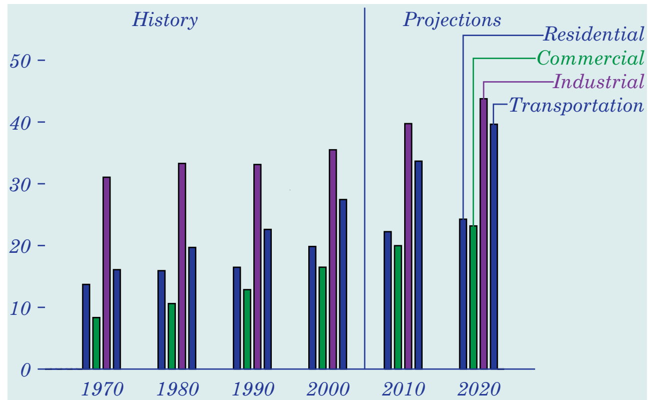
Consumption of petroleum products, mainly for transportation, is expected to claim the largest share of primary energy use in the *AEO2002* forecast (Figure 25). Energy demand growth in the transportation sector averaged 2.0 percent per year during the 1970s but was slowed in the 1980s by rising fuel prices and new Federal efficiency standards, leading to a 2.1-percent annual increase in average vehicle fuel economy. In the forecast, fuel economy gains are projected to slow as a result of expected stable real fuel prices and the absence of new legislative mandates. Projected growth in population and in travel per capita are expected to result in increases in demand for gasoline throughout the forecast.

Increased competition and technological advances in electricity generation and distribution are expected to slightly reduce the real cost of electricity. Despite low projected prices, however, growth in electricity use is expected to be slower than the rapid growth of the 1970s. Excluding consumption for electricity generation, demand for natural gas is projected to grow at a slightly slower rate than overall end-use energy demand, in contrast to the recent trend of more rapid growth in the use of gas as the industry was deregulated. Natural gas is projected to meet 24 percent of end-use energy requirements in 2020.

End-use demand for renewable energy from sources such as wood, wood wastes, and ethanol is projected to increase by 1.6 percent per year. Geothermal and solar energy use in buildings is expected to increase by about 3.1 percent per year but is not expected to exceed 1 percent of energy use for space and water heating.

U.S. Primary Energy Use Approaches 131 Quadrillion Btu per Year by 2020

Figure 26. Primary energy consumption by sector, 1970-2020 (quadrillion Btu)



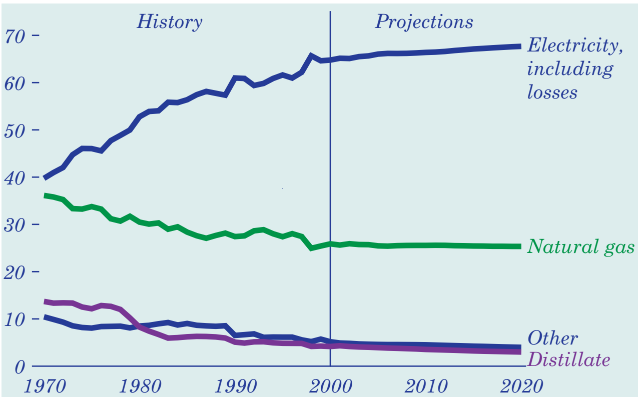
Primary energy use in the reference case is projected to reach 130.9 quadrillion Btu by 2020, 32 percent higher than the 2000 level. In the early 1980s, as energy prices rose, sectoral energy consumption grew relatively little (Figure 26). Between 1985 and 2000, however, stable energy prices contributed to a marked increase in sectoral energy consumption.

In the forecast, energy demand in the residential sector is projected to grow at one-third the expected growth rate for GDP and in the commercial sector at just over one-half the GDP growth rate. Demand for energy is expected to grow more rapidly in the transportation sector than in the buildings sectors as a result of increased per capita travel and slower fuel efficiency gains. Assumed efficiency gains in the industrial sector are projected to cause the demand for primary energy to grow more slowly than GDP.

To bracket the uncertainty inherent in any long-term forecast, alternative cases were used to highlight the sensitivity of the forecast to different oil price and economic growth paths. At the consumer level, oil prices primarily affect the demand for transportation fuels. Projected oil use for transportation in the high world oil price case is 3 percent lower than in the low world oil price case in 2020, as consumer choices favor more fuel-efficient vehicles and the demand for travel services is reduced slightly. In contrast, variations in economic growth assumptions lead to larger changes in the projections of overall energy demand in each of the end-use sectors [*78*]. For 2020, the projection of total annual energy use in the high economic growth case is 11 percent higher than in the low economic growth case.

Residential Energy Use Grows by 22 Percent From 2000 to 2020

Figure 27. Residential primary energy consumption by fuel, 1970-2020 (percent of total)



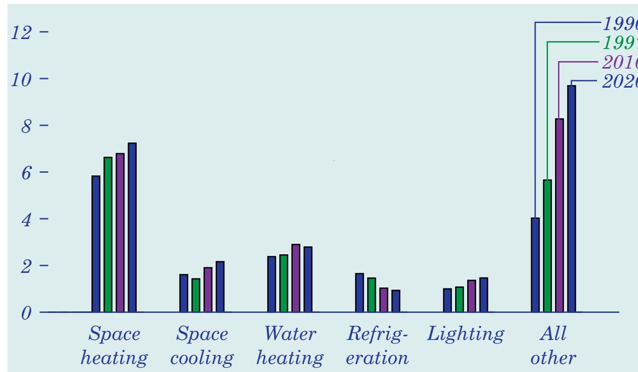
Residential energy consumption is projected to increase by 22 percent overall between 2000 and 2020. Most (81 percent) of the growth in total energy use is related to increased use of electricity. Sustained growth in housing in the South, where almost all new homes use central air conditioning, is an important component of the national trend, along with the penetration of consumer electronics, such as home office equipment and security systems (Figure 27).

