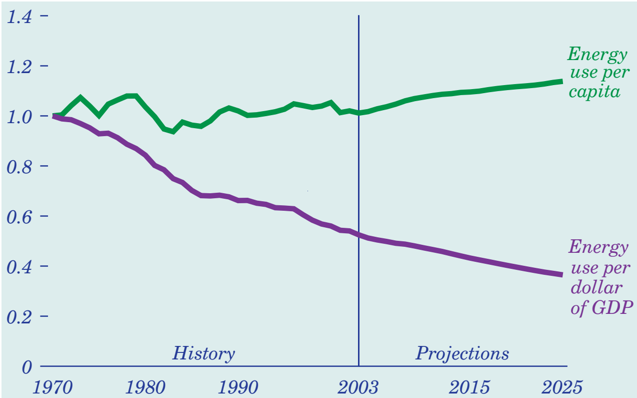
Average Energy Use per Person Increases in the Forecast

Figure 42. Energy use per capita and per dollar of gross domestic product, 1970-2025 (index, 1970 = 1)



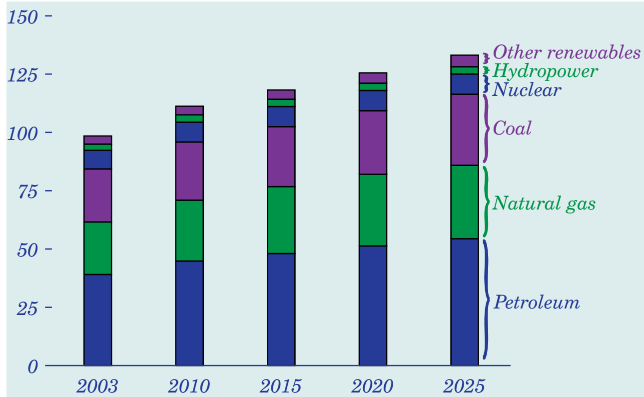
Energy intensity, as measured by energy use per 2000 dollar of GDP, is projected to decline at an average annual rate of 1.6 percent, with efficiency gains and structural shifts in the economy offsetting growth in demand for energy services (Figure 42). The projected rate of decline falls between the average rate of 2.3 percent from 1970 through 1986, when energy prices increased in real terms, and the 0.7-percent rate from 1986 through 1992, when energy prices were generally falling. Since 1992, energy intensity has declined on average by 1.9 percent per year.

During the late 1970s and early 1980s, energy consumption per capita fell in response to high energy prices and weak economic growth. From the late 1980s through the mid-1990s, with declining energy prices and strong economic growth, per capita energy use increased. Since the mid-1990s, energy consumption per capita has declined in some years and increased in others. Per capita energy use is projected to increase in the *AEO2005* forecast at an average annual rate of 0.5 percent, with growth in demand for energy services only partially offset by efficiency gains.

The potential for more energy conservation has received increased attention recently as energy prices have risen. *AEO2005* does not assume policy-induced conservation measures beyond those in existing legislation and regulation, nor does it assume behavioral changes that could result in greater energy conversation, beyond those experienced in the past.

Petroleum and Natural Gas Lead Increases in Primary Energy Use

Figure 43. Primary energy use by fuel, 2003-2025 (quadrillion Btu)



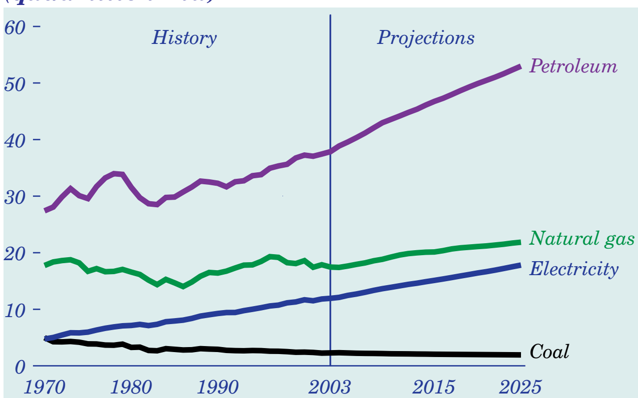
Total primary energy consumption, both in the end-use sectors and for electric power generation, is projected to grow from 98.2 quadrillion Btu in 2003 to 133.2 quadrillion Btu in 2025 (Figure 43). Petroleum consumption increases from 39.1 quadrillion Btu in 2003 to 54.4 quadrillion Btu in 2025, with about 80 percent of the increase expected in fuel use for transportation and the remainder in the industrial, commercial, and electricity generation sectors.

Natural gas consumption grows from 22.5 quadrillion Btu in 2003 to 31.5 quadrillion Btu in 2025. Over 50 percent of the expected increase is for electric power generation. Although some growth in other uses is also expected, particularly for industrial applications, their share of total natural gas use is projected to decline as a result of strong growth in demand in the electricity generation sector. Electricity generation is also expected to account for most of the growth in coal consumption, from 22.7 quadrillion Btu in 2003 to 30.5 quadrillion Btu in 2025. Much of the increase is expected after 2010, when higher natural gas prices make coal a more competitive fuel for power plants.

Smaller increases are projected for nuclear energy and primary renewable energy consumption. No new nuclear facilities are projected to be built before 2025, but higher capacity factors at existing plants lead to an expected increase from 8.0 quadrillion Btu in 2003 to 8.7 quadrillion Btu in 2025. Use of renewable energy from nonhydropower sources is projected to grow from 3.4 quadrillion Btu in 2003 to 5.4 quadrillion Btu in 2025 as a result of State mandates for renewable electricity generation, higher natural gas prices, and renewable energy production tax credits.

