Chapter 2

Energy Consumption by End-Use Sector

In the IEO2007 projections, end-use energy consumption depends on resource endowment, economic growth, and other political, social, and demographic factors.

One way of looking at the future of world energy markets is to consider trends in energy consumption at the end-use sector level. With the exception of the transportation sector, which is dominated by petroleum-based liquids products at present, the mix of energy use in the residential, commercial, and industrial sectors varies widely by region, depending on a combination of regional factors, such as the availability of energy resources, the level of economic development, and political, social, and demographic factors. This chapter outlines *IEO2007* reference case projections for delivered energy consumption by end-use sector in the OECD and non-OECD regions.

Transportation Sector

Energy use in the transportation sector includes the energy consumed in moving people and goods by road, rail, air, water, and pipeline. The road transport component includes light-duty vehicles, such as automobiles, sport utility vehicles, minivans, small trucks, and motorbikes, as well as heavy-duty vehicles, such as large trucks used for moving freight and buses for passenger travel. Growth in economic activity and population growth are the key factors that determine transportation sector energy demand. Economic growth spurs growth in industrial output, which requires the movement of raw materials to manufacturing sites as well as movement of manufactured goods to end users. In developing economies, increased economic activity expands per-capita income; and as standards of living rise, demand for personal transportation increases.

Over the next 25 years, demand for petroleum and other liquid fuels is expected to increase more rapidly in the transportation sector than in any of the other end-use sectors. In the OECD countries, which are projected to remain the greatest users of energy for transportation, the transportation sector's share of total liquids demand is projected to rise from 58 percent in 2004 to 63 percent in 2030. In the non-OECD countries, the transportation sector is projected to account for a rising share of liquids consumption, and the liquids share of transportation energy use grows from 42 percent in 2004 to nearly 50 percent in 2030.

A primary factor contributing to the expected increase in energy demand for transportation is steadily increasing demand for personal travel in both the developing and mature economies. Increases in urbanization and in personal incomes have contributed to increases in air travel as well as increased motorization (i.e., more vehicles) in the growing economies. Modal shifts in the transport of goods are expected to result from strong GDP growth in both OECD and non-OECD economies. For freight transportation, trucking is expected to lead the growth in demand for transportation fuels. In addition, as trade among countries increases, the volumes of freight transported by air and marine vessels is expected to increase rapidly over the projection period [***1***].

In the price environment of the past several years, alternative transportation fuels have received growing attention worldwide. The United States, for instance, has passed legislation to increase the amount of ethanol in the U.S. liquids mix and has increased funding for research on cellulosic biofuels. In OECD Europe, there has been a major push to increase the use of alternative fuels for transportation, including natural gas. Alternative fuels remain fairly expensive, however. Barring any widespread increase in penetration of new technologies, whether driven by policy changes or other factors, the world's use of alternative fuels in the transportation sector is expected to remain relatively modest through 2030 in both OECD and non-OECD countries.

OECD Countries

Energy demand for transportation in the OECD economies is projected to grow at an average annual rate of 0.9 percent, from 57.9 quadrillion Btu in 2004 to 63.7 quadrillion Btu in 2015 and 73.4 quadrillion Btu in 2030 (Figure 25). As a whole, the OECD transportation sector can be characterized as fully established, with extensive infrastructure that includes highways, airport facilities, and rail systems. Transportation uses are expected to account for nearly all the growth in demand for liquids in the OECD countries over the projection period.

In the United States, the transportation sector continues to account for almost one-fourth of the country's total energy consumption; and in the *IEO2007* reference case, U.S. transportation energy demand is projected to grow from 27.9 quadrillion Btu in 2004 to 32.1 quadrillion Btu in 2015 and 39.3 quadrillion Btu in 2030. The United States is the largest user of transportation energy among the OECD nations and is projected to consume

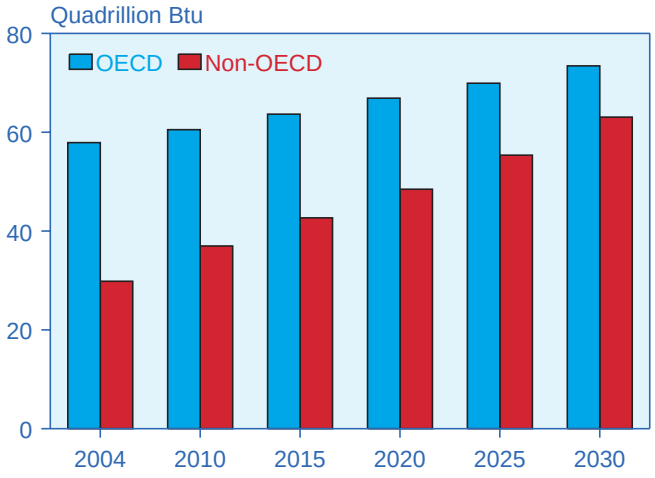
54 percent of the region's total for the transportation sector in 2030. Freight trucks are projected to be the fastest growing mode of travel in the United States, with vehicle miles traveled by freight trucks increasing at an average rate of 2.2 percent per year from 2004 to 2030, while their energy use increases by 1.8 percent per year. U.S. air travel is projected to increase by an average of 1.7 percent per year over the period; however, advanced aircraft technologies are expected to improve the efficiency of air travel, and so fuel use for air travel grows by only 1.4 percent per year.

Income growth and stable fuel prices are expected to continue the demand for larger, more powerful vehicles in the United States; however, advanced technologies and materials are expected to provide increased performance and size while improving new vehicle fuel economy. In March 2006, the National Highway Traffic Safety Administration finalized corporate average fuel economy (CAFE) standards requiring higher fuel economy performance for light-duty trucks in model years (MY) 2008 through 2011 [*2*]. The new CAFE standards specify a continuous mathematical function that determines minimum fuel economy requirements by vehicle footprint, defined as the wheelbase (the distance from the center of the front axle to the center of the rear axle) times the average track width (the distance between the center lines of the tires) of the vehicle in square feet. U.S. fuel economy standards for cars are assumed to remain at the current (2004) level of 27.5 miles per gallon through 2030.

In Mexico, strong GDP growth (3.6 percent per year) is projected to increase energy consumption in the transportation sector at an average rate of 2.3 percent per year, from 1.8 quadrillion Btu in 2004 to 2.3 quadrillion Btu in 2015, and 3.3 quadrillion Btu in 2030. The projected increase in transportation fuel use is based on expected growth in trade with the United States and overall improvement in the country's standard of living [*3*].

Transportation energy demand in OECD Europe is projected to increase by only 0.2 percent per year, from current usage of 18.5 quadrillion Btu in 2004 to 18.9 quadrillion Btu in 2015 and 19.6 quadrillion Btu in 2030. The transportation share of total energy use in OECD Europe is projected to decline slightly, from 23 percent in 2004 to about 22 percent in 2030. Low population growth, high taxes on transportation fuels, and environmental policies to discourage growth in transportation energy use are expected to slow the growth of transportation demand in OECD Europe.

Figure 25. OECD and Non-OECD Transportation Sector Delivered Energy Consumption, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Non-OECD Countries

The projected average growth rate of transportation energy use in the non-OECD countries from 2004 to 2030, at 2.9 percent per year, is more than triple the projected rate for OECD countries, and their use of liquids in the transportation sector is expected to double over the period (Figure 25). Among the non-OECD countries, China, India, and the nations of Central and South America are expected to be significant contributors to the growth in transportation sector energy consumption. China and India are expected to show the largest increases among the non-OECD countries. The combined growth rate for transportation energy use in all the countries of Central and South American economies is projected to be similar to that in India.

Historically, growth in transportation activity has been tied to income growth, indicating a strong relationship between per-capita GDP and passenger car travel per capita in countries with developing economies [*4*]. In many countries of OECD Asia, the availability of financing and an increase in the debt tolerance of middle class families are contributing to increased vehicle purchases.

Total transportation energy demand in the non-OECD countries is projected to grow from 29.8 quadrillion Btu in 2004 to 42.7 quadrillion Btu in 2015 and 63.1 quadrillion Btu in 2030. The transportation sector is projected to account for nearly 60 percent of the total increase in liquids use in non-OECD countries from 2004 to 2030. The growth in transportation energy use is expected to be led by greater demand for aviation fuel. Expanding ownership of private automobiles and an increasing role of trucking in freight transportation also play a significant role in the expected increase in energy demand. In 2004, the non-OECD economies accounted for about 34 percent of world energy use for transportation. In 2030, their share is projected to be 46 percent, as the gap

between transportation energy consumption in the non-OECD and OECD economies narrows substantially over the projection period (Figure 25).

China's energy use for transportation is projected to grow by an average of 4.9 percent per year, from 4.4 quadrillion Btu in 2004 to 7.7 quadrillion Btu in 2015 and 15.5 quadrillion Btu in 2030. Virtually all the growth in transportation energy consumption in China is projected to be in the form of liquids, mostly petroleum-based. As the country's economy expands, its energy use for air travel is expected to grow more rapidly than energy use for road transport (see box on page 22). Personal travel in China has soared in the past two decades, with passenger miles traveled increasing fivefold [***5***]. Still, in 2005 there were 4.5 million automobiles in China [***6***], as compared with 130.8 million automobiles in the United States [***7***].

After China, India is expected to experience the fastest expansion in transportation sector energy use in the world. India's transportation energy use is projected to grow at an average rate of 3.3 percent per year in the *IEO2007* reference case, compared with the world average of 1.7 percent per year. In comparison with other countries in the emerging, non-OECD Asia region, India's transportation infrastructure is well developed and used effectively by a large section of the population. Its railways are particularly established—although many rural areas still are largely inaccessible by rail. The *IEO2007* reference case anticipates that India will continue to expand its public transportation networks over the projection period, allowing robust increases in both road and rail transport and resulting in a more than doubling of transportation energy use between 2004 and 2030.

The pace and extent of transportation infrastructure improvements in China and India will influence the pace of growth in their transportation energy use. Interconnecting cities with major ports will allow goods and people to flow more quickly, making motorized road travel—for both freight transport and personal motor vehicles—more attractive. India launched its National Highways Development Project (NHDP) in 1998 to modernize its major highways [***8***]. The first phase of the project—the "Golden Quadrilateral," a 3,625-mile multilane highway system that connects Delhi, Mumbai, Chennai, and Calcutta—was completed at the end of 2006. The second phase—the North-South and East-West national highways that will connect the outermost points of the country—will comprise more than 4,200 miles of highway, with a scheduled completion date of December 2007. Additional NHDP projects are scheduled beyond that.

Transportation infrastructure investments are also occurring in China. In Beijing, a considerable amount of road construction and repair is underway in advance of the 2008 Olympic Games, with more than 40 main roads being repaired and 27 new arteries and 9 expressways under construction [***9***]. The country also has an ambitious plan to construct a 53,125-mile national expressway network to connect all its major transportation hubs, including railways, airports, and ports [***10***]. The "7918 Network" will, upon completion in 2020, connect Beijing with 7 major population centers or transportation hubs; 9 highways will connect the northern and southern parts of the country; and 18 highways will provide east-west connections. The need to expand road infrastructure is also evident in China's rural areas. For example, the Xinjiang Uighur Autonomous Region has announced plans to invest some $1.2 billion on road works in 2007, to build more than 2,400 miles of new roadway [***11***].

The Middle East has a relatively small population and is not a major energy consumer but rather an exporter; however, rapid population growth in the region is expected to result in increased demand for transportation. The region's energy demand for transportation is projected to grow from 4.5 quadrillion Btu in 2004 to 6.9 quadrillion Btu in 2015 and 9.0 quadrillion Btu in 2030.

Residential Sector

Energy use in the residential sector, which accounted for about 11 percent of worldwide delivered energy consumption in 2004, is defined as the energy consumed by households, excluding transportation uses. For residential buildings, the physical size of the structures is one key indicator of the amount of energy used by their occupants. Larger homes require more energy to provide heating, air conditioning, and lighting, and they tend to include more energy-using appliances, such as televisions and laundry equipment. Smaller structures require less energy, because they contain less space to be heated or cooled, produce less heat transfer with the outdoor environment, and typically have fewer occupants.

The type and amount of energy used by households vary from country to country, depending on income levels, natural resources, climate, and available energy infrastructure. In general, typical households in the OECD use more energy than those in non-OECD nations, in part because higher income levels allow OECD households to purchase more energy-using equipment. Consequently, residential sector energy use in the OECD countries accounts for about 60 percent of the world's residential delivered energy use, although the OECD nations account for only 18 percent of the world's population.

Whereas households in the OECD nations used more energy in 2004 in total than did the non-OECD nations, more rapid growth of residential energy consumption is

China's Transportation Sector: Recent Developments and Long-Term Projections

What happens in China in terms of liquids demand can have a substantial impact on world oil markets. China, with a rapidly expanding transportation sector, is the world's fastest-growing oil consumer. In the past 2 years, China alone accounted for more than 30 percent of the world's incremental consumption of liquid fuels.[a] China's strong growth in consumption helped to support high world oil prices in 2005 and 2006.

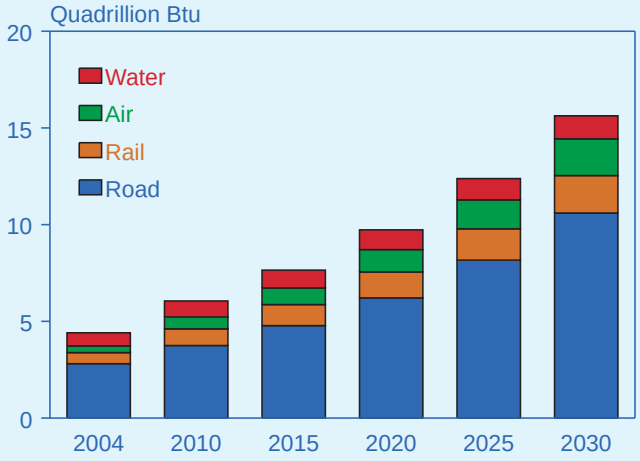
Transportation use is likely to define much of the growth in China's liquids consumption. An understanding of potential developments in China's transportation energy use over the coming decades is important, because it can allow analysts to consider how China's liquids markets will evolve and their potential impacts on world oil markets.

Economic growth, rapid urbanization, and the emergence of a modern transportation system all have contributed to the recent increase in China's liquids consumption. In the *IEO2007* reference case, total liquids consumption in China is projected to average 3.5-percent growth annually—higher than the growth rate for any other country in the world—and to reach 32 quadrillion Btu (about 16 million barrels oil equivalent per day) in 2030. In comparison, U.S. liquids consumption grows at an average rate of 1.0 percent per year over the projection period, to more than 52 quadrillion Btu in 2030. China is projected to account for 28 percent of the total increase in world liquids consumption from 2004 to 2030 and for 14 percent of the world's total consumption in 2030, nearly double its share in 2004.

In the *IEO2007* projections, China's energy use for transportation grows at a rate that is only about 20 percent less than its GDP growth rate, and the transportation share of its total liquids use increases from 32 percent in 2004 to 47 percent by 2030. Similar trends have characterized other developing economies in the past, both in the west and in Asian countries, including South Korea and Japan. High rates of economic growth in developing economies (particularly if growth is linked to manufacturing) typically require increased transportation services to connect production facilities with raw materials and energy sources, and to transport manufactured goods to consumer markets in growing urban areas. In addition, rising per-capita incomes historically have been associated with rapid increases in personal travel by road and air.

In China, most of the growth in transportation energy consumption is expected to be for road use (see figure below). Total transportation energy use is projected to increase by more than 11 quadrillion Btu from 2004 to 2030, and road vehicles are projected to account for nearly 70 percent of the increase. Air, rail, and marine transportation modes account for 14, 12, and 5 percent of the projected increase, respectively. Factors affecting the projections for transportation energy use by mode include urbanization and expansion of the middle class, efficiency improvements, consumer preferences, costs, and lag times associated with infrastructure development.

Transportation Energy Use in China by Mode, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

In the projections by travel mode, China's energy use for air travel has the highest growth rate, consistently exceeding the growth rate for GDP despite the expectation of significant improvements in fuel efficiency for air travel (see top figure on page 23). Similarly, Boeing Commercial Airplanes has estimated that revenue passenger-miles in China will grow about 20 percent faster than GDP from 2005 to 2025.[b] Energy use for rail transportation (both passenger and freight) increases more slowly, at about 75 percent the rate of GDP growth on average from 2004 to 2030.[c]

(continued on page 23)

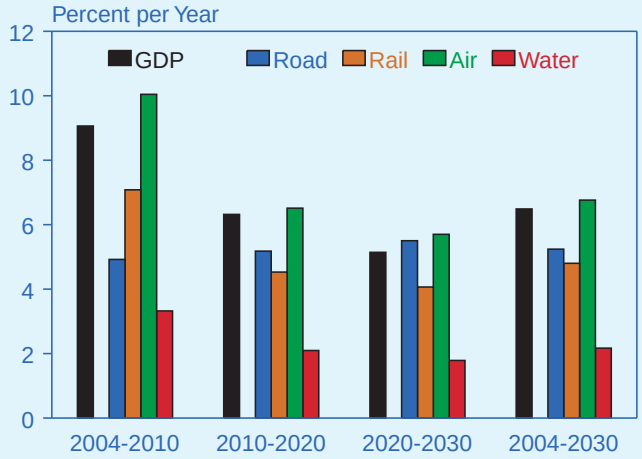
[a]Energy Information Administration, *International Petroleum Monthly* (February 7, 2007), web site www.eia.doe.gov/ipm; and *Short-Term Energy Outlook* (February 2007), web site www.eia.doe.gov/emeu/steo.

[b]Boeing Commercial Airplanes, *Current Market Outlook 2006* (Seattle, WA), p. 24, web site www.boeing.com/commercial/cmo/pdf/CMO_06.pdf.

[c]The energy use projection incorporates an estimated 15-percent efficiency improvement over the forecast.

China's Transportation Sector: Recent Developments and Long-Term Projections (Continued)

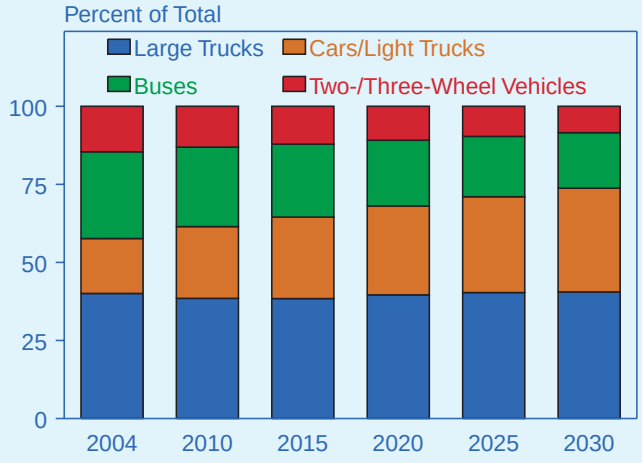
Average Annual Growth in China's GDP and Transportation Energy Use by Mode, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

As China's per-capita income rises, cars are expected to be the mode of choice for an increasing share of passenger travel, as has been observed in other developing economies. Buses and two- and three-wheeled vehicles, which accounted for 42 percent of road energy use in China in 2004, are projected to decline to a 26-percent share in 2030, while the share represented by cars and light trucks increases from 18 percent in 2004 to 33 percent in 2030 (see figure below).

China's Energy Use for Road Transportation by Vehicle Type, 2004-2030

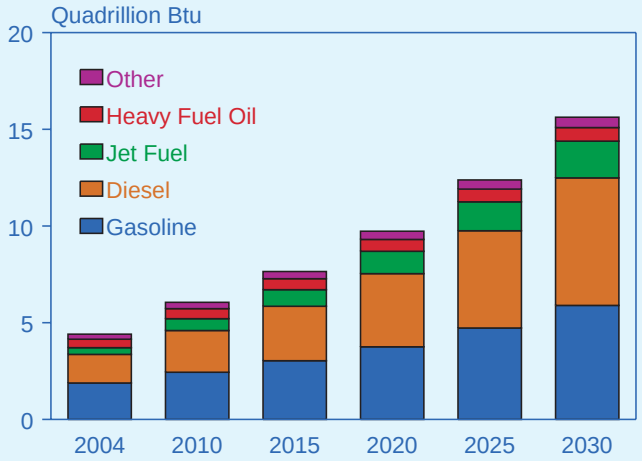


Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

The projections for road transportation assume that the ongoing development of China's road infrastructure will keep pace with increases in vehicle use. From 1994 to 2004, the country's total highway length grew at an average annual rate of 5.3 percent,[d] and similar increases will be needed annually from 2004 to 2030. If the pace of infrastructure construction cannot be maintained, China's transportation energy use could grow more slowly than projected.

Consumption of all transportation fuels in China (with the exception of coal used in older steam locomotives) increases in the projections (see figure below). Total liquids consumption for transportation in 2030 is projected to be 11.2 quadrillion Btu more than the 2004 total. Diesel fuel, gasoline, and jet fuel account for 46 percent, 36 percent, and 14 percent of the increase, respectively; and diesel fuel and gasoline together account for 80 percent of China's total projected energy use for transportation in 2030. Consumption of diesel fuel is expected to increase more rapidly than gasoline use, however, because it is the primary rail fuel and a major fuel for marine transport, and because diesel-fueled trucks are projected to account for an increasing share of total fuel use by large trucks. Following historical trends, coal use in China's transportation sector is projected to decline steadily, as diesel locomotives replace older railroad equipment.

China's Transportation Energy Use by Fuel Type, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

[d]National Bureau of Statistics of China, *China Statistical Yearbook 2005* (Beijing, People's Republic of China: China Statistics Press), web site www.stats.gov.cn/tjsj/ndsj/2005/indexeh.htm.

projected for the non-OECD than for the OECD countries, and in 2020 non-OECD residential energy use is expected to exceed OECD residential energy use (Figure 26). Worldwide, the projected increase in residential electricity demand accounts for nearly 60 percent of the growth in overall residential energy demand from 2004 through 2030. By 2025, electricity overtakes natural gas as the world's largest source of energy for household use.

OECD Countries

Households in OECD nations use energy more intensively than those in non-OECD nations, primarily because of their higher income levels. The United States and OECD Europe together consumed nearly one-half (49 percent) of the world's delivered residential energy in 2004; however, their share is expected to fall to 38 percent in 2030 as a result of increasing efficiency and slower growth in residential energy use than projected for the non-OECD countries.

Growth in electricity use in the OECD countries accounts for about 81 percent of the total projected growth in OECD residential energy demand (Figure 27), which will require additional power plants and corresponding increases in fuel use for electricity generation. Mexico's residential energy use is projected to show the highest rate of increase among the OECD nations, as its real GDP grows at a projected rate that is 44 percent higher than the OECD average. In OECD Asia, residential (and total) energy demand is projected to grow very little, because little or no growth is expected in the region's total population.

Non-OECD Countries

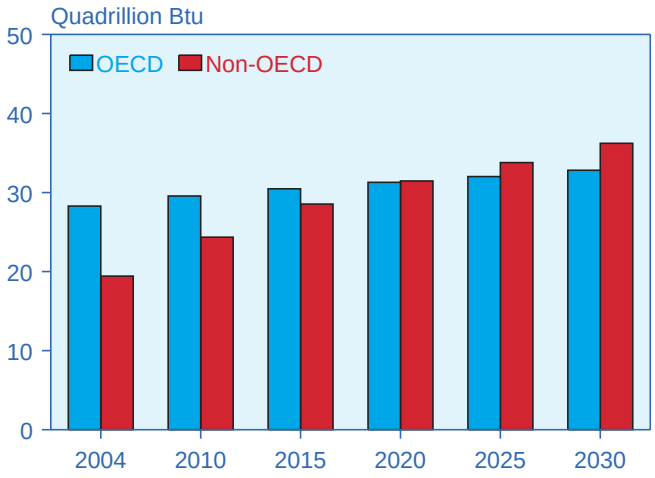
Household energy use is projected to increase more rapidly in the non-OECD countries than in the OECD countries over the coming decades (Figure 27). In China and India, population growth, rising income levels, and urbanization are expected to produce large increases in demand for residential energy services. For the non-OECD region as a whole, real GDP is projected to grow by more than 5 percent per year on average from 2004 through 2030, population is projected to grow by more than 1 percent per year, and household energy use is projected to grow at a robust rate of 2.4 percent per year, as higher incomes foster increased use of energy-using appliances. As a result, households in the non-OECD nations are projected to consume about 10 percent more energy than households in the OECD nations in 2030, requiring more than 86 percent more energy in 2030 than was consumed in the region in 2004. China and India are expected to account for more than 40 percent of the increase in residential energy use in the non-OECD countries through 2030, as their economies continue to grow rapidly over the projection period.

In many non-OECD countries today, households still use traditional, non-marketed energy sources, including wood and waste, for heating and cooking. Regional economic development should displace some of that use as incomes rise and marketed fuels, such as propane and electricity, become more widely accessible.

Commercial Sector

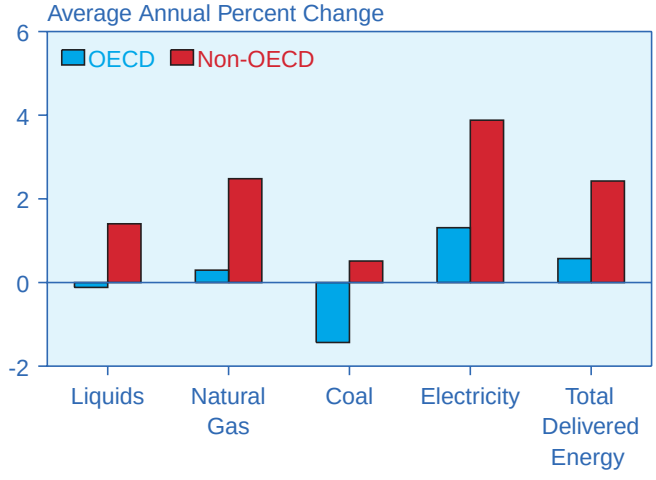
The commercial sector—often referred to as the services sector or the services and institutional sector—consists

Figure 26. OECD and Non-OECD Residential Sector Delivered Energy Consumption, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Figure 27. Growth in OECD and Non-OECD Residential Sector Delivered Energy Consumption by Fuel, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

of businesses, institutions, and organizations that provide services. The sector encompasses many different types of buildings and a wide range of activities and energy-related services. Examples of commercial sector facilities include schools, stores, correctional institutions, restaurants, hotels, hospitals, museums, office buildings, banks, and even stadiums that hold sporting events. Most commercial energy use occurs in buildings or structures, supplying services such as space heating, water heating, lighting, cooking, and cooling. Energy consumed for services not associated with buildings, such as for traffic lights and city water and sewer services, is also categorized as commercial sector energy use.

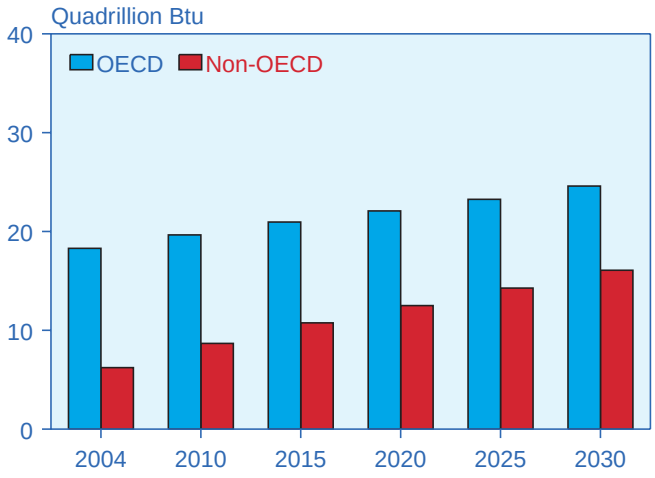
Economic and population growth trends drive commercial sector activity and the resulting energy use. The need for services (health, education, financial, government) increases as populations increase. The degree to which these additional needs are met depends in large measure on economic resources—whether from domestic or foreign sources—and economic growth. Economic growth also determines the degree to which additional commercial sector activities are offered and utilized. Higher levels of economic activity and disposable income lead to increased demand for hotels and restaurants to meet business and leisure requirements; for office and retail space to house and service new and expanding businesses; and for cultural and leisure space such as theaters, galleries, and arenas.

OECD Countries

Slow population growth in most of the OECD nations contributes to a slower rate of increase in the region's commercial energy demand in the *IEO2007* projections than has been seen in the past. In addition, continued efficiency improvements are expected to moderate the growth of energy demand over time, as energy-using equipment is replaced with newer, more efficient stock. Conversely, strong economic growth is expected to include continued growth in business activity, with its associated energy use, in areas such as retail and wholesale trade and business, financial, and leisure services. The combination of these factors causes commercial delivered energy consumption in the OECD countries to increase by an average of 1.2 percent per year from 2004 to 2030 in the reference case (Figure 28). Although the fastest growth in commercial energy demand among the OECD economies is expected to be in the countries with the fastest economic growth (Mexico and South Korea), the United States remains the largest consumer of commercial delivered energy in the OECD, accounting for one-half of the 24.6 quadrillion Btu of commercial energy use in the OECD as a whole in 2030.

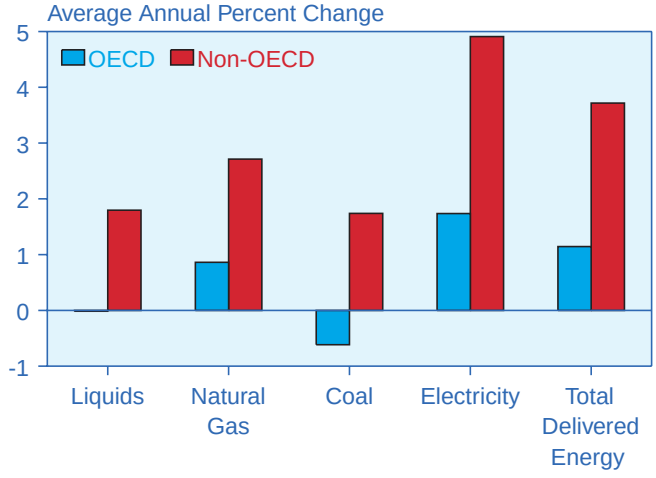
Commercial electricity demand in the OECD nations is projected to grow by 1.7 percent per year from 2004 to 2030, with continued advances in technology and the introduction of new electronic appliances and equipment (Figure 29). Electricity delivered to commercial consumers in the OECD countries, which totaled 8.6 quadrillion Btu in 2004, is projected to reach 10.8 quadrillion Btu in 2015 and 13.5 quadrillion Btu in 2030, surpassing projected OECD residential electricity use of 12.9 quadrillion Btu by the end of the projection period. Natural gas continues to displace petroleum products and coal as the preferred heating fuel in the OECD region.

Figure 28. OECD and Non-OECD Commercial Sector Delivered Energy Consumption, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Figure 29. Growth in OECD and Non-OECD Commercial Sector Delivered Energy Consumption by Fuel, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Non-OECD Countries

Economic growth and commerce are expected to increase rapidly in the non-OECD nations, fueling additional energy demand in the services sector. Faster population growth is also expected, relative to that in the OECD countries, portending increases in the need for education, health care, and social services and the energy required to provide them. Under these circumstances, commercial delivered energy use in non-OECD countries is projected to double between 2004 and 2020, to 12.5 quadrillion Btu, and to continue growing to 16.1 quadrillion Btu in 2030. Over the 2004 to 2030 period, commercial energy use in the non-OECD region increases at an average annual rate of 3.7 percent.

Electricity demand for commercial applications is projected to grow rapidly in the non-OECD nations as more clinics, schools, and businesses gain access to electricity. Annual growth in commercial delivered electricity use averages 4.9 percent through 2030 (Figure 29), with projected consumption of 6.1 quadrillion Btu in 2015 and 10.5 quadrillion Btu in 2030. The largest increases in commercial electricity demand are projected for nations with rapidly growing economies, particularly China and India, as their burgeoning economies foster increases in demand for services.

In the *IEO2007* projections, commercial demand for natural gas grows by 3.6 percent per year from 2004 to 2015 and by 2.7 percent from 2004 to 2030, as several countries focus on expanding the infrastructure necessary for delivery of the fuel. Commercial sector liquids consumption is projected to increase from 1.6 quadrillion Btu in 2004 to 2.2 quadrillion Btu in 2015 and 2.5 quadrillion Btu in 2030 in the non-OECD region, increasing more rapidly in areas where the availability of natural gas is limited. Commercial sector coal use in the non-OECD countries increases from 0.5 quadrillion Btu in 2004 to 0.8 quadrillion Btu in 2030, with most of the growth occurring between 2004 and 2015. Coal remains an economically attractive choice for commercial water heating, space heating, and cooking in non-OECD countries in the projections, especially in China and India, which together account for around 80 percent of non-OECD commercial coal use from 2004 through 2030.

Industrial Sector

Energy is consumed in the industrial sector by a diverse group of industries—including manufacturing, agriculture, mining, and construction—and for a wide range of activities, such as process and assembly uses, space conditioning, and lighting. Inputs that typically are considered energy products are included in industrial sector energy use. For example, natural gas and petroleum products used as feedstocks to produce non-energy products, such as plastics, are counted as energy used in the industrial sector. Industrial sector energy demand varies across regions and countries of the world, based on the level and mix of economic activity, technological development, and population, among other factors.

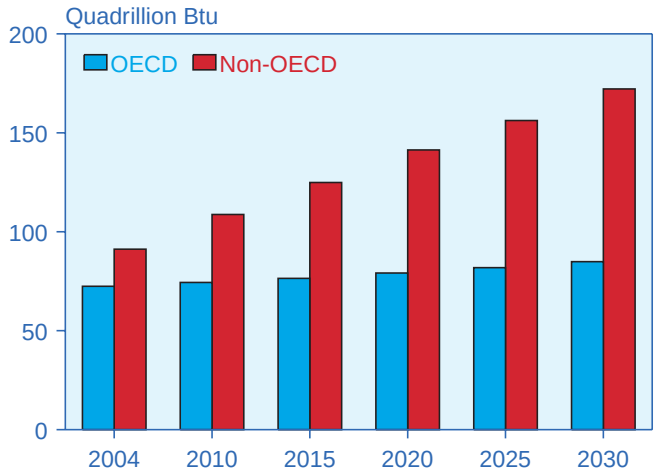
The industrial sector is the largest of the end-use sectors, consuming more than 50 percent of the delivered energy worldwide in 2004. Worldwide, energy consumption in the industrial sector is projected to increase by an average of 1.8 percent per year from 2004 through 2030, as compared with 1.0-percent average annual growth in the global population. Industrial energy consumption is expected to increase in all countries and regions; however, much slower growth in industrial sector energy use is projected for the OECD region than for the non-OECD region, with annual average increases of 0.6 percent and 2.5 percent, respectively (Figure 30).

OECD Countries

Industrial sector energy use among the OECD nations increases by 0.6 percent per year in the *IEO2007* reference case, from 72.4 quadrillion Btu in 2004 to 84.9 quadrillion Btu in 2030. The United States accounts for more than one-third of the OECD's total industrial energy consumption in 2030, and OECD Europe accounts for approximately another one-third of the OECD total, just as they did in 2004.

The OECD economies generally have more energy-efficient industrial operations and a mix of industrial output that is more heavily weighted toward non-energy-intensive sectors than do the non-OECD countries. Also, in the United States, the manufacturing share of total economic output has declined steadily over the past two decades, while the output share for service

Figure 30. OECD and Non-OECD Industrial Sector Delivered Energy Consumption, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

industries (included in the commercial sector) has increased. These general trends are projected to continue.

Similar developments are expected for the other OECD economies, as increasing international trade fosters a shift toward a less energy-intensive mix of industrial activity. For example, many of Japan's heavy industries are reducing their output as demand for energy-intensive materials increasingly is met by imports from China and other Asian countries. In the projections, the industrial sector in Mexico has the fastest energy consumption growth among the OECD countries, at nearly 2.2 percent per year. In Germany, a decline in industrial energy intensity in the early 1990s was largely the result of closures of heavy industries in the former East Germany after reunification. Much of the inefficient, energy-intensive capacity in the eastern part of Germany has already been shut down, but further improvements are projected as capital stock is replaced and modernized.

Electricity accounted for about 16 percent of OECD industrial energy use in 2004, and its share increases slightly over the projection period. Oil and natural gas were the most heavily used fuels in the OECD countries' industrial sectors in 2004, together accounting for two-thirds of the energy consumed in the sector. The two energy sources are projected to maintain their overall share in 2030, but consumption of natural gas is projected to grow almost five times as rapidly as that of liquids (Figure 31). Electricity and coal make up the bulk of the remaining projected energy consumption, while renewables remain a minor energy source for the sector.

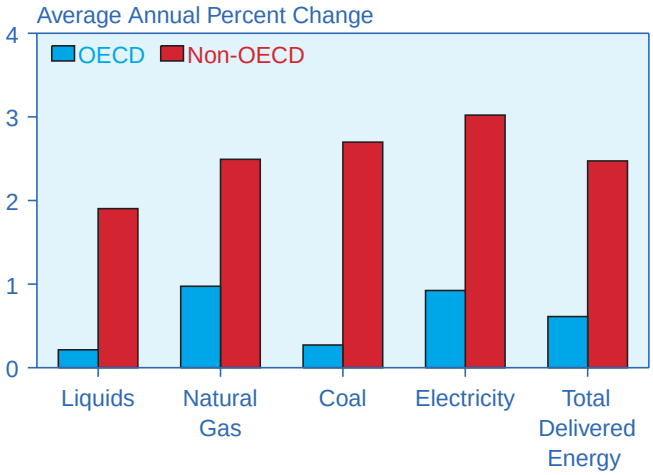
Non-OECD Countries

Industrial sector energy consumption is projected to increase by 2.5 percent per year in the non-OECD countries between 2004 and 2030 (Figure 30). The non-OECD economies generally have higher industrial sector energy consumption relative to GDP than do the OECD countries. On average, the ratio is almost 40 percent higher in the non-OECD countries. This is particularly true of Russia and the Eastern European countries which still have energy-inefficient capital remaining from the days of central planning. Per dollar of GDP, Russia's industrial sector consumed almost 8,000 Btu of delivered energy in 2004, and the non-OECD European and other Eurasian countries averaged 5,500 Btu, as compared with the overall non-OECD average of 3,500 Btu per dollar of GDP and the overall OECD average of around 2,500 Btu per dollar of GDP. As inefficient facilities in non-OECD Europe and Eurasia are replaced with modern capacity, industrial energy intensities in the region are expected to decline more rapidly than in most of the rest of the world.

Of the non-OECD economies, China, India, and the other Asian nations are expected to have the most rapid increases in industrial sector energy consumption between 2004 and 2030. Whereas the economies of the OECD countries have largely moved away from heavy, energy-intensive industries (such as steel and cement) toward a greater emphasis on light manufacturing and service activities, the economies of many of the non-OECD countries and regions have growing energy-intensive, heavy manufacturing sectors.

Although electricity is expected to become an increasingly important component of industrial sector delivered energy demand in the non-OECD economies, oil, coal, and natural gas were the most heavily used fuels in 2004, and they are projected to remain so in 2030. Liquids use in the non-OECD industrial sector increases at a slower rate than natural gas or coal use (Figure 31). The continued importance of coal in the non-OECD industrial sector is largely attributable to China, which accounts for 70 percent of industrial coal use in the non-OECD economies in 2030.

Figure 31. Growth in OECD and Non-OECD Industrial Sector Delivered Energy Consumption by Fuel, 2004-2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

References

1. Energy Information Administration, *Annual Energy Outlook 2007* , DOE/EIA-0383(2006) (Washington, DC, February 2007), web site www.eia.doe.gov/oiaf/aeo.
2. *Asian Automotive Business Review*, Vol. 17, No.2 (April 2006).

3. International Energy Agency, *World Energy Outlook 2006* (Paris, France, November 2006), web site www.worldenergyoutlook.org.
4. International Energy Agency, *World Energy Outlook 2006* (Paris, France, November 2006), web site www.worldenergyoutlook.org.
5. International Energy Agency, *World Energy Outlook 2006* (Paris, France, November 2006), web site www.worldenergyoutlook.org.
6. *Asian Automotive Business Review*, Vol. 17, No.2 (April 2006).
7. S.C. Davis and S.W. Diegel, *Transportation Energy Data Book: Edition 25*, ORNL-6974 (Oak Ridge, TN: Oak Ridge National Laboratory, 2006), Tables 3.1 and 3.2, web site http://cta.ornl.gov/data/download25.shtml.
8. National Highways Authority of India, "About NHDP: NHDP Important Dates," web site www.nhai.org.
9. "Beijing Intensifies Road Construction," Xinhua news agency, web site CHINAdaily.com.cn (January 15, 2007).
10. S.C. Johnson, "Cruising the '7918 Network' (China Plans National Expressway Network)," *Electronic Business* (August 1, 2006).
11. Global Insight, Inc., "China Regional—Analysis: Xinjiang Uighur Autonomous Region: Xinjiang Plans Major Roadway Initiative for 2007," web site www.globalinsight.com (February 12, 2007).