While its share of total residential primary energy consumption remains about the same over time, natural gas use in the residential sector is projected to grow by 0.9 percent per year through 2020. Natural gas prices to residential customers are projected to decline in the forecast and to be lower than the prices of other fuels, such as heating oil. The number of homes heated by natural gas is projected to increase more than the number heated by electricity and oil. Petroleum use is projected to fall, with the number of homes using petroleum-based fuels for space heating applications expected to decrease over time.

Newly built homes are, on average, 14 percent larger than the existing stock, with correspondingly greater needs for heating, cooling, and lighting. Under current building codes and appliance standards, however, energy use per square foot is typically lower for new construction than for the existing stock. Further reductions in residential energy use per square foot could result from additional gains in equipment efficiency and more stringent building codes, requiring more insulation, better windows, and more efficient building designs.

Efficiency Standards Moderate Residential Energy Use

Figure 28. Residential primary energy consumption by end use, 1990, 1997, 2010, and 2020 (quadrillion Btu)



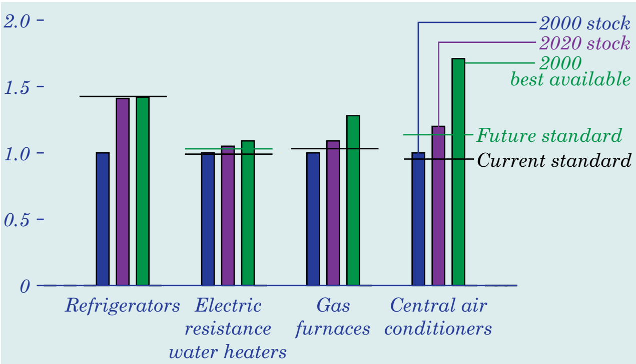
Energy use for space heating, the most energy-intensive end use in the residential sector, grew by 1.9 percent per year from 1990 to 1997 (Figure 28). Future growth is expected to be slowed by higher equipment efficiency and tighter building codes. Building shell efficiency gains are projected to cut space heating demand by about 7 percent per household in 2020 relative to the demand in 1997.

A variety of appliances are now subject to minimum efficiency standards, including heat pumps, air conditioners, furnaces, refrigerators, and water heaters. Current standards for a typical residential refrigerator, which became effective in July 2001, limit electricity use to 478 kilowatthours per year. Energy use for refrigeration has declined by 1.7 percent per year from 1990 to 1997 and is expected to decline by about 1.9 percent per year through 2020, as older, less efficient refrigerators are replaced with newer models.

The “all other” category, which includes smaller appliances such as personal computers, dishwashers, clothes washers, and dryers, has grown by 5 percent per year from 1990 to 1997 (Figure 28) and now accounts for 32 percent of residential primary energy use. It is projected to account for 40 percent in 2020, as small electric appliances continue to penetrate the market. The promotion of voluntary standards, both within and outside the appliance industry, is expected to forestall even larger increases. Even so, the “all other” category is projected to exceed other components of residential demand by 2020, growing at an annual rate of 2.1 percent from 2000 to 2020.

Available Technologies Can Slow Future Residential Energy Demand

Figure 29. Efficiency indicators for selected residential appliances, 2000 and 2020 (index, 2000 stock efficiency =1)

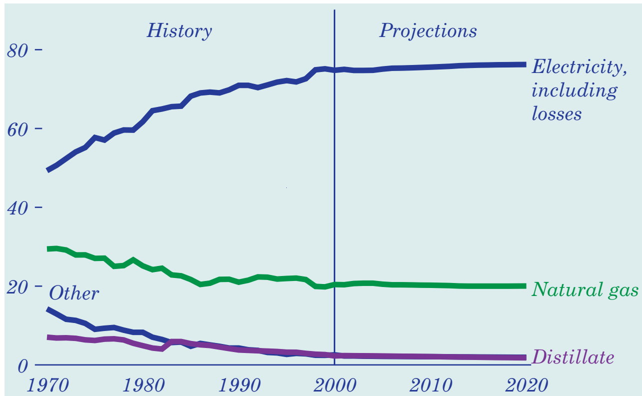


The *AEO2002* reference case projects an increase in the stock efficiency of residential appliances, as stock turnover and technology advances in most end-use services reduce residential energy intensity over time. For most appliances covered by the National Appliance Energy Conservation Act of 1987, the most recent Federal efficiency standards are higher than the 2000 stock, ensuring an increase in stock efficiency (Figure 29) without any additional new standards. Future updates to the Federal standards could have a significant effect on residential energy consumption, but they are not included in the reference case. Effective dates for new efficiency standards for water heaters, clothes washers, central air conditioners, and heat pumps were announced in January 2001 and are included in the reference case, which assumes that current legal challenges will not prevent implementation of the standards in the most recent DOE announcement on July 25, 2001.

For almost all end-use services, existing technologies can significantly curtail future energy demand if they are purchased by consumers. The most efficient technologies can provide significant long-run savings in energy bills, but their higher purchase costs tend to restrict their market penetration. For example, condensing technology for natural gas furnaces, which reclaims heat from exhaust gases, can raise efficiency by more than 20 percent over the current standard; and variable-speed scroll compressors for air conditioners and refrigerators can increase their efficiency by 50 percent or more. In contrast, there is little room for efficiency improvements in electric resistance water heaters, because the technology is approaching its thermal limit.

Energy Fuel Shares for Commercial Users Are Expected To Remain Stable

Figure 30. Commercial primary energy consumption by fuel, 1970-2020 (percent of total)

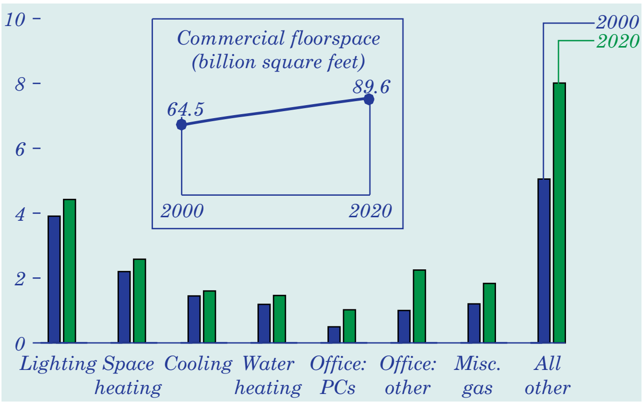


Projected energy use trends in the commercial sector show stable shares for all fuels, with growth in overall consumption slowing from its pace over the past three decades (Figure 30). Commercial energy use, including electricity-related losses, is projected to grow at about the same rate as commercial floorspace, by 1.7 percent per year between 2000 and 2020. Energy consumption per square foot is projected to increase by a modest 0.1 percent per year, with efficiency standards, voluntary government programs aimed at improving efficiency, and other technology improvements expected to balance the effects of a projected increase in demand for electricity-based services and stable or declining fuel prices.

Electricity is projected to account for three-fourths of commercial primary energy consumption throughout the forecast. Expected efficiency gains in electric equipment are expected to be offset by the continuing penetration of new technologies and greater use of office equipment. Natural gas, which accounted for 20 percent of commercial energy consumption in 2000, is projected to maintain that share throughout the forecast. Distillate fuel oil made up only 2 percent of commercial demand in 2000, down from 6 percent in the years before deregulation of the natural gas industry. The fuel share projected for distillate remains at 2 percent in 2020, as natural gas continues to compete for space and water heating uses. With stable prices projected for conventional fuels, no appreciable growth in the share of renewable energy in the commercial sector is anticipated.

Commercial Lighting Is the Sector's Most Important Energy Application

Figure 31. Commercial primary energy consumption by end use, 2000 and 2020 (quadrillion Btu)

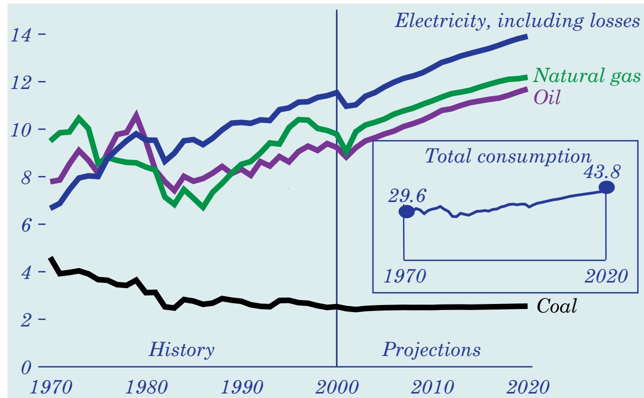


Through 2020, lighting is projected to remain the most important individual end use in the commercial sector [*79*]. Energy use for lighting is projected to increase slightly, as growth in lighting requirements is expected to outpace the adoption of more energy-efficient lighting equipment. Efficiency of space heating, space cooling, and water heating is also expected to improve, moderating growth in overall commercial energy demand. A projected increase in building shell efficiency, which affects the energy required for space heating and cooling, contributes to the trend (Figure 31).

The highest growth rates are expected for end uses that have not yet saturated the commercial market. Energy use for personal computers is projected to grow by 3.7 percent per year and for other office equipment, such as copiers, fax machines, and larger computers, by 4.1 percent per year. The projected growth in electricity use for office equipment reflects a trend toward more powerful equipment, the response to projected declines in real electricity prices, and increases in the market for commercial electronic equipment. Natural gas use for such miscellaneous uses as cooking and self-generated electricity is expected to grow by 2.1 percent per year. New telecommunications technologies and medical imaging equipment are projected to increase electricity demand in the "all other" end-use category, which also includes ventilation, refrigeration, minor fuel consumption, service station equipment, and vending machines. Annual growth of 2.3 percent is expected for the "all other" category, slowing somewhat in the later years of the forecast as emerging technologies achieve greater market penetration.

Industrial Energy Use Could Grow by 23 Percent by 2020

Figure 32. Industrial primary energy consumption by fuel, 1970-2020 (quadrillion Btu)



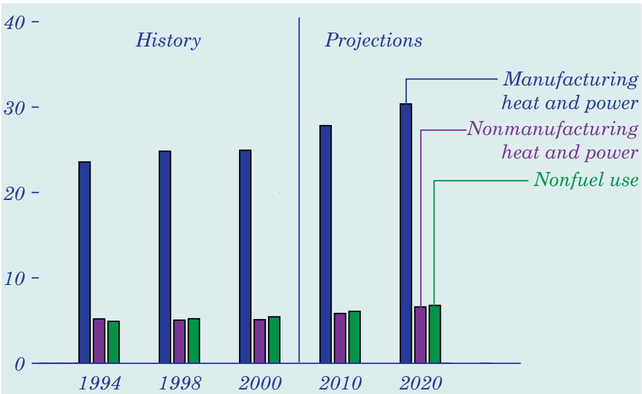
From 1970 to 1986, with demand for coking coal reduced by declines in steel production and natural gas use falling as a result of end-use restrictions and curtailments, electricity's share of industrial energy use increased from 23 percent to 33 percent. The natural gas share fell from 32 percent to 24 percent, and coal's share fell from 16 percent to 9 percent. After 1986, natural gas began to recover its share as end-use regulations were lifted and supplies became more certain and less costly. As on-site cogeneration increased, the share of industrial delivered energy use made up by purchased electricity declined.

Primary energy use in the industrial sector—which includes the agriculture, mining, and construction industries in addition to traditional manufacturing—is projected to increase by 1.1 percent per year (Figure 32). Electricity (for machine drive and some production processes) and natural gas (given its ease of handling) are the major energy sources for the industrial sector. Industrial delivered electricity use is projected to increase by 32 percent, with competition in the generation market keeping electricity prices low. Despite a projected increase in natural gas prices after 2002, its use for energy in the industrial sector is expected to increase by 25 percent between 2000 and 2020. Industrial petroleum use is also projected to grow by 27 percent. Coal use is expected to remain essentially constant, as new steelmaking technologies continue to reduce demand for metallurgical coal, offsetting modest growth in coal use for boiler fuel and as a substitute for coke in steelmaking.

Industrial Sector Energy Demand

Industrial Energy Use Grows Steadily in the Projections

Figure 33. Industrial primary energy consumption by industry category, 1994-2020 (quadrillion Btu)



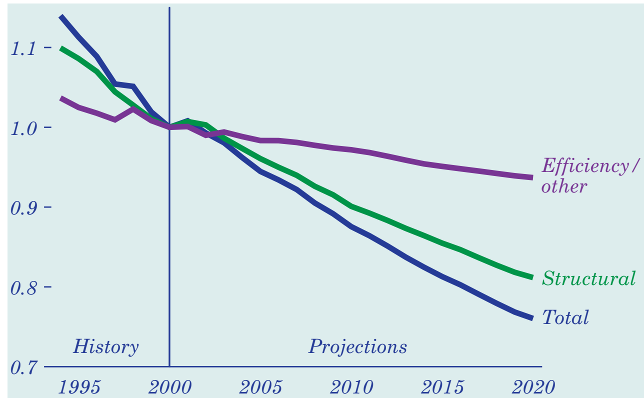
Approximately 70 percent of all the energy consumed in the industrial sector is used to provide heat and power for manufacturing. The remainder is approximately equally distributed between nonmanufacturing heat and power and consumption for nonfuel purposes, such as raw materials and asphalt (Figure 33).

Nonfuel use of energy in the industrial sector is projected to grow more rapidly (1.1 percent per year) than heat and power consumption (1.0 percent per year). The feedstock portion of nonfuel use is projected to grow at a slightly lower rate (0.9 percent per year) than the output of the bulk chemical industry (1.1 percent per year) due to limited substitution possibilities. In 2020, feedstock consumption is projected to be 5.0 quadrillion Btu. Asphalt use, the other component of nonfuel energy use, is projected to grow by 1.6 percent per year, to 1.8 quadrillion Btu in 2020. The construction industry is the principal consumer of asphalt for paving and roofing. Asphalt use does not grow as rapidly as construction output (2.0 percent per year), because not all construction activities require asphalt.

Petroleum refining, chemicals, and pulp and paper are the largest end-use consumers of energy for heat and power in the manufacturing sector. These three energy-intensive industries used 8.9 quadrillion Btu in 2000. The major fuels used in petroleum refineries are still gas, natural gas, and petroleum coke. In the chemical industry, natural gas accounts for 60 percent of the energy consumed for heat and power. The pulp and paper industry uses the most renewables, in the form of wood and spent liquor.

Output From U.S. Industries Grows Faster Than Energy Use

Figure 34. Industrial delivered energy intensity by component, 1994-2020 (index, 2000 = 1)

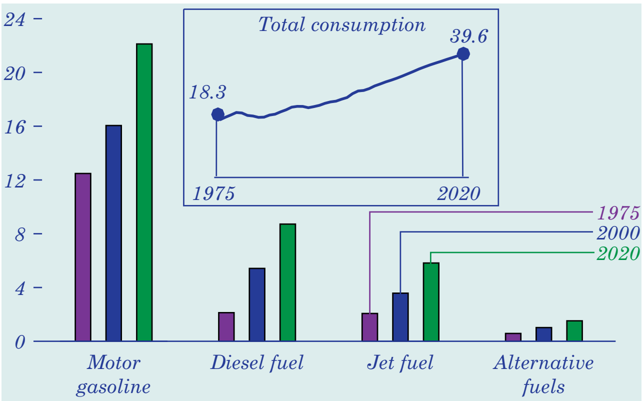


Changes in industrial energy intensity (consumption per unit of output) can be separated into two effects. One component reflects underlying increases in equipment and production efficiencies; the other arises from structural changes in the composition of manufacturing output. Since 1970, the use of more energy-efficient technologies, combined with relatively low growth in the energy-intensive industries, has dampened growth in industrial energy consumption. Thus, despite a 53-percent increase in industrial output, total energy use in the sector grew by only 8 percent between 1978 and 2000. These basic trends are expected to continue.

Industrial output is projected to grow by 2.6 percent per year from 2000 to 2020. The share of total industrial output attributed to the energy-intensive industries is projected to fall from 22 percent in 2000 to 17 percent in 2020. Consequently, even if no specific industry experienced a decline in intensity, aggregate industrial intensity would decline. Figure 34 shows projected changes in energy intensity due to structural effects and efficiency effects separately [*80*]. Over the forecast period, industrial delivered energy intensity is projected to drop by 25 percent, and the changing composition of industrial output alone is projected to result in approximately a 19-percent drop. Thus, three-fourths of the expected change in delivered energy intensity for the sector is attributable to structural shifts and the remainder to changes in energy intensity associated with projected increases in equipment and production efficiencies.

Alternative Fuels Make Up 2 Percent of Light-Duty Vehicle Fuel Use in 2020

Figure 35. Transportation energy consumption by fuel, 1975, 2000, and 2020 (quadrillion Btu)



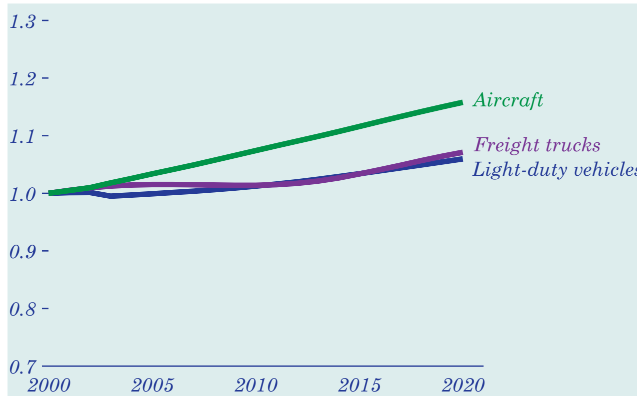
By 2020, total energy demand for transportation is expected to be 39.6 quadrillion Btu, compared with 27.5 quadrillion Btu in 2000 (Figure 35). Petroleum products dominate energy use in the sector. Motor gasoline use is projected to increase by 1.6 percent per year in the reference case, making up 56 percent of transportation energy demand. Alternative fuels are projected to displace about 184,000 barrels of oil equivalent per day [*81*] by 2020 (2 percent of light-duty vehicle fuel consumption), in response to current environmental and energy legislation intended to reduce oil use. Gasoline's share of demand is expected to be sustained, however, by low gasoline prices and slower fuel efficiency gains for conventional light-duty vehicles (cars, vans, pickup trucks, and sport utility vehicles) than were achieved during the 1980s.

Assumed industrial output growth of 2.6 percent per year through 2020 leads to an increase in freight transport, with a corresponding 2.4-percent annual increase in diesel fuel use. Economic growth and low projected jet fuel prices yield a 3.5-percent projected annual increase in air travel, causing jet fuel use to increase by 2.5 percent per year.

In the forecast, energy prices directly affect the level of oil use through travel costs and average vehicle fuel efficiency. Most of the price sensitivity is seen as variations in motor gasoline use in light-duty vehicles, because the stock of light-duty vehicles turns over more rapidly than the stock for other modes of travel. In the high oil price case, gasoline use increases by 1.5 percent per year, compared with 1.7 percent per year in the low oil price case.

Average Horsepower for New Cars Is Projected To Grow by 35 Percent

Figure 36. Projected transportation stock fuel efficiency by mode, 2000-2020 (index, 2000 = 1)



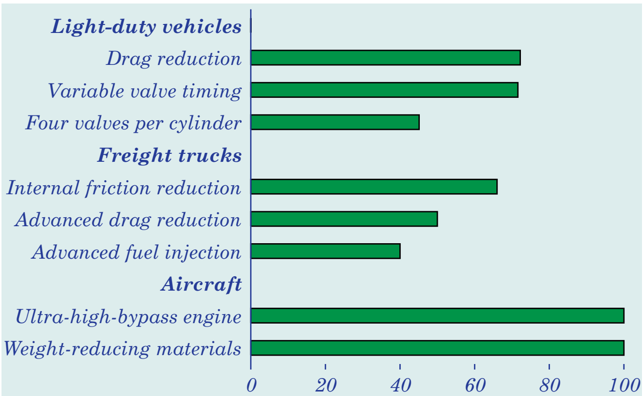
Fuel efficiency is projected to improve at a slower rate through 2020 than it did in the 1980s (Figure 36), with fuel efficiency standards for light-duty vehicles assumed to stay at current levels and projected low fuel prices and higher personal income expected to increase the demand for larger, more powerful vehicles. Average horsepower for new cars in 2020 is projected to be about 35 percent above the 2000 average (Table 8), but advanced technologies and materials are expected to keep new vehicle fuel economy from declining [*82*]. Advanced technologies such as variable valve timing and direct fuel injection, as well as electric hybrids for both gasoline and diesel engines, are projected to boost the average fuel economy of new light-duty vehicles by about 3 miles per gallon, to 27.2 miles per gallon in 2020. A small percentage gain in efficiency is expected for freight trucks (from 5.9 miles per gallon in 2000 to 6.3 in 2020), and a larger gain is expected for aircraft (a 16-percent increase over the forecast period).

Table 8. New car and light truck horsepower ratings and market shares, 1990-2020

	Cars			Light trucks		
Year	Small	Medium	Large	Small	Medium	Large
1990						
Horsepower	119	145	176	132	157	185
Sales share	0.60	0.28	0.12	0.48	0.21	0.30
2000						
Horsepower	145	175	226	167	186	223
Sales share	0.54	0.34	0.11	0.33	0.32	0.36
2010						
Horsepower	182	211	263	199	231	285
Sales share	0.52	0.36	0.13	0.32	0.33	0.35
2020						
Horsepower	203	227	268	211	242	303
Sales share	0.51	0.35	0.14	0.31	0.34	0.35

New Technologies Promise Better Vehicle Fuel Efficiency

Figure 37. Projected technology penetration by mode of travel, 2020 (percent)



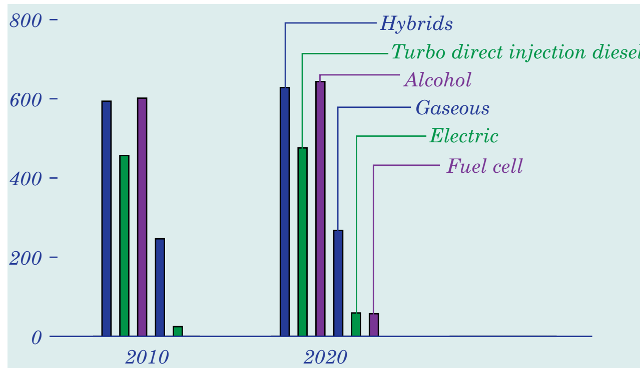
New automobile fuel economy is projected to reach approximately 31.7 miles per gallon by 2020, as a result of advances in fuel-saving technologies (Figure 37). Three of the most promising are advanced drag reduction, variable valve timing, and extension of four valve per cylinder technology to six-cylinder engines, each of which would provide over 8 percent higher fuel economy. Advanced drag reduction reduces air resistance over the vehicle; variable valve timing optimizes the timing of air intake into the cylinder with the spark ignition during combustion; and increasing the number of valves on the cylinder improves efficiency through more complete combustion of fuel in the engine.

Due to concerns about economic payback, the trucking industry is more sensitive to the marginal cost of fuel-efficient technologies; however, several technologies can increase fuel economy significantly, including components to reduce internal friction (2 percent improvement), advanced drag reduction (2 percent), and advanced fuel injection systems (5 percent). These technologies are anticipated to penetrate the heavy-duty truck market by 2020. Advanced technology penetration is projected to increase new freight truck fuel efficiency from 6.1 miles per gallon to 6.6 miles per gallon between 2000 and 2020.

New aircraft fuel efficiencies are projected to increase by 15 percent from 2000 levels by 2020. Ultra-high-bypass engine technology can potentially increase fuel efficiency by 10 percent, and increased use of weight-reducing materials may contribute up to a 15-percent improvement.

Advanced Technologies Could Reach 12 Percent of Sales by 2020

Figure 38. Projected sales of advanced technology light-duty vehicles by fuel type, 2010 and 2020 (thousand vehicles sold)

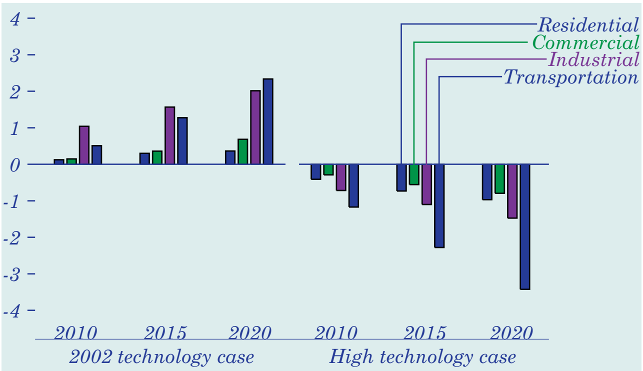


Advanced technology vehicles, representing automotive technologies that use alternative fuels or require advanced engine technology, are projected to reach 2.1 million vehicle sales per year by 2020 (12 percent of total projected light-duty vehicle sales). Hybrid electric vehicles, introduced into the U.S. market by two manufacturers in 2000, are anticipated to sell well, at about 628,000 units by 2020 (Figure 38). Alcohol flexible-fueled vehicles are expected to lead advanced technology vehicle sales, reaching approximately 644,000 vehicle sales by 2020. Sales of turbo direct injection diesel vehicles are projected to increase to 476,000 units by 2020. These advanced technologies will initially sell for less than $3,000 above an equivalent gasoline vehicle, but only the gasoline hybrid and the turbo direct injection diesel can achieve vehicle ranges that exceed 600 miles while delivering 20 to 30 percent better fuel economy than a comparable gasoline vehicle.

About 80 percent of advanced technology sales are a result of Federal and State mandates for either fuel economy standards, emissions programs, or other energy regulations. Alcohol flexible-fueled vehicles are currently sold by manufacturers who receive fuel economy credits to comply with corporate average fuel economy regulations. The majority of projected gasoline hybrid and electric vehicle sales result from compliance with low-emission vehicle programs in California, New York, Maine, Vermont, and Massachusetts. For a description of the ZEV accounting process for advanced technology vehicles, see “Legislation and Regulations,” pages 16-17.

Alternative Cases Analyze Effects of Advances in Technology

Figure 39. Projected variation from reference case primary energy use by sector in two alternative cases, 2010, 2015, and 2020 (quadrillion Btu)



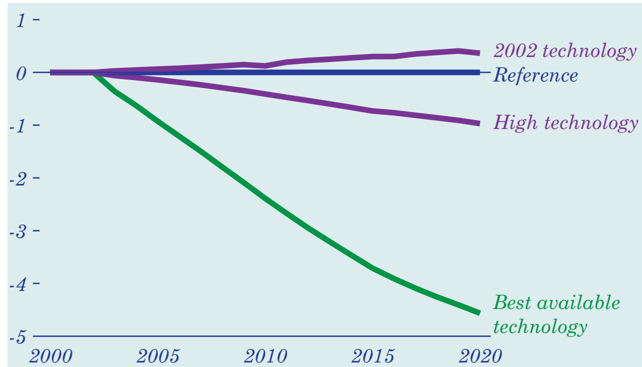
The availability and market penetration of new, more efficient technologies are uncertain. Alternative cases for each sector, based on a range of assumptions about technological progress, show the effects of these assumptions (Figure 39). The alternative cases assume that current equipment and building standards are met but do not include feedback effects on energy prices or on economic growth.

For the residential and commercial sectors, the 2002 technology case holds equipment and building shell efficiencies at 2002 levels. The best available technology case assumes that the most energy-efficient equipment and best residential building shells available are chosen for new construction each year regardless of cost, and that efficiencies of existing residential and all commercial building shells improve from their reference case levels. The high technology case assumes earlier availability, lower costs, and higher efficiencies for more advanced technologies than in the reference case.

The 2002 technology cases for the industrial and transportation sectors and the high technology case for the industrial sector use the same assumptions as the buildings sector cases. The high transportation technology case includes lower costs for advanced light-duty vehicle and aircraft technologies and improved efficiencies, comparable to those used in a Department of Energy (DOE) interlaboratory study for air, rail, and marine travel and provided by DOE's Office of Energy Efficiency and Renewable Energy and the American Council for an Energy-Efficient Economy for light-duty vehicles and by Argonne National Laboratory for freight trucks [*83*].

Advanced Technologies Could Reduce Residential Energy Use by 19 Percent

Figure 40. Projected variation from reference case primary residential energy use in three alternative cases, 2000-2020 (quadrillion Btu)



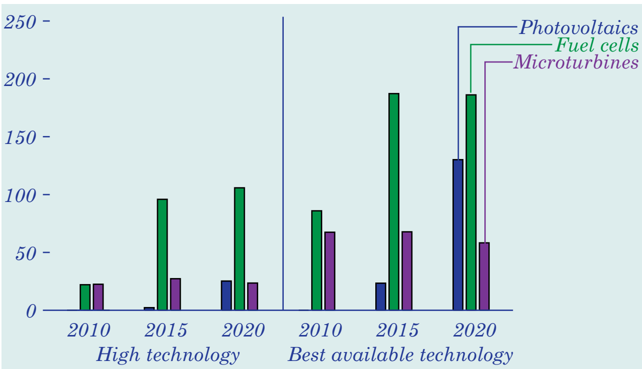
The *AEO2002* reference case forecast includes the projected effects of several different policies aimed at increasing residential end-use efficiency. Examples include minimum efficiency standards and voluntary energy savings programs designed to promote energy efficiency through innovations in manufacturing, building, and mortgage financing. In the 2002 technology case, which assumes no further increases in the efficiency of equipment or building shells beyond that available in 2002, 2 percent more energy would be required in 2020 (Figure 40).

In the best available technology case, assuming that the most energy-efficient technology considered is always chosen regardless of cost, projected energy use in 2020 is 19 percent lower than in the reference case, and household primary energy use in 2020 is 20 percent lower than in the 2002 technology case. Through 2020, projected additional investment of $270 billion would be necessary to save a projected $136 billion in energy costs in this case [*84*].

The high technology case does not constrain consumer choices. Instead, the most energy-efficient technologies are assumed to be available earlier, with lower costs and higher efficiencies. The consumer discount rates used to determine the purchased efficiency of all residential appliances in the high technology case do not vary from those used in the reference case; that is, consumers value efficiency equally across the two cases. Energy savings in this case relative to the reference case are projected to reach 4 percent in 2020; however, the savings are not as great as those projected in the best available technology case.

Advanced Technologies Could Slow Electricity Sales Growth for Buildings

Figure 41. Buildings sector electricity generation from advanced technologies in alternative cases, 2010-2020 (percent change from reference case)



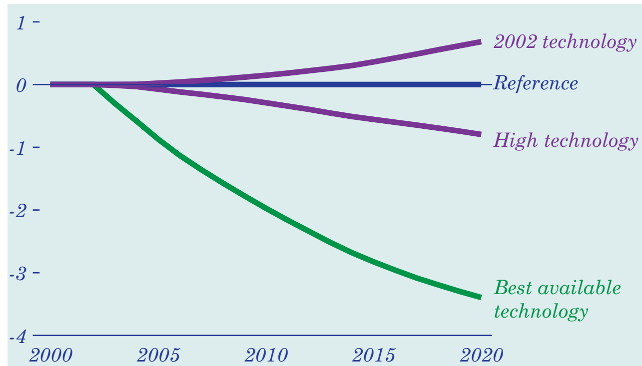
Alternative technology cases for the buildings sectors include a range of assumptions for the availability and market penetration of advanced distributed generation technologies. Some of the heat produced by fossil-fuel-fired generating systems may be used to satisfy heating requirements, increasing system efficiency and the attractiveness of the advanced technologies, particularly in alternative cases with more optimistic technology assumptions.

In the high technology case, solar photovoltaic systems, fuel cells, and microturbines are projected to provide 11 billion kilowatthours (41 percent) more electricity in 2020 than in the reference case, most of which offsets residential and commercial electricity purchases (Figure 41). In the best technology case, projected electricity generation in buildings in 2020 is 22 billion kilowatthours (79 percent) higher than in the reference case. In the 2002 technology case, assuming no further technological progress or cost reductions after 2002, electricity generation in buildings in 2020 is 16 billion kilowatthours (58 percent) lower than projected in the reference case.

The additional natural gas use projected for fuel cells and microturbines to provide heat and power in commercial buildings in the high technology case offsets reductions from improved building shells and end-use equipment. Although the best technology case projects even higher adoption of these technologies, including residential fuel cells, the additional end-use savings projected when the most efficient technologies are chosen, regardless of cost, outweigh the additional natural gas consumption needed to fuel distributed generation systems.

Advanced Technologies Could Reduce Commercial Energy Use by 15 Percent

Figure 42. Projected variation from reference case primary commercial energy use in three alternative cases, 2000-2020 (quadrillion Btu)

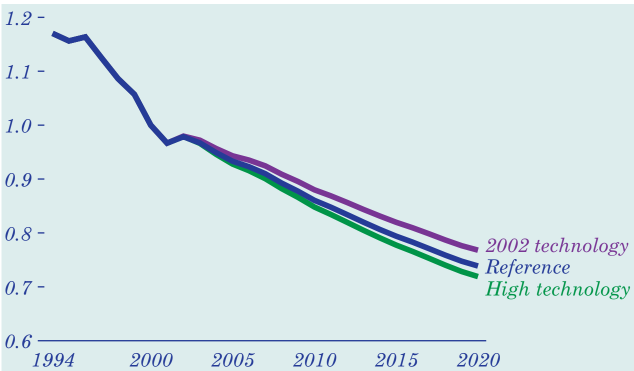


The *AEO2002* reference case incorporates efficiency improvements for commercial equipment and building shells, holding commercial energy intensity to a 0.1-percent annual increase over the forecast. The 2002 technology case assumes that future equipment and building shells will be no more efficient than those available in 2002. The high technology case assumes earlier availability, lower costs, and higher efficiencies for more advanced equipment than in the reference case and more rapid improvement in building shells. The best available technology case assumes that only the most efficient technologies will be chosen, regardless of cost, and that building shells will improve at the rate assumed in the high technology case.

Energy use in the 2002 technology case is projected to be 3 percent higher than in the reference case by 2020 (Figure 42) as the result of a 0.2-percent annual increase in commercial primary energy intensity. The high technology case projects an additional 3-percent energy savings in 2020, with primary energy intensity falling by 0.1 percent per year from 2000 to 2020. Assuming the purchase of only the most efficient equipment in the best available technology case yields energy use that is 15 percent lower than in the reference case by 2020. Commercial primary energy intensity in this case is projected to decline more rapidly than in the high technology case, by 0.7 percent per year. More optimistic assumptions result in additional projected energy savings from both renewable and conventional fuel-using technologies. Commercial solar photovoltaic systems are projected to generate 19 percent more electricity in the best technology case than in the reference case.

Alternative Technology Cases Show Range of Industrial Efficiency Gains

Figure 43. Projected industrial primary energy intensity in two alternative cases, 1994-2020 (index, 2000 = 1)



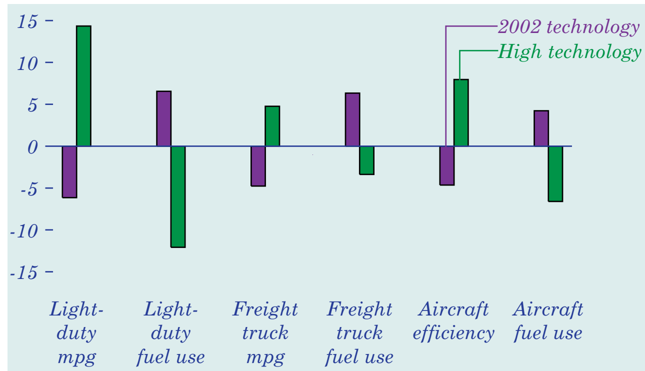
Efficiency gains in both energy-intensive and non-energy-intensive industries are projected to reduce overall energy intensity in the industrial sector. Expected growth in machinery and equipment production, driven primarily by investment and export-related demand, is a key factor. In the reference case, these less energy-intensive industries are projected to grow 53 percent faster than the industrial average (4.0 percent and 2.6 percent per year, respectively).

In the high technology case, 1.5 quadrillion Btu less energy is projected to be used in 2020 than for the same level of output in the reference case. Industrial primary energy intensity is projected to decline by 1.7 percent per year through 2020 in this case, compared with a 1.5-percent annual decline in the reference case (Figure 43). Industrial cogeneration capacity is projected to increase more rapidly in the high technology case (3.5 percent per year) than in the reference case (2.4 percent per year).

In the 2002 technology case, industry is projected to use 2.0 quadrillion Btu more energy in 2020 than in the reference case. Energy efficiency remains at the level achieved by new plants in 2002, but average efficiency still improves as old plants are retired. Aggregate industrial energy intensity is projected to decline by 1.3 percent per year because of reduced efficiency gains. The change in industrial structure is the same in the 2002 technology and high technology cases as in the reference case, because the same macroeconomic assumptions are used for the three cases. Industrial cogeneration capacity is projected to increase by 2.3 percent per year from 2000 through 2020 in the 2002 technology case.

Vehicle Technology Advances Reduce Transportation Energy Demand

Figure 44. Projected changes in key components of the transportation sector in two alternative cases, 2020 (percent change from reference case)



The transportation high technology case assumes lower costs, higher efficiencies, and earlier introduction for new technologies. Projected energy use for transportation is 3.4 quadrillion Btu (9 percent) lower in 2020 than in the reference case, reducing projected carbon dioxide emissions by 66 million metric tons carbon equivalent. About 76 percent (2.6 quadrillion Btu) of the difference is attributed to light-duty vehicles. Advances in conventional technologies and in vehicle attributes for advanced technologies are projected to raise the average efficiency of the light-duty vehicle fleet to 24.0 miles per gallon, as compared with a projected increase to 21.0 miles per gallon in the reference case (Figure 44).

Projected fuel demand for freight trucks in 2020 is 0.3 quadrillion Btu lower in the high technology case than in the reference case, and the projected stock efficiency is 5 percent higher. Advanced aircraft technologies are also projected to improve aircraft efficiency by 8 percent above the reference case projection, reducing the projected fuel use for air travel in 2020 by 0.4 quadrillion Btu.

In the 2002 technology case, with new technology efficiencies fixed at 2002 levels, efficiency improvements can result only from stock turnover. In 2020, the total projected energy demand for transportation is 2.3 quadrillion Btu (6 percent) higher than in the reference case, and projected carbon dioxide emissions are higher by 45 million metric tons carbon equivalent. The average fuel economy of new light-duty vehicles is projected to be 24.6 miles per gallon in 2020 in the 2002 technology case, 2.6 miles per gallon lower than projected in the reference case.