# Transportation Energy Use

***Oil is expected to remain the primary fuel source for transportation throughout the world, and transportation fuels are projected to account for almost 57 percent of total world oil consumption by 2020.***

Transportation fuel use is expected to grow substantially over the next two decades, despite oil prices that hit 10-year highs in 2000. The relatively immature transportation sectors in much of the developing world are expected to expand rapidly as the economies of developing nations become more industrialized. In the reference case of the *International Energy Outlook 2001* (*IEO2001*), energy use for transportation is projected to increase by 4.8 percent per year in the developing world, compared with average annual increases of 1.6 percent in the industrialized countries, where transportation systems are largely established and motorization levels (per capita vehicle ownership) are, in many nations, expected to reach saturation levels over the 21-year forecast horizon (Table 22).

The high world oil prices of 2000 have had little effect on demand for transportation fuels, so far. Oil prices recovered from their 1998 record lows throughout 1999 and surpassed $30 per barrel in the fourth quarter of 2000. The efforts of the Organization of Petroleum Exporting Countries (OPEC) to bring prices down to what it considers the optimal range of $22 to $28 per barrel by adding 700 thousand barrels per day to production in July and another 800 thousand in September were largely unsuccessful [***1***].

Some consumers in the United States, especially those in the Midwest and in California, saw summer motor gasoline prices surpass $2 per gallon—the result of a combination of high world oil prices, supply problems related to pipeline disruptions, and the higher refinery costs of new Federal regulations on motor gasoline. High gasoline prices focused consumer attention on the issue in the atmosphere of a U.S. presidential election year. Political discussions included suggestions for temporarily reducing or removing Federal motor gasoline taxes, but with lower prices after the summer peak the issue was dropped.

In contrast, in Western Europe, the combination of high world oil prices and heavy government taxes provoked angry protests among the region's ordinarily subdued petrol users. Consumers in Europe typically accept increases in motor fuel prices because the prices are already high relative to U.S. levels. Taxes often make up more than 50 percent of the total fuel cost in Europe. In September 2000, with $35 per barrel (and higher) oil prices stubbornly hanging on, French farmers and freight carriers waged a 3-week protest against the high costs of fuel, and eventually they were able to persuade the French government to reduce some motor gasoline taxes by 15 percent. Strikes quickly spread to other

**Table 22. Transportation Energy Use by Region, 1990-2020**

| Region | Transportation Energy Consumption (Million Barrels Oil Equivalent per Day) | | | | Average Annual Percent Change | |
|---|---|---|---|---|---|---|
| | 1990 | 1999 | 2010 | 2020 | 1990-1999 | 1999-2020 |
| **Industrialized** | **21** | **25** | **3!** | **35** | **2.0** | **1.6** |
| North America | 13 | 15 | 19 | 23 | 2.1 | 2.0 |
| Western Europe | 6 | 7 | 8 | 9 | 1.8 | 1.0 |
| Industrialized Asia | 2 | 3 | 3 | 3 | 2.4 | 1.0 |
| **EE/FSU** | **3** | **2** | **3** | **4** | **-5.0** | **2.8** |
| **Developing** | **7** | **11** | **18** | **29** | **5.2** | **4.8** |
| Asia | 3 | 6 | 10 | 16 | 6.8 | 5.1 |
| Middle East | 1 | 2 | 3 | 5 | 4.1 | 4.8 |
| Africa | 1 | 1 | 2 | 2 | 3.4 | 3.0 |
| Central and South America | 2 | 2 | 4 | 6 | 3.4 | 4.6 |
| **Total World** | **31** | **38** | **51** | **68** | **2.2** | **2.8** |

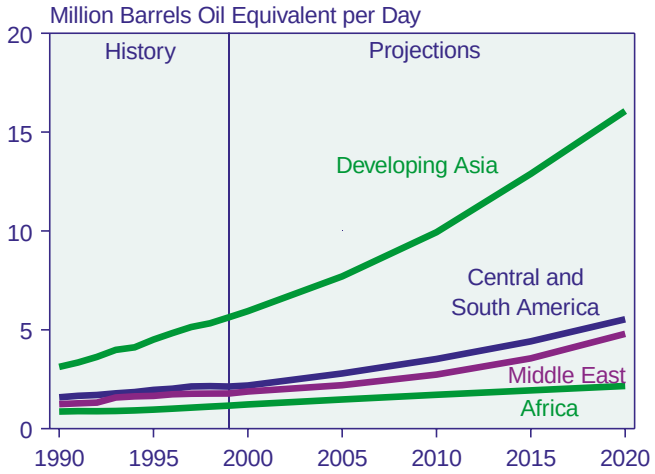
Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Western European countries, including Belgium, Germany, Italy, the Netherlands, Poland, and the United Kingdom, and strikes were threatened in Spain, Sweden, Greece, and Ireland.