Petroleum and Electricity Lead Growth in Energy Consumption

Figure 44. Delivered energy use by fuel, 1970-2025 (quadrillion Btu)



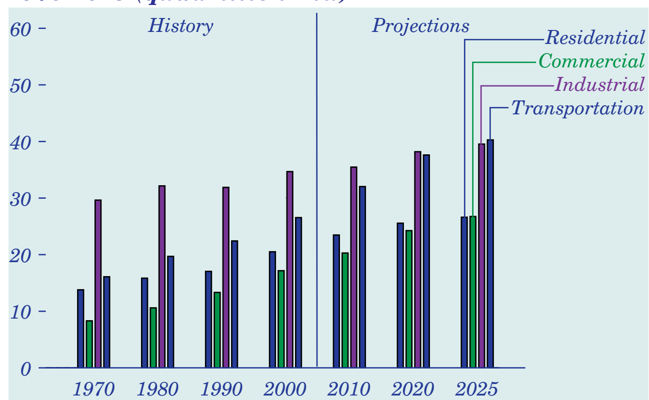
Consumption of petroleum products, mainly for transportation, makes up the largest share of delivered energy use in the residential, commercial, industrial, and transportation sectors in the *AEO2005* forecast (Figure 44). Total delivered energy use (excluding energy used for generation in the electric power sector) grows by 1.5 percent per year on average from 2003 to 2025, and transportation sector energy use grows by 1.8 percent per year. Transportation use grew by 2.0 percent per year in the 1970s and more slowly in the 1980s as a result of rising fuel prices and new Federal fuel economy standards. Stable fuel prices and a lack of new fuel economy standards are expected to reduce fuel economy gains in the forecast, while population growth and more travel per capita increase demand for gasoline.

Growth in delivered electricity consumption is slowed by efficiency improvements and by market saturation of end uses such as air conditioning in some regional markets.

Natural gas use is projected to grow at a slower rate than overall delivered energy demand, in contrast to its more rapid growth during the 1990s. As a result, natural gas is expected to meet 22 percent of total end-use energy requirements in 2025, compared with 24 percent in 2003. End-use demand for energy from renewables such as wood and ethanol is projected to grow by 1.2 percent per year as a result of continued competition from traditional purchased fuels.

U.S. Primary Energy Use Exceeds 133 Quadrillion Btu per Year by 2025

Figure 45. Primary energy consumption by sector, 1970-2025 (quadrillion Btu)



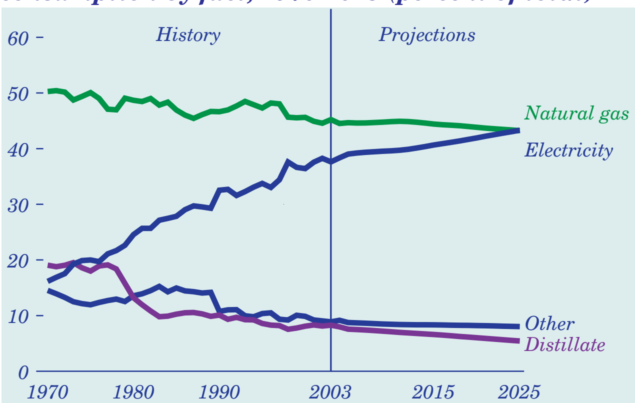
Primary energy use in 2025 (including electricity generation losses) is projected to be 133.2 quadrillion Btu in 2025 in the reference case, 36 percent higher than in 2003 (Figure 45). In the early 1980s energy prices rose, and sectoral energy consumption grew relatively little. After the early 1980s, however, declining real energy prices contributed to a marked increase in energy consumption. With higher energy prices since the late 1990s, energy consumption has again slowed.

Primary 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 almost two-thirds 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, higher real energy prices, and structural shifts between industries are projected to cause industrial 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 A world oil price case is 5.8 percent lower than in the low world oil price case in 2025, as consumer choices favor more fuel-efficient vehicles and the demand for travel services is reduced slightly. For 2025, the projection of transportation energy use in the high economic growth case is 13.2 percent greater than in the low economic growth case.

Electricity Share Expected To Match Natural Gas in Residential Energy Use

Figure 46. Residential delivered energy consumption by fuel, 1970-2025 (percent of total)



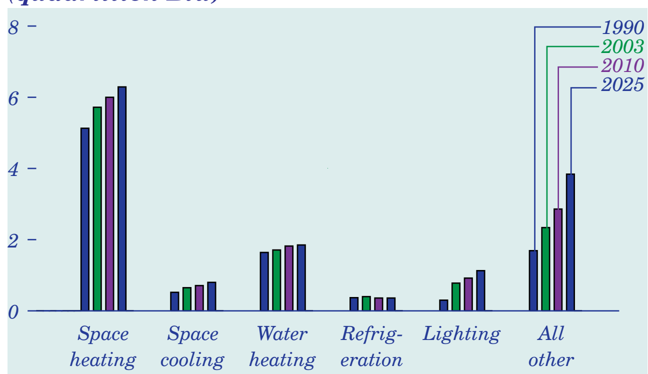
Residential delivered energy use is projected to increase by 23 percent between 2003 and 2025 (9 percent by 2010). Most (68 percent) of the growth results from increased use of electricity. Sustained growth in housing in the South, where almost all new homes use central air conditioning, is an important component of the national trend, along with the penetration of consumer electronics, such as home office equipment and security systems (Figure 46).

Natural gas use in the residential sector is projected to grow by 1.1 percent per year from 2003 to 2010 and 0.6 percent per year from 2010 to 2025 while losing share in residential delivered energy consumption. Average natural gas prices from 2003 to 2025 are projected to be 14 percent below 2004 prices (7 percent below 2003), remaining competitive with heating oil. The number of homes heated with natural gas is projected to increase by more than the number heated with electricity or oil. Distillate use is projected to fall by 19 percent between 2003 and 2025, as energy efficiency gains outpace the increase in the number of homes using oil for space heating applications.

Newly built homes today are, on average, 13 percent larger than the existing housing 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 47. Residential delivered energy consumption by end use, 1990, 2003, 2010, and 2025 (quadrillion Btu)



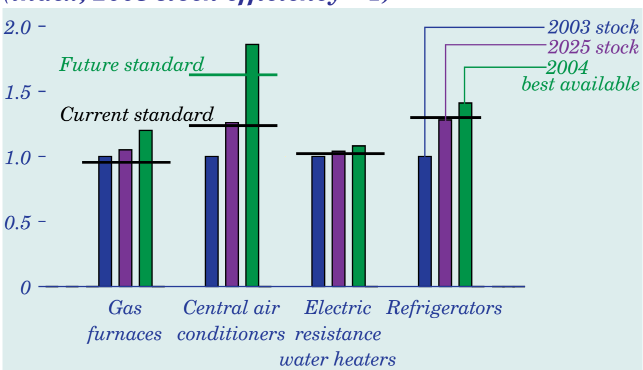
Delivered energy use for space heating grew by 0.8 percent per year from 1990 to 2003 (Figure 47). Future growth is expected to be slowed by higher equipment efficiency and more stringent building codes. Gains in building shell efficiency are projected to reduce demand for space heating per household by about 7 percent in 2010 and 16 percent in 2025 relative to 2003; however, those improvements are offset to a degree by better accounting of additions to existing homes and by the increased height of ceilings in new homes.

A variety of appliances are now subject to minimum efficiency standards, including heat pumps, air conditioners, furnaces, refrigerators, and water heaters. Current (July 2001) standards for a typical residential refrigerator limit electricity use to 510 kilowatthours per year. Energy use for refrigeration is projected to decline by 1.4 percent per year from 2003 to 2010 and 0.5 percent per year to 2025 as older refrigerators are replaced with new models. With no new standards for refrigerators assumed in the forecast, the decline slows when large numbers of the older, less efficient units have been replaced.

The "all other" category, which accounted for 20 percent of residential delivered energy use in 2003, is projected to account for 27 percent in 2025. Voluntary programs, both within and outside the appliance industry, are expected to forestall even larger increases. At annual rates of 2.9 percent from 2003 to 2010 and 2.3 percent from 2003 to 2025, growth in the "all other" demand category is projected to exceed the growth rates of other components through 2025.

Available Technologies Can Slow Growth in Residential Energy Use

Figure 48. Efficiency indicators for selected residential appliances, 2003 and 2025 (index, 2003 stock efficiency =1)

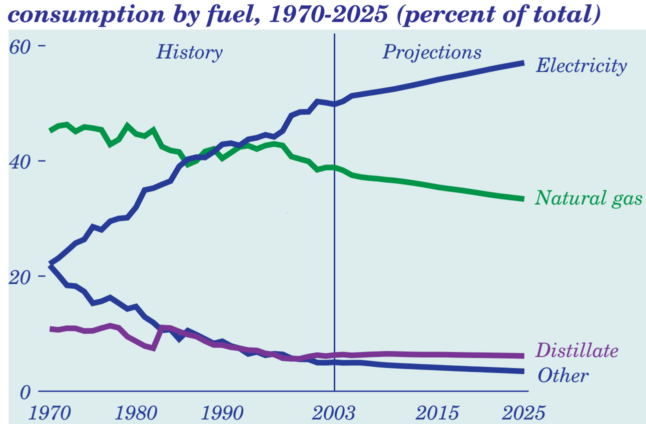


The *AEO2005* reference case projects an increase in the stock efficiency of residential appliances, as stock turnover and technology advances in most end-use services reduce residential energy intensity over time. For most appliances covered by the National Appliance Energy Conservation Act of 1987, the most recent Federal efficiency standards are higher than the 2003 stock, ensuring an increase in stock efficiency (Figure 48) 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. The new efficiency standards for water heaters, clothes washers, central air conditioners, and heat pumps that were announced in January 2001 are included in the reference case.

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 (and in some cases, unsuitability for retrofit applications) 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 units that just meet 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.

Electricity Share of Commercial Energy Use Is Expected To Increase

Figure 49. Commercial delivered energy consumption by fuel, 1970-2025 (percent of total)

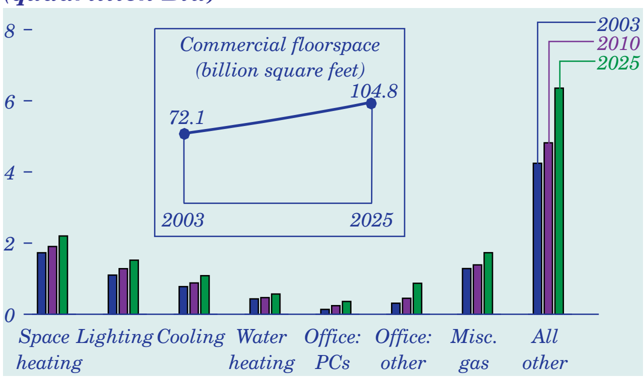


Recent trends in commercial sector fuel shares are expected to continue, with growth in overall consumption similar to its pace over the past two decades (Figure 49). Commercial delivered energy use (excluding primary energy losses in electricity generation) is projected to grow by 1.9 percent per year between 2003 and 2025, slightly faster than the projected growth rate for commercial floorspace of 1.7 percent. Energy consumption per square foot is projected to show little increase, 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 a slow rise in energy prices after 2010.

Electricity accounted for 50 percent of commercial delivered energy consumption in 2003, and its share is projected to increase to 57 percent in 2025. Expected efficiency gains in electric equipment are projected to be offset by the continuing penetration of new technologies and greater use of office equipment. Natural gas, which accounted for 39 percent of commercial energy consumption in 2003, is projected to decline to a 33-percent share by the end of the forecast. Distillate fuel oil, which accounted for 10 percent of commercial demand in the years before deregulation of the natural gas industry, made up only 6 percent of commercial energy demand in 2003. The distillate fuel share is projected to remain at 6 percent in 2025, as fuel oil continues to compete with natural gas for space and water heating uses. With conventional fuel prices projected to increase only slowly, no appreciable growth in the share of renewable energy in the commercial sector is anticipated.

Commercial Efficiency Gains Are Not Expected To Balance Demand

Figure 50. Commercial delivered energy consumption by end use, 2003, 2010, and 2025 (quadrillion Btu)

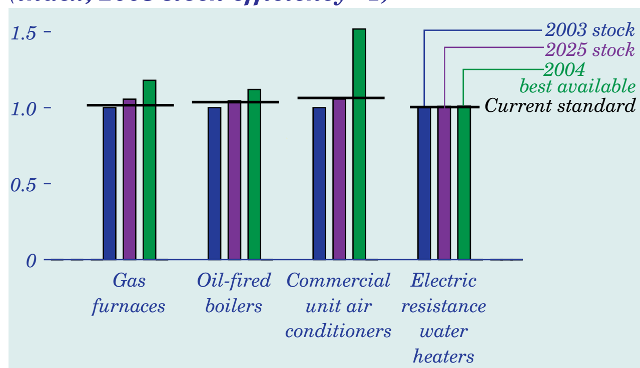


Energy use for the major commercial end uses is projected to increase slightly, as growth in requirements outpaces the adoption of more energy-efficient equipment. Minimum efficiency standards, which contribute to projected efficiency improvements in space heating, space cooling, water heating, and lighting, moderate the expected 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 50).

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 4.5 percent per year and for other office equipment, such as copiers, fax machines, and larger computers, by 4.8 percent per year through 2025. The growth in electricity use for office equipment reflects a trend toward more powerful equipment, increases in the market for commercial electronic equipment, and, while electricity prices fluctuate somewhat (declining between 2005 and 2011 and increasing later), generally low real electricity prices. Natural gas use for such miscellaneous uses as cooking and self-generated electricity is expected to grow by 1.4 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, and energy use for a myriad of other uses, such as municipal water services, service station equipment, elevators, and vending machines. Annual growth of 1.9 percent is expected for the "all other" category.

Current Technologies Provide Potential Energy Savings

Figure 51. Efficiency indicators for selected commercial equipment, 2003 and 2025 (index, 2003 stock efficiency=1)

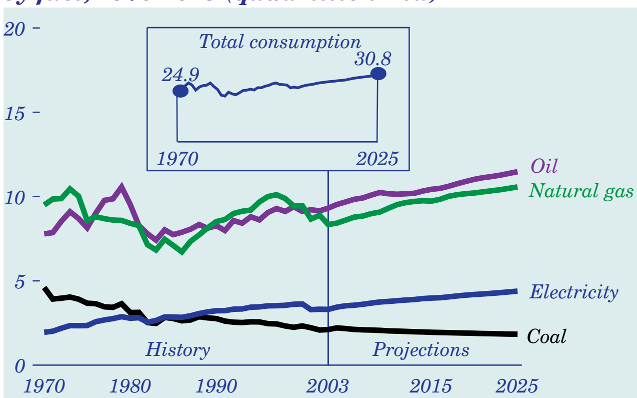


The stock efficiency of energy-using equipment in the commercial sector, as illustrated by the index shown in Figure 51, is projected to increase in the *AEO2005* reference case. As equipment is replaced and new buildings are built, technology advances are expected to reduce commercial energy intensity in most end-use services, although the long equipment service lives for many technologies moderate the pace of efficiency improvement in the forecast. For the majority of equipment covered by the Energy Policy Act of 1992, the existing Federal efficiency standards are higher than the average efficiency of the 2003 stock, ensuring some increase in the stock average efficiency as new equipment is added. A variety of commercial technologies, such as air-cooled air conditioners and gas-fired boilers, are currently being considered for more stringent standards. Future updates to the Federal standards could have significant effects on commercial energy consumption, but they are not included in the reference case.

Currently available technologies have the potential to reduce commercial energy consumption significantly. Improved heat exchangers for oil-fired boilers can raise efficiency by 8 percent over the current standard; and the use of multiple compressors and enhanced heat exchanger surfaces can increase the efficiency of unit air conditioners by more than 50 percent. When a business is considering an equipment purchase, however, the additional capital investment required for the most efficient technologies often carries more weight than do future energy savings, limiting the adoption of more efficient technologies.

Industrial Energy Use Could Grow by 24 Percent by 2025

Figure 52. Industrial delivered energy consumption by fuel, 1970-2025 (quadrillion Btu)

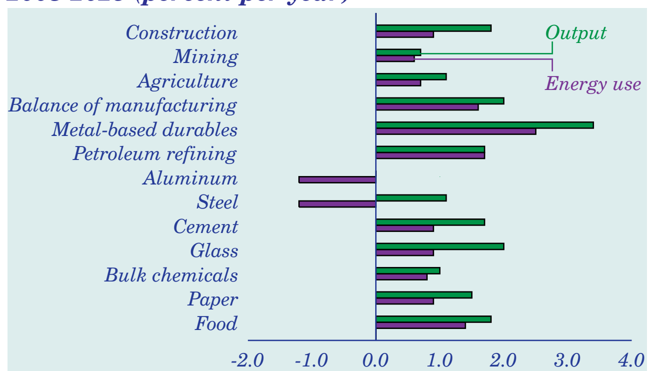


Industrial sector delivered energy consumption increased from 24.5 quadrillion Btu in 1990 to 26.4 quadrillion Btu in 2000, but economic recession in 2001 and rising natural gas prices had reduced industrial energy use to 24.9 quadrillion Btu in 2003. Natural gas use fell by 1.1 quadrillion Btu, accounting for most of the decline. With high natural gas prices expected to continue, industrial use is not projected to surpass its 1997 peak until after 2020.

Delivered energy use in the industrial sector (including agriculture, mining, construction, and traditional manufacturing) is projected to increase by 1.0 percent per year from 2003 to 2025 (Figure 52). Electricity (for machine drive and some production processes) and natural gas are the major energy sources used for heat and power in the industrial sector. Industrial use of purchased electricity is projected to increase by 1.3 percent per year from 2003 to 2025. Delivered natural gas prices in the industrial sector in 2025 are projected to be lower than in 2004; consequently, industrial natural gas use is expected to increase by 1.1 percent per year from 2003 to 2025. Petroleum use in the industrial sector is projected to grow by 1.0 percent per year from 2003 to 2025, whereas coal use is expected to decline by 0.6 percent per year as new steelmaking technologies continue to reduce demand for metallurgical coal. Coal use for boiler fuel is expected to remain essentially flat. Renewable energy (predominantly biomass) is the fastest growing industrial fuel in the forecast at a rate of 1.5 percent per year, but its share of the sector's delivered energy use remains small, at 8 percent in 2025.

Energy-Intensive Industries Grow Less Rapidly Than Industrial Average

Figure 53. Average growth in manufacturing output and delivered energy consumption by sector, 2003-2025 (percent per year)

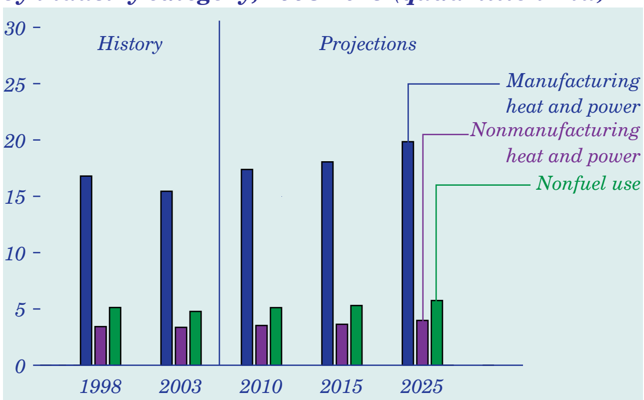


In *AEO2005*, industrial output is based on the North American Industry Classification System rather than the Standard Industrial Classification used in previous *AEO*s. The new classifications reduce manufacturing output by 3 percent in 1997 and lead to reduction in the historical growth rates for some industries. In the *AEO2005* forecast, industrial output grows at an average rate of 2.3 percent per year from 2003 to 2025, and growth in output growth varies widely by industry, from no growth in the aluminum industry to 3.4 percent in the metal-based durables industry (Figure 53). Metal-based durables, including fabricated metal products, machinery, electronic and electric products, and transportation equipment, accounted for one-third of industrial output in 2003.

Energy consumption growth also varies widely among specific industries. For example, the steel industry is expected to rely increasingly on scrap-based steelmaking techniques with lower energy requirements, and the aluminum industry is assumed to add no new primary smelting capacity, which is the most energy-intensive component of aluminum manufacturing. Relatively low output growth is also projected for both steel and aluminum, and as a result, energy consumption in both the steel and aluminum industries is projected to decline. The metal-based durables industry is projected to have the most rapid growth in energy consumption, at 2.5 percent per year, but its energy use accounts for only 7 percent of all industrial energy consumption in 2025.

Industrial Energy Use Grows Steadily in the Projections

Figure 54. Industrial delivered energy consumption by industry category, 1998-2025 (quadrillion Btu)



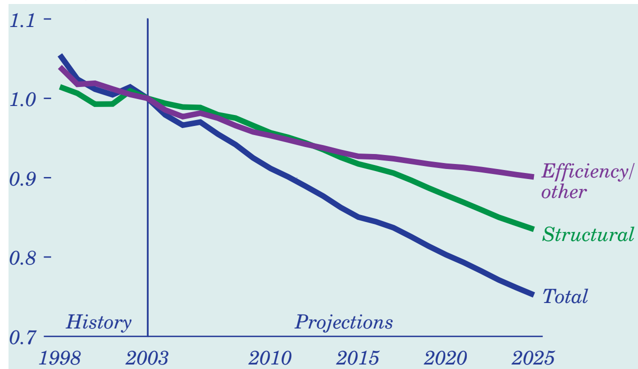
Two-thirds of the energy consumed in the industrial sector is used to provide heat and power for manufacturing. Of the remainder approximately 14 percent is used for nonmanufacturing heat and power, and 19 percent goes to nonfuel uses, such as raw materials and asphalt (Figure 54).

Nonfuel use of energy (feedstocks and asphalt) in the industrial sector is projected to grow at a slightly slower rate than heat and power consumption (0.8 percent and 1.1 percent per year, respectively). The feedstock portion of nonfuel use is projected to grow by 0.9 percent per year, marginally slower than the growth of output from the bulk chemical industry (1.0 percent per year through 2025), because of changes in the product mix. In 2025, feedstock consumption is projected to total 4.3 quadrillion Btu. Asphalt use is projected to grow by 0.7 percent per year, to 1.4 quadrillion Btu in 2025. The construction industry is the principal consumer of asphalt for paving and roofing. Asphalt use grows more slowly than construction output (1.8 percent per year through 2025), because not all construction activities require asphalt.

Petroleum refining, bulk chemicals, and pulp and paper are the largest consumers of energy for heat and power in the industrial sector. These three energy-intensive industries used 11.7 quadrillion Btu of energy (including feedstocks) in 2003. Energy use for petroleum refining grows more rapidly than any other energy-intensive industry, by 1.7 percent per year through 2025. Growth in energy use for the bulk chemicals and pulp and paper industries is projected at 0.8 percent and 0.9 percent, respectively.

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

Figure 55. Components of improvement in industrial delivered energy intensity, 1998-2025 (index, 2003 = 1)

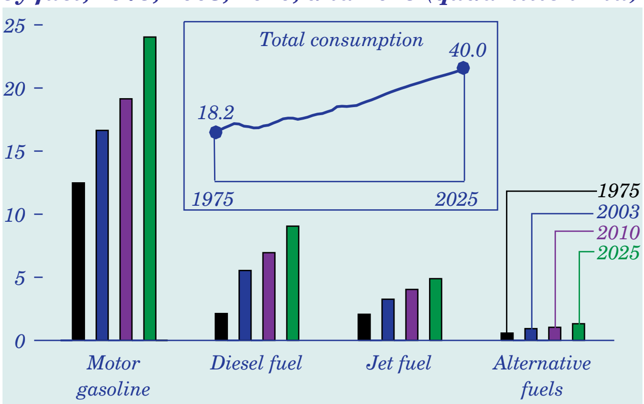


Changes in industrial energy intensity (consumption per unit of output) can be separated into two components. One reflects underlying increases in equipment and production efficiencies; the other arises from structural changes in the composition of industrial value of shipments. The use of more energy-efficient technologies, combined with relatively slow growth in the energy-intensive industries, has dampened growth in industrial energy consumption over the past decade. Thus, despite a 25-percent increase in industrial output, energy use in the sector grew by only 2 percent between 1990 and 2003.

Industrial value of shipments is projected to grow by 2.3 percent between 2003 and 2025. The share of total industrial shipments attributed to the energy-intensive industries is projected to fall from 21 percent in 2003 to 17 percent in 2025. Consequently, even if no specific industry experienced a decline in intensity, aggregate industrial energy intensity would decline. Figure 55 shows projected changes in energy intensity due to structural effects and efficiency effects separately [*131*]. From 2003 to 2025, industrial delivered energy intensity is projected to drop by 25 percent. The changing composition of industrial output is expected to result in a drop in energy intensity of approximately 16 percent by 2025. Thus, almost two-thirds 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 2.2 Percent of Light-Duty Vehicle Fuel Use in 2025

Figure 56. Transportation energy consumption by fuel, 1975, 2003, 2010, and 2025 (quadrillion Btu)



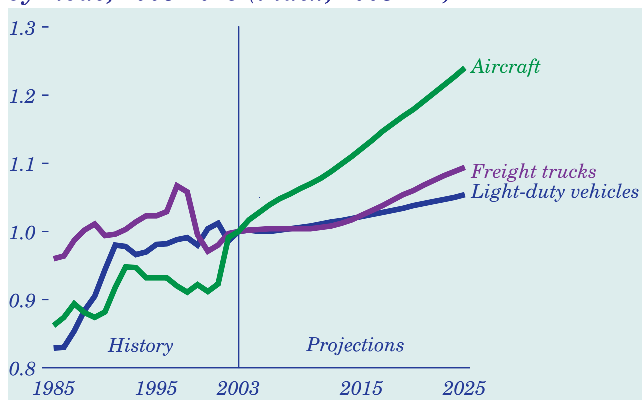
Energy demand for transportation is projected to grow from 27.1 quadrillion Btu in 2003 to 40.0 quadrillion Btu in 2025 (Figure 56). In the reference case, motor gasoline use increases by 1.7 percent per year from 2003 to 2025, when it makes up 60 percent of transportation energy use. Alternative fuels are projected to displace 207,000 barrels of oil equivalent per day [*132*] in 2010 and 280,500 barrels per day (2.2 percent of light-duty vehicle fuel consumption) in 2025, 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 prices relative to the rate of inflation and slower fuel efficiency gains for conventional cars, vans, pickup trucks, and sport utility vehicles than were achieved in the 1980s.

Assumed industrial output growth of 2.3 percent per year from 2003 to 2025 leads to an increase in freight truck use, with a corresponding 2.3-percent annual increase in diesel fuel use. Economic growth and low projected jet fuel prices yield an annual increase in air travel of 2.2 percent from 2003 to 2025 and a 1.9-percent average annual increase in jet fuel use.

Demand for light-duty vehicle fuels is projected to increase from 16.2 quadrillion Btu in 2003 to 24.5 quadrillion Btu in 2025. Light-duty diesel vehicles are assumed to meet the emission standards for diesel fuel, and diesel fuel grows from 1.5 percent of total light-duty vehicle fuel consumption in 2003 to 4.4 percent in 2025. Alternative fuels, consisting mostly of ethanol used in gasoline blending (71 percent in 2025) and liquefied petroleum gas (14 percent) grow from 1.7 percent of the 2003 total to 2.2 percent in 2025.

Average Horsepower for New Cars Is Projected To Grow by 26 Percent

Figure 57. Transportation stock fuel efficiency by mode, 2003-2025 (index, 2003 = 1)



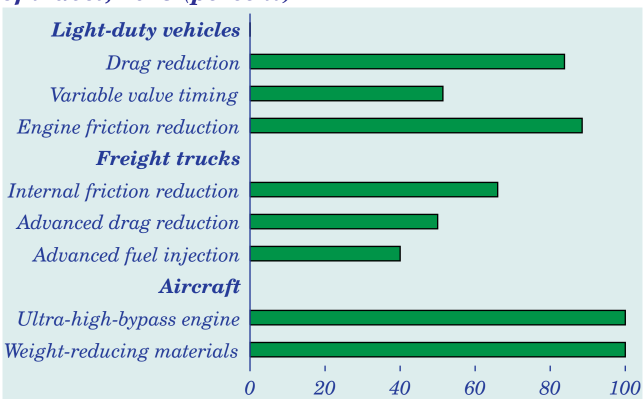
Fuel efficiency is projected to improve more rapidly from 2003 to 2025 than it did during the 1990s. Fuel economy for the light-duty vehicle stock is projected to improve by 5 percent, and for the stock of freight trucks from 6.0 miles per gallon in 2003 to 6.6 in 2025 (Figure 57). No changes are assumed in currently promulgated fuel efficiency standards for cars and light trucks. Low fuel prices and higher personal incomes are expected to increase the demand for larger, more powerful vehicles, with average horsepower for new cars projected to be 26 percent above the 2003 average in 2025 (Table 26). Advanced technologies and materials are expected to provide increased performance and size while improving new vehicle fuel economy [*133*]. Advanced technologies are projected to boost the average fuel economy of new light-duty vehicles by about 1.8 miles per gallon, to 26.9 miles per gallon in 2025 from 25.1 miles per gallon in 2003.

Table 26. New car and light truck horsepower ratings and market shares, 1990-2025

	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
2003						
Horsepower	149	184	224	181	193	241
Sales share	0.54	0.33	0.13	0.31	0.34	0.35
2010						
Horsepower	171	211	247	208	212	276
Sales share	0.50	0.35	0.15	0.30	0.34	0.35
2025						
Horsepower	188	233	265	223	219	284
Sales share	0.50	0.35	0.15	0.30	0.34	0.35

New Technologies Promise Better Vehicle Fuel Efficiency

Figure 58. Technology penetration by mode of travel, 2025 (percent)



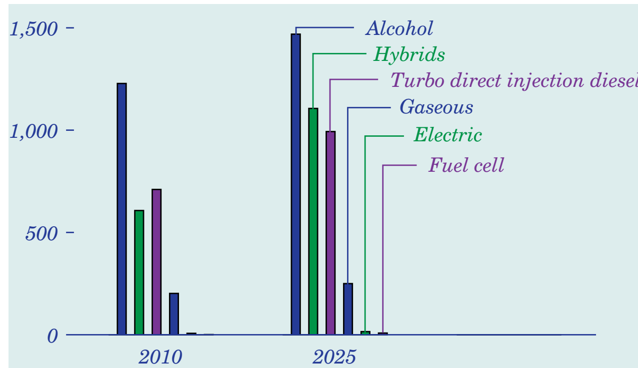
Fuel economy for new light-duty vehicles is projected to be 26.9 miles per gallon in 2025 (automobiles 31.0 miles per gallon, light-duty trucks 24.6 miles per gallon) as a result of advances in fuel-saving technologies (Figure 58). Three of the most promising would provide more than 4 percent higher fuel economy each: advanced drag reduction, variable valve timing and lift, and technologies that reduce internal engine friction. 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 reduced engine friction increases engine efficiency through more efficient designs, bearings, and coatings that reduce resistance between moving parts.

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 expected to penetrate the heavy-duty truck market by 2025. Advanced technology penetration is projected to increase the average fuel efficiency of new freight trucks from 6.1 miles per gallon in 2003 to 6.8 miles per gallon in 2025.

New aircraft fuel efficiencies are projected to increase by 19 percent from 2003 levels by 2025. 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 Are Projected To Reach 19 Percent of Sales by 2025

Figure 59. Sales of advanced technology light-duty vehicles by fuel type, 2010 and 2025 (thousand vehicles sold)



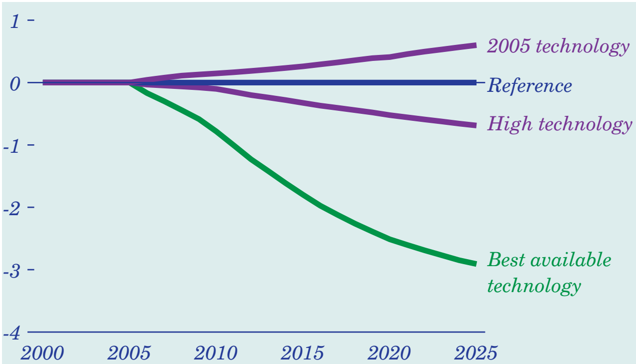
Advanced technology vehicles, representing automotive technologies that use alternative fuels or require advanced engine technology, are projected to reach 3.8 million vehicle sales per year and make up 19.1 percent of total light-duty vehicle sales in 2025. Alcohol flexible-fueled vehicles are projected to continue to lead advanced technology vehicle sales, at 1.5 million vehicles in 2025 (Figure 59). Hybrid electric vehicles (specifically designed to use electric motors and batteries in combination with a combustion engine to drive the vehicle), introduced into the U.S. market by two manufacturers in 2000, are anticipated to sell well: 607,000 units are projected to be sold in 2010, increasing to 1.1 million units in 2025. Sales of turbo direct injection diesel vehicles are projected to increase to 710,000 units in 2010 and 1 million units in 2025.

About 80 percent of advanced technology sales are as a result of Federal and State mandates for fuel economy standards, emissions programs, or other energy regulations. Currently, manufacturers selling alcohol flexible-fueled vehicles receive fuel economy credits that count toward compliance with corporate average fuel economy regulations. In the *AEO2005* forecast, the majority of projected gasoline hybrid, fuel cell, and electric vehicle sales result from compliance with low-emission vehicle programs in California, New York, Maine, Vermont, and Massachusetts. *AEO2005* does not include the impacts of California Assembly Bill 1493, which effectively sets carbon emission standards for light-duty vehicles, because of uncertainty about the State's ability to enforce the standards.

Energy Demand in Alternative Technology Cases

Advanced Technologies Could Reduce Residential Energy Use

Figure 60. Variation from reference case delivered residential energy use in three alternative cases, 2003-2025 (quadrillion Btu)



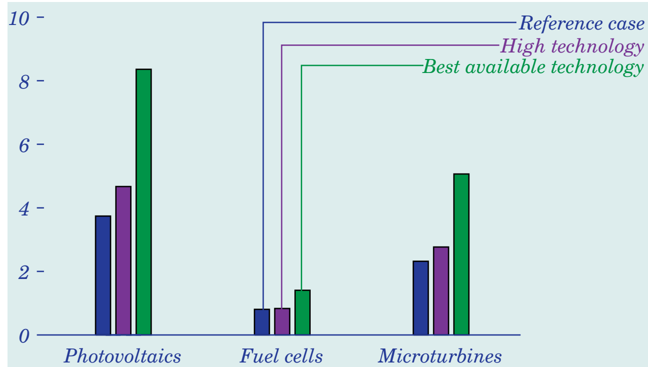
The reference case includes the effects of several policies aimed at increasing residential end-use efficiency, including minimum efficiency standards and voluntary energy savings programs to promote energy efficiency through innovations in manufacturing, building, and mortgage financing. In the 2005 technology case, assuming no increase in efficiency of equipment or building shells beyond that available in 2005, 4 percent more energy would be required in 2025 than projected in the reference case (Figure 60).

In the best available technology case, assuming that the most energy-efficient technology considered is always chosen regardless of cost, projected residential delivered energy use in 2025 is 20 percent lower than in the reference case and 24 percent lower than in the 2005 technology case. Through 2025, projected additional investment of $442 billion relative to that in the reference case would be necessary to save a projected $139 billion in energy costs in the best available technology case [*134*].

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. Delivered energy consumption in 2025 in the high technology case is projected to be 5 percent lower than in the reference case; 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 61. Buildings sector electricity generation from advanced technologies in alternative cases, 2025 (billion kilowatthours)



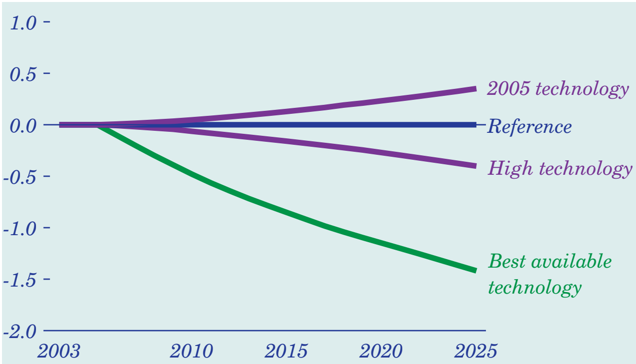
Alternative technology cases for the residential and commercial sectors include varied assumptions for the availability and market penetration of advanced distributed generation technologies (solar photovoltaic systems, fuel cells, and microturbines). Some of the heat produced by fossil-fuel-fired generating 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, buildings are projected to generate 1.4 billion kilowatthours (8 percent) more electricity in 2025 than in the reference case (Figure 61), most of which offsets residential and commercial electricity purchases. In the best available technology case, projected electricity generation in buildings in 2025 is 8.0 billion kilowatthours (47 percent) higher than in the reference case. In the 2005 technology case, assuming no further technological progress or cost reductions after 2005, electricity generation in buildings in 2025 is 6.5 billion kilowatthours (38 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, 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

Figure 62. Variation from reference case delivered commercial energy use in three alternative cases, 2003-2025 (quadrillion Btu)

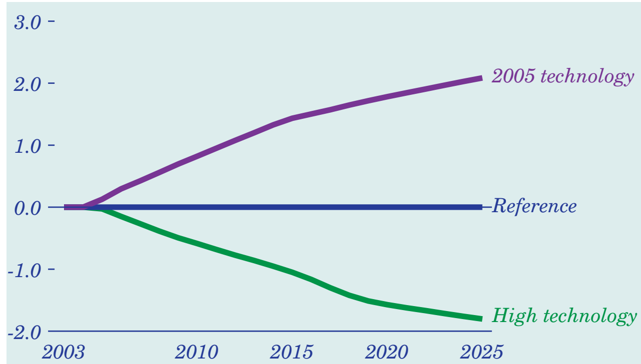


The *AEO2005* reference case incorporates efficiency improvements for commercial equipment and building shells, which help to limit the projected rate of increase in commercial energy intensity (delivered energy use per square foot of floorspace) to 0.2 percent per year over the forecast. The 2005 technology case assumes that future equipment and building shells will be no more efficient than those available in 2005. 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 a faster rate than assumed in the high technology case.

In the 2005 technology case, projected energy use in 2025 is 3 percent higher than the 12.5 quadrillion Btu in the reference case (Figure 62), as a result of an 0.3-percent average annual increase in commercial delivered energy intensity. The high technology case projects a 3-percent energy savings in 2025 relative to the reference case, with little change in energy intensity from 2003 to 2025. In the best available technology case, commercial delivered energy intensity is projected to improve by 0.4 percent per year, and projected energy use in 2025 is 11 percent lower than in the reference case. More optimistic assumptions result in additional projected energy savings from both renewable and conventional fuel-using technologies. In 2025, commercial solar photovoltaic systems are projected to generate more than twice as much electricity in the best technology case as in the reference case.

Alternative Technology Cases Show Range of Industrial Efficiency Gains

Figure 63. Variation from reference case delivered industrial energy use in two alternative cases, 2003-2025 (quadrillion Btu)



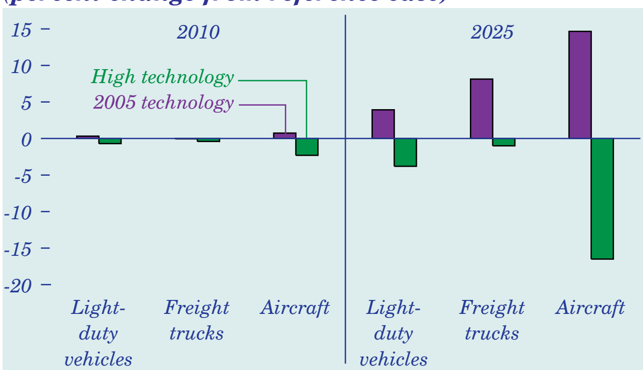
Efficiency gains in both energy-intensive and non-energy-intensive industries are projected to reduce overall energy intensity in the industrial sector. Expected output growth in metal-based durables (3.4 percent per year), driven primarily by investment and export-related demand, is a key factor. In the reference case, this non-energy-intensive group of industries grows more than twice as fast as the energy-intensive sectors (1.5 percent per year).

In the high technology case, 1.8 quadrillion Btu less energy is used in 2025 than for the same level of output in the reference case. Industrial energy intensity improves by 1.6 percent per year through 2025 in this case, compared with 1.3-percent annual improvement in the reference case (Figure 63). Industrial cogeneration capacity is projected to increase more rapidly in the high technology case (2.7 percent per year) than in the reference case (2.2 percent per year).

In the 2005 technology case, industry is projected to use 2.1 quadrillion Btu more energy in 2025 than in the reference case. Energy efficiency remains at the level achieved by new equipment in 2005, but average efficiency still improves as old equipment is retired. Aggregate industrial energy intensity is projected to decline by 1.0 percent per year because of reduced efficiency gains. The change in industrial structure is the same in the 2005 technology and high technology cases as in the reference case, because the same macroeconomic assumptions are used for the three cases, but the relative effects of the change varies, accounting for 63 percent of the change in intensity in the reference case, 52 percent in the high technology case, and 83 percent in the 2005 technology case.

Vehicle Technology Advances Reduce Transportation Energy Demand

Figure 64. Changes in projected transportation fuel use in two alternative cases, 2010 and 2025 (percent change from reference case)

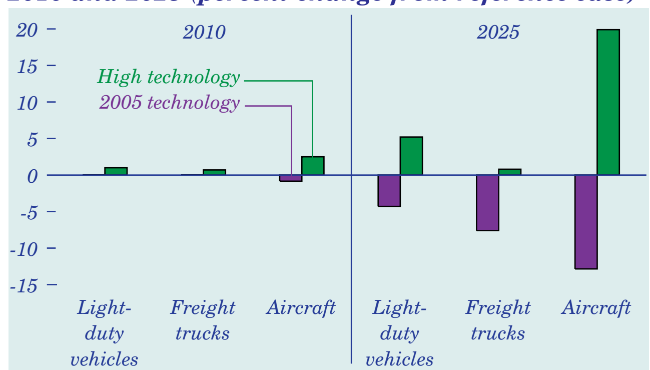


In the *AEO2005* reference case, delivered energy use in the transportation sector is projected to increase from 27.1 quadrillion Btu in 2003 to 40.0 quadrillion Btu in 2025. In the high technology case, the projection for 2025 is 1.9 quadrillion Btu (4.7 percent) lower, with about 54 percent (1.0 quadrillion Btu) of the difference attributed to efficiency improvements in light-duty vehicles (Figure 64) as a result of increased penetration of advanced technologies, including variable valve lift, electrically driven power steering pumps, and advanced electronic transmission controls. Similarly, projected fuel use by heavy freight trucks in 2025 is 0.1 quadrillion Btu lower in the high technology case than in the reference case, and advanced aircraft technologies are projected to reduce fuel use for air travel by 0.7 quadrillion Btu in 2025.

In the 2005 technology case, with new technology efficiencies fixed at 2005 levels, efficiency improvements can result only from stock turnover. As a result, total delivered energy demand for transportation in 2025 is 2.3 quadrillion Btu (5.8 percent) higher in 2025 in the 2005 technology case than projected in the reference case. Projected fuel use for air travel in 2025 is 0.7 quadrillion Btu (15 percent) higher in the 2005 technology case than in the reference case, and freight trucks are projected to use 0.6 quadrillion Btu (8.3 percent) more fuel in 2025 [*135*].

Technology Assumptions Include Improvements in Vehicle Efficiency

Figure 65. Changes in projected transportation fuel efficiency in two alternative cases, 2010 and 2025 (percent change from reference case)



The high technology case assumes lower costs and higher efficiencies for new transportation technologies. Advances in conventional technologies are projected to increase the average fuel economy of new light-duty vehicles in 2025 from 26.9 miles per gallon in the reference case to 28.8 miles per gallon in the high technology case. The average efficiency of the light-duty vehicle stock is 20.3 miles per gallon in 2010 and 22.1 miles per gallon in 2025 in the high technology case, compared with 20.1 miles per gallon in 2010 and 21.0 miles per gallon in 2025 in the reference case (Figure 65).

For freight trucks, average stock efficiency in the high technology case is 0.6 percent higher in 2010 and 1.0 percent higher in 2025 than the reference case projection of 6.6 miles per gallon. Advanced aircraft technologies increase projected aircraft efficiency by 3 percent in 2010 and 20 percent in 2025 relative to the reference case projections.

In the 2005 technology case, the average fuel economy of new light-duty vehicles is projected to be 24.9 miles per gallon in 2025, and the projected average for the entire light-duty vehicle stock is 20.1 miles per gallon in 2025. For freight trucks, the projected average stock efficiency in 2025 is 6.1 miles per gallon. Aircraft efficiency in 2025 is projected to average 59.7 seat-miles per gallon in the 2005 technology case, compared with 68.5 seat-miles per gallon in the reference case.