High world oil prices also caused concern in the developing world, particularly in the recently recovering economies of southeast Asia, where further recovery was threatened by the sustained high world oil prices. In Indonesia—the last southeast Asian economy to show some recovery from the 1997-1999 recession—efforts to raise gasoline prices to reflect the higher world oil prices were met by demonstrations from consumers after the first day of the rate increases. Oil demand in Asia remained strong during 2000, but there are growing fears that high petroleum product costs will weaken demand growth, drive up inflation, and stop the region's economic expansion in the short run.

The mid-term forecast for the transportation sectors of the countries in southeast Asia is one of strong growth. The *IEO2001* reference case projects robust growth in transportation energy use in developing Asia, by 5.1 percent per year between 1999 and 2020. Rapid growth is also projected for the Middle East and for Central and South America, at 4.8 and 4.6 percent per year, respectively (Figure 84). Much of the growth is expected to be in road use, a combination of freight movement and personal motor vehicle ownership. Personal vehicle ownership is seen as a symbol of emerging prosperity in many of the urban centers of the developing world, and annual car sales have grown by double-digit percentages in many Asian countries.

**Figure 84. Transportation Energy Consumption in the Developing World by Region, 1990-2020**



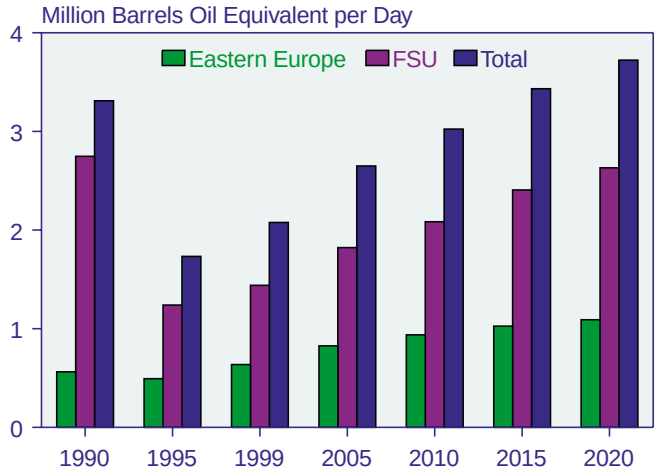

Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

There are many factors that might hinder the growth of the transportation sector in the developing world. For example, many of the economies with the greatest projected growth also have the most immature transportation infrastructures. In major cities such as Mumbai (formerly Bombay), Bangkok, Mexico City, and Shanghai, congestion is a major problem that causes high levels of air pollution and increasing instances of respiratory disease. Indeed, there is increasing interest in the development of vehicle fleets that are run on fuels other than petroleum, such as natural gas, to address pollution problems (see box on page 140). In addition to pollution issues, many countries, such as India and China, have not established major highways (along with gasoline stations and other necessary amenities) to connect cities, making it difficult to travel by automobile. In order for motorization levels to continue to grow apace over the forecast period, developing nations will have to invest substantially to improve transportation networks and address increasing congestion on the roads of major urban centers.

In the former Soviet Union (FSU), high world oil prices have helped to boost the economies of the oil-exporting republics, notably Russia, the region's largest economy. The August 1998 devaluation of the Russian ruble resulted in a sharp reduction in imports, and domestic production subsequently increased to meet consumer needs. Industrial production increased by 8.1 percent in 1999, by 11.2 percent in the first quarter of 2000, and by 8.5 percent in the second quarter [***2***]. The improved economic situation in Russia was accompanied by similar growth in its transportation sector. Freight transport in the country grew by a reported 5.2 percent in 1999 (rail 18.1 percent, air 13.8 percent, and road 3.3 percent) [***3***]. In the *IEO2001* reference case, oil use in the transportation sector is expected to continue to recover in the FSU, growing at an average annual rate of 2.9 percent per year and nearly recovering to the region's Soviet-era consumption levels by 2020 (Figure 85).

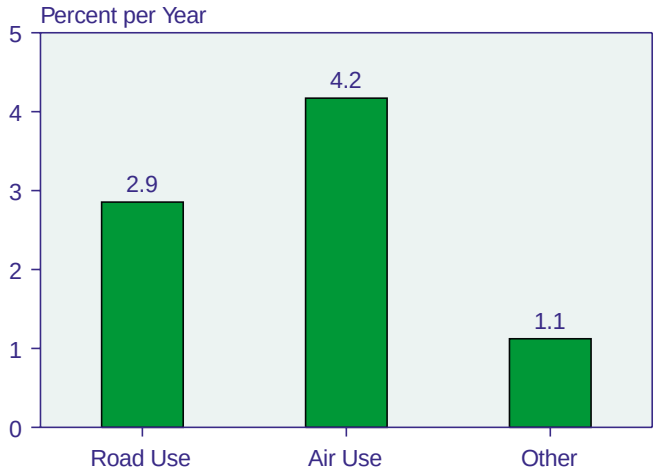
Although fuel for road use remains the dominant form of transportation sector energy consumption worldwide, the fastest-growing mode of transportation energy use in the *IEO2001* reference case forecast is air (Figure 86). *IEO2001* projects that air travel will increase by 4.2 percent per year worldwide over the 21-year projection period, compared with projected average annual growth rates of 2.9 percent for road energy use and 1.1 percent for "other" transportation energy use (rail, inland water, marine bunker, and pipeline transport). The forecast is based on the expectation that as economic expansion takes hold in the developing countries, their standards of living will rise and air travel for both business and leisure will increase. Substantial investment will be required, particularly in the developing world, to

**Figure 85. Transportation Energy Consumption in Eastern Europe and the Former Soviet Union, 1990-2020**




Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

**Figure 86. Projected Annual Growth in World Transportation Energy Consumption by Mode, 1999-2020**




Sources: **1999:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2020:** EIA, World Energy Projection System (2001).

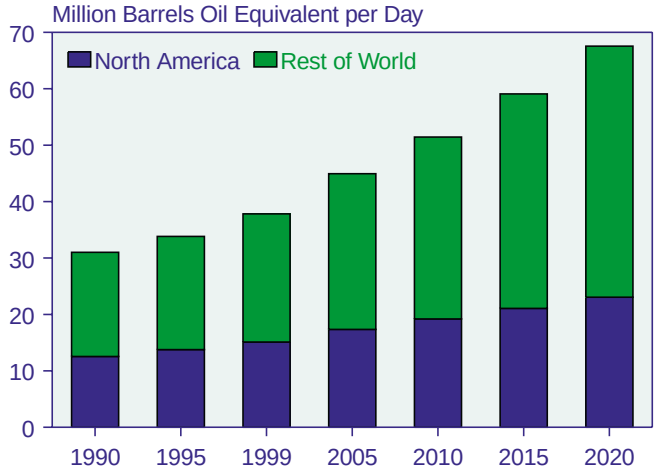
improve and expand airport infrastructures to accommodate the expected growth in demand for air travel.

## Regional Activity

### North America

North America currently accounts for about 40 percent of the energy consumed for transportation worldwide, but its share is projected to decline to about 34 percent in 2020 as the transportation sectors of emerging economies expand (Figure 87). Geographically widespread, consumers in the United States and Canada use personal motor vehicles to commute and travel greater distances than their counterparts in Western Europe and Japan, where mass transit networks are often well-established in major urban areas. Mexico's transportation energy use expanded by an average annual rate of 5.0 percent between 1980 and 1999, compared with 1.3 percent per year in the United States and 0.8 percent per year in Canada. Mexico's transportation sector is projected to continue to grow at the rapid pace of 5.2 percent per year through 2020 (Figure 88).

**Figure 87. Transportation Energy Consumption in North America and the Rest of the World, 1990-2020**




Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

#### *United States*

In the United States, transportation sector energy consumption is projected to increase at an average annual rate of 1.8 percent from 1999 to 2020. Growth in U.S. transportation sector energy demand averaged 2.0 percent per year during the 1970s but was slowed in the 1980s by rising fuel prices and the implementation of Federal vehicle efficiency standards. Average vehicle fuel efficiency increased by an unprecedented 2.1 percent per year during the 1980s; however, a slower rate of improvement is expected in the forecast, despite expectations for technological advances such as gasoline fuel cells, direct fuel injection, and electric hybrids for both gasoline and diesel engines. Fuel efficiency standards for U.S. light-duty vehicles are expected to remain at current levels, and relatively low world oil prices and higher personal incomes are expected to increase consumer demand for larger and more powerful vehicles. The average fuel economy of the light-duty fleet is projected to grow from 24.2 miles per gallon in 1999 to 28.0 miles per gallon in 2020.

## Natural Gas Vehicles: Worldwide Status

Natural-gas-fueled vehicles are not a new technology, having been in use since the 1930s and accounting for more than a million of the motor vehicles on the road today worldwide.[a] More than 100,000 natural gas vehicles (NGVs) are operating in the United States alone; however, this is not to suggest that NGVs make up a substantial portion of the American automotive fleet. The entire highway vehicle fleet of the United States was 212 million in 1997, and NGVs accounted for less than 0.1 percent of the country's total vehicle population.[b]

Interest in expanding the NGV fleet is growing in many parts of the world. Concerns over the pollutants released by gasoline- and diesel-fueled vehicles has helped NGVs gain momentum, and many of the new emissions standards that have recently been enacted in the United States, Canada, and Europe may increase the penetration of NGVs. For instance, in December 2000, President Clinton approved a proposal by the U.S. Environmental Protection Agency (EPA) to reduce substantially the amounts of sulfur and nitrogen oxide released by heavy-duty vehicles.[c] This followed the Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements finalized by the EPA earlier in 2000, tightening emissions standards for passenger cars and light-duty trucks, minivans, and sport utility vehicles.

Canada announced in May 2000 that it would launch a national program to study measures for reducing pollution from motor vehicles with the intention to "meet or exceed the new standards that the United States will have in place beginning with the 2004 model year and culminating with the 2009 model year."[d] Similarly, the European Union (EU) passed its Auto Oil I Programme in 1997, which eliminated the use of leaded fuel by EU member countries on January 1, 2000 (except for Spain, Italy, Greece, and the French Territories, for which extensions were granted until 2002) and issued limits on sulfur, benzene, and aromatics.[e] The EU is already working on an Auto Oil II Programme, which will further tighten motor vehicle emissions standards.[f]

There are two ways in which natural gas is currently used as a motor vehicle fuel: compressed natural gas (CNG) and liquefied natural gas (LNG). CNG is the most common form of natural gas use as an alternative fuel, although there is a growing market for use of LNG in heavy-duty vehicles. The basic difference between CNG and LNG is energy density; the liquid form of the fuel carries more energy per pound than the gaseous form.[g] In the United States, an estimated 101,991 CNG vehicles and 1,682 LNG vehicles were operating in 2000.[h] In Canada, nearly 40,000 NGVs operate with a network of 125 public fueling stations.[i]

In most parts of the world, NGVs are introduced to replace buses and other public vehicle fleets, as well as taxi fleets. This has become increasingly popular in European countries where there is a concern about air quality in congested urban areas with well-established mass transit. It is also increasingly true for cities like Mumbai and Mexico City, both of which have struggled to control worsening air pollution problems. Mexico, however, has only two CNG service stations, although there are plans to increase the number to 30 before 2003.[j] Mexico hopes to increase the penetration of NGVs from 2,000 in 2000 to 35,000 to 50,000 vehicles over the next few years. The Mexican Regulatory Commission of Energy estimates that it will be able to increase the number of NGVs to 100,000 by 2008.

In Europe, the penetration of NGVs has been increasing rapidly. The EU's four largest natural-gas-consuming members, the United Kingdom, Germany, France, and Italy, are all introducing new incentives for CNG-fueled vehicles.[k] Germany offers a low tax on CNG, and the government is committed to maintaining the low tax rate until 2009. The tax on CNG is only 15 percent of the service station price of DM 1.10 per kilogram (equivalent to paying about DM 0.75 per liter for the same amount of motor gasoline, whereas the current price of motor gasoline is DM 1.85 per liter). The tax benefit for using CNG will be even more attractive in 2003, when a new ecological tax is scheduled to be levied on petroleum fuels.

*(continued on page 141)*

[a]Ford Motor Company, "Natural Gas Vehicles," web site www.ford.com (2000).

[b]U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Statistics Annual Report 1999*, BTS99-03 (Washington, DC, 1999), web site www.bts.gov.

[c]D. Jehl, "New Rules To Cut Diesel Emissions," *The New York Times on the Web*, web site www.nytimes.com (December 21, 2000).

[d]Environment Canada Press Release, "Environment Minister David Anderson Announces Immediate and Long Term Actions To Bring Cleaner Air to Canadians," web site www.ec.gc.ca (May 19, 2000).

[e]Commission of the European Communities, "Guide to the Approximation of European Union Environmental Legislation: The Auto-Oil Programme" (August 25, 1997).

[f]Standard & Poor's, *World Energy Service: European Outlook, Volume I, 1999* (Lexington, MA, 1999), pp. 5-6.

[g]NGV.org, "Information: Natural Gas as a Vehicle Fuel," web site www.ngv.org (2000).

[h]Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1998* (Washington, DC, 2000), web site www.eia.doe.gov.

[i]Natural Gas Vehicle Coalition, "Questions and Answers About Natural Gas Vehicles: Where Are NGVs Used Now?" web site www.ngvc.org/qa.html (no date).

[j]"Bid To Beat Mexico Smog Has NGV Chief Fuming," *Financial Times: International Gas Report*, No. 411 (November 10, 2000), pp. 7-8.

[k]"NGVs—Moving Up a Gear," *Financial Times: International Gas Report*, No. 413/14 (December 8, 2000), pp. 34-35.

## Natural Gas Vehicles: Worldwide Status (Continued)

France is also trying to expand its NGV fleet. The country currently has 4,500 NGVs operating. In November 1999, state-run Gaz de France joined with PSA Peugeot Citroen, Renault, and Union Francaise des Industries Petrolieres to promote the NGV market, and Gaz de France has created a subsidiary, GNVert, whose purpose it is to develop a network of CNG stations along the country's road network. France has already managed to introduce CNG-fueled buses in half of its cities with populations over 200,000, and another 500 CNG buses are on order.

The United Kingdom has fewer NGVs operating than does France, only 835 and most are buses and garbage trucks.[k] The government is promoting NGVs through the 1995/1996 Powershift Programme, under which subsidies between 40 and 75 percent are offered for conversions of vehicles to CNG or liquefied petroleum gas (LPG). Funding for the project was recently tripled to about $15 million. The primary focus of the program has been on LPG use, which is growing at a rapid pace in the United Kingdom, and LPG-fueled vehicles are expected to reach 33,000 by the end of 2001.

Italy has the greatest number of NGVs in Western Europe, with some 345,000 vehicles currently operating.[l] It also has a well-established infrastructure with 340 service stations that can supply consumers with CNG. Italian natural gas supplier, Snam, has ambitious plans to expand the CNG infrastructure by doubling the distribution network and is also working with Fiat in the development of NGVs.[k] CNG service stations are expected to reach 600 by 2005.[l]

Outside the industrialized world, the potential market for NGVs could be very lucrative. In Argentina, the NGV stock increased from a few hundred in 1990 to about 600,000 in 2000, supported by 850 CNG service stations.[k] Low taxes on CNG have helped support the growth; CNG is sold for between 30 and 35 cents per liter, less than one-third the price of motor gasoline (currently about $1.10 per liter).

In Egypt, the NGV market has increased from nearly zero in 1997 to an estimated 20,000 in 2000—with most of the operating vehicles in Cairo. The supporting infrastructure for CNG has increased apace, with up to 30 public stations already operating. The Egyptian government is requiring all taxis and micro-buses to convert to CNG within a 3-year period. Even Russia has more than 200,000 NGVs operating with plans to convert another 1 million vehicles by 2010.[i]

India has committed to creating a major fleet of CNG-fueled public transport buses in Delhi, where the state government will invest $48.1 million to buy 1,100 CNG buses and will convert another 1,000 diesel-fueled buses to CNG engines.[m] An order for 1,500 CNG buses has already been placed, in part as a response to the Indian Supreme Court deadline of March 31, 2001, for Delhi to phase out all diesel-run buses in an effort to reduce air pollution. Delhi has already established 50 CNG service stations, and there are another 20 operating in Mumbai.[n] Overall, India currently has 25,000 vehicles already converted from diesel to CNG.

The major drawback for establishing a strong NGV program is lack of infrastructure. For example, the firm Gas Natural launched a program to introduce NGVs in Bogota, Colombia, but thus far there are only 110 motorists using the gas-fueled cars and only two service stations available to them.[o] The company hopes to expand the number of service stations to eight within a year's time, but the current lack of infrastructure tends to retard expansion of the NGV fleet.

One way in which countries increase their NGV fleets is through conversions of motor-gasoline-fueled cars. In Argentina, for example, vehicle conversions from motor gasoline to natural gas are averaging around 6,000 per month.[n] Vehicle conversion costs vary according to the size of the engine (typical sedans can be converted for around $4,000 excluding labor, but the conversion costs for heavy-duty engines, trucks, and buses are between $30,000 and $50,000 because of the number of cylinders needed to obtain the desired travel range of the vehicle).[p] New light-duty NGVs can cost as much as $6,000 over the price of conventional gasoline and diesel vehicles.

[l]"Methane Motors On Slowly," *Financial Times: International Gas Report*, No. 408 (September 29, 2000), pp. 10-11.

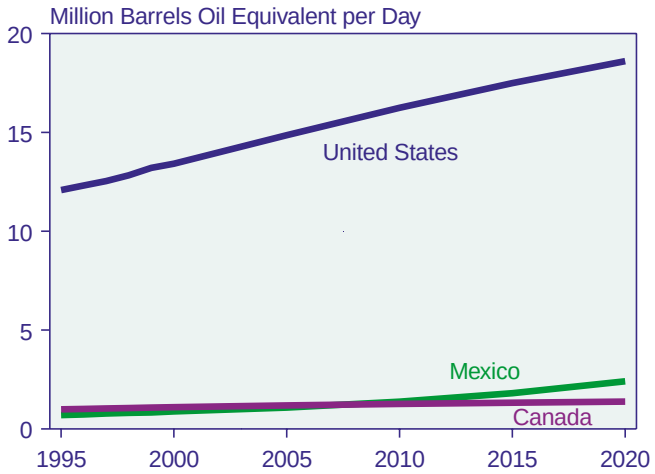
[m]"Delhi in CNG Bus Push," *Financial Times: International Gas Report*, No. 412 (November 24, 2000), p. 28.

[n]P. Hamling, "NGVs—Bridging the Gap to a Hydrogen Future," *Financial Times: International Gas Report*, No. 411 (November 10, 2000), pp. 34-38.

[o]"Colombians Try Natural Gas Cars," *The Oil Daily*, Vol. 50, No. 108 (June 6, 2000), p. 7.

[p]International Association for Natural Gas Vehicles Online, "NGV FAQs: How Much Do NGVs Cost?" web site www.iangv.org/html/sources/qa.html (December 2, 2000).

**Figure 88. Transportation Energy Consumption in North America by Region, 1995-2020**




Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Petroleum products are expected to continue to dominate transportation energy use in the United States. Motor gasoline consumption is projected to increase by 1.4 percent per year between 1999 and 2020, accounting for more than half the fuel use in the transportation sector in 2020 [***4***]. At the end of the forecast, alternative fuel use is projected to contribute about 203 thousand barrels oil equivalent per day, or about 2.1 percent of all light-duty vehicle fuel consumption, in response to current environmental and energy legislation intended to reduce oil use.[24] Low gasoline prices and slower fuel efficiency gains in conventional light-duty vehicles (cars, vans, pickup trucks, and sport utility vehicles) are projected to result in a stable market share for gasoline over the forecast horizon.

Air travel is also projected to increase in the forecast, but at the same time, new aircraft fuel efficiencies are expected to increase by more than 17 percent from 1999 levels by 2020. Ultra-high-bypass engine technology alone may increase fuel efficiency by as much as 15 percent, and increased use of weight-reducing materials may also help to increase fuel efficiency by up to 15 percent. As in the case of motor gasoline, robust economic growth and low projected jet fuel prices are expected to result in strong growth in air travel (an estimated 3.6 percent per year between 1999 and 2020) and a corresponding 2.6-percent average annual gain in jet fuel consumption.

The United States has taken steps to limit exhaust emissions from its motor vehicle fleet. The Clean Air Act Amendments of 1990 (CAAA90) set "Tier 1" exhaust emission standards for carbon monoxide, hydrocarbons, nitrous oxides, and particulate matter for light-duty vehicles and trucks beginning with model year 1994. CAAA90 also required the U.S. Environmental Protection Agency (EPA) to study more extensive "Tier 2" standards that would be enforced on 2004 model year cars. In July 1998, the EPA provided Congress with a Tier 2 study which concluded that tighter vehicle standards are needed to attain National Ambient Air Quality Standards for ozone and particulate matter between 2007 and 2010.

In February 2000, the EPA published its Final Rule on "Tier 2" Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements [***5***]. The Final Rule includes standards that will significantly reduce the sulfur content of gasoline throughout the United States to ensure the effectiveness of emissions control technologies that will be needed to meet the Tier 2 emissions targets in new automobiles and light-duty trucks, minivans, and sport utility vehicles (SUVs). The new standards represent the first time that the same set of emissions standards will be applied to all passenger vehicles, and the EPA has stated that the single standard is appropriate given the increased use of light trucks for personal transportation. The reference case projections for the U.S. transportation sector incorporate the new Tier 2 standards and low-sulfur gasoline requirements.

On December 21, 2000, the EPA also finalized new regulations to reduce emissions from heavy-duty trucks and buses substantially [***6***]. The sulfur content of highway diesel fuel is to be reduced from its current level of 500 parts per million (ppm) to 15 ppm beginning in June 2006. Refiners and importers will be required to produce diesel meeting a 15 ppm maximum requirement by June 1, 2006. Diesel meeting the new specification will be required at terminals by July 15, 2006, and at retail stations and wholesale outlets by September 1, 2006. This time schedule is driven by the need to provide fuel for the 2007 model year diesel vehicles that will become available in September 2006. New standards for heavy-duty gasoline engines and vehicles will reduce both hydrocarbons and nitrous oxide for all vehicles over 8,500 pounds not covered in the Tier 2 standards, beginning in 2005.

Under a "temporary compliance option" (phase-in), a refinery may produce up to 20 percent of its total annual highway diesel fuel at the current 500 ppm on-highway level. The remaining 80 percent must meet the new 15 ppm maximum. The rule provides for an averaging, banking and trading (ABT) program. Refineries that

[24]For example, the Energy Policy Act of 1992 sets new vehicle purchase mandates for vehicle fleet owners, whereby 70 percent of all vehicles must be fueled by alternative fuels by 2006. Also, under the Low Emission Vehicle Program, 10 percent of all new vehicle sales in States that agree to participate will be zero-emission vehicles by 2003.

produce more than 80 percent of their highway diesel to meet the 15 ppm limit can receive credits that may be traded with other refineries within the same PADD that do not meet the 80 percent production requirement. Starting on June 1, 2005, refineries can accrue credits for producing any volume of highway diesel that meets the 15 ppm limit.[25] The trading program will end on May 31, 2010, after which all refineries must produce 100 percent of their highway diesel at 15 ppm. The ABT program will not include refineries in States that have State-approved diesel fuel programs, such as California, Hawaii, and Alaska. There are also various provisions for small refiners[26] and for refiners in the so-called "Geographical Phase-In Area" (GPA).[27]

### Canada

The transportation sector in Canada is similar to that in the United States. Like the United States, Canada is a geographically large country, and its population density is much lower than in many Western European countries or Japan. The Canadian consumer can be expected to drive almost as much as the American consumer, although motorization rates are slightly lower in Canada than in the United States (607 motor vehicles per thousand persons in Canada compared with 777 in the United States in 1999). Canada's vehicle fleet closely resembles that of the United States, in part because the North American Free Trade Agreement has served to unify the North American vehicle market [***7***].

Petroleum use dominates transportation in Canada, accounting for 90 percent of total energy use in the transportation sector. On-road vehicles use 74 percent of the oil consumed for transportation, and the remainder is used for air, rail, maritime, and agricultural purposes [***8***]. Transportation sector uses are also expected to account for more than 97 percent of the increment in Canada's oil use over the forecast period.

The Canadian government has instituted a voluntary average fleet efficiency program for new cars and light trucks that is similar to the programs established in the United States. Cars and light trucks have achieved the voluntary efficiency standards, but light-duty vehicle (LDV) efficiency improvements have slowed in recent years because of the increase in light trucks (including vans and sport utility vehicles) in the personal motor vehicle population [***9***]. Efficiency improvements have also slowed because turnover in the total vehicle stock has narrowed the gap between the efficiencies of the total stock and new vehicles. Future gains in efficiencies will be difficult because of the popularity of sport utility vehicles and vans. As in the United States, high per capita economic growth in Canada is expected to lead to higher consumer demand for larger, more powerful vehicles, which may offset the effects of technological advances that might improve efficiency.

The air infrastructure is well established in Canada with 26 airports that each handle more than 200,000 passengers annually. More than 26.7 million passengers passed through the country's largest airport, Lester B. Pearson International Airport in Toronto, in 1998 [***10***]. High economic growth is expected to increase the number of people traveling by air as higher personal wealth allows people to use air travel for vacations as well as business travel. The Greater Toronto Airports Authority expects the number of passengers passing through Lester B. Pearson to escalate in the next two decades and has begun work on a 10-year $2.9 billion renovation and expansion project for the airport that will include two new runways and the replacement of the two existing terminals with a single terminal capable of handling 50 million passengers. The airport expansion should be completed by the end of 2005.

### Mexico

Per capita vehicle ownership is lower in Mexico than in the other countries of North America, estimated at 158 cars per thousand persons in 1999. Despite a lower motorization level, however, motor vehicle transportation has contributed to making Mexico City one of the most polluted cities in the world. When the city's smog reaches dangerous proportions, the center of the city is closed to traffic and production is shut down in several of the city's factories.

In an attempt to reduce air pollution caused by Mexico City's 2.5 million vehicles, the government has instituted a policy to restrict car use, the Un Día Sin Auto (One Day Without a Car) law. Cars with license plate numbers ending in 0 or 1 cannot be driven on Mondays, those ending in 2 or 3 cannot be driven on Tuesdays, and so forth, with no restrictions on weekends [***11***]. The success of the policy is questionable, however. While it appears to offer some measure of pollution relief by removing a certain percentage of cars from Mexico City's streets each day, some argue that people have simply found ways to get around the restrictions by either purchasing additional cars or adjusting their scheduled driving to meet the requirements, without actually reducing total driving time.

Mexico has invested at least $5 billion over the past decade in an effort to clean the air in Mexico City [***12***]. Outdated diesel buses have been replaced, a city oil

[25]Credits for 15 ppm diesel fuel can be accrued prior to this date if the refiner can certify that the fuel is to be used in vehicles certified to meet the heavy-duty engine standards for model year 2007.

[26]Small refiners are defined as those with fewer than 1,500 employees and corporate capacity of less then 155,000 barrels per day.

[27]Including, Colorado, Idaho, Montana, New Mexico, North Dakota, Utah, Wyoming, and parts of Alaska

refinery has been closed, and some of the hills near the city have been reforested, but ozone levels remain high. In September 1999, two transportation agencies in Mexico, Coordinacion De Transporte De Mexico, A.C., and "Ruta 89" Union De Taxistas Camesinos Libres Independientes, A.C., contracted with IMPCO Technologies to convert 4,100 public transportation vehicles in Mexico City to liquid propane gas systems from gasoline systems [***13***]. There are plans to convert 70,000 commercial vehicles in the city to liquid propane.

Mexico began producing cars with emissions controls in 1991 to mitigate growing concerns about air pollution [***14***]. The government has also established strict legislation on emission controls in taxis, trucks, minibuses, and private cars, and the state-owned oil company, Pemex, has been reducing production of leaded gasoline. In 1997, Pemex increased sales of unleaded gasoline; replaced Nova gas—which was a poor quality and highly polluting gasoline—with a higher octane gasoline; and replaced the high-sulfur diesel that was produced at the refineries with the new Pemex Diesel, which contains about 0.05 percent sulfur. These measures are expected to help limit growth in air pollution somewhat, but increasing levels of car ownership and rising highway use for trading purposes with Central America and the United States will mean that pollution will remain a problem for the country's urban areas.

### Western Europe

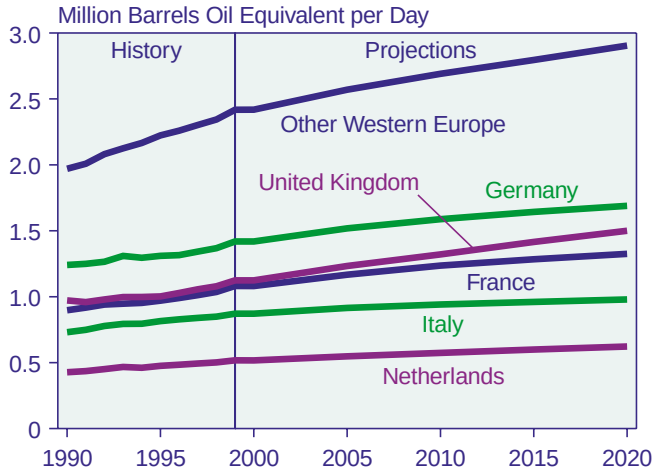
Western Europe's transportation sector was the subject of much discord at the end of 2000. High world oil prices had a profound effect in the region, where high motor fuel costs were previously thought to be impervious to the volatility of world oil markets. In the third quarter of 2000, world oil prices edged passed $37 per gallon to the 10-year high level hit during the 1990-1991 Persian Gulf War, and European consumers (primarily truck drivers, taxi drivers, farmers, and fishermen) staged widespread strikes protesting the high fuel costs and demanding that governments lower federal gasoline taxes. The protests have ceased as oil prices have moderated.

Few European governments are expected to reduce motor fuel taxation levels. Taxes have been put in place to increase national revenues and to help keep consumer demand lower, and when oil prices begin to moderate gasoline and diesel prices are expected once again to fall into ranges that consumers can tolerate. Many European countries have urban mass transit systems that allow consumers to reduce driving commutes, unlike much of the United States. In the *IEO2001* reference case, demand for transportation fuels is expected to grow slowly in most Western European nations, averaging between 0.6 percent (Italy) and 1.5 percent (United Kingdom) annual growth from 1999 to 2020 (Figure 89).

One short-term effect of high gasoline prices in the United Kingdom has been a move toward smaller, more efficient motor vehicles. The United Kingdom has the heaviest federal tax burden on motor gasoline among Western European countries, at about 75 percent of the total cost of the fuel, including value-added tax and duties. The Royal Commission on Environmental Pollution has released a study showing that carbon dioxide emissions from new cars fell for the third year in a row in 1999, by 2.2 percent [***15***]. Further, compact car sales in the United Kingdom increased by 20 percent in the first half of 2000 alone, and mid-size and luxury car sales declined by 23 percent. This is in contrast to the United States where there has been little change in the relatively strong demand for sport utility vehicles. Instead, U.S. consumers have switched from premium to regular gasoline in the high oil price environment. As prices in the United States rose in 2000, the combined sales of mid-grade and premium gas fell by 21 percent in the first 9 months of the year, whereas sales of regular gasoline—typically about 10 percent cheaper—grew by 5 percent, accounting for more than 3 of every 4 gallons sold by the end of 2000 [***16***].

The strikes in Great Britain were especially dramatic, with freight trucks and taxi cabs blockading oil refineries throughout the country. More than 90 percent of the country's 13,000 filling stations were reporting shortages or ran out of fuel altogether as panic buying spread and refinery tanker drivers were unable or unwilling to risk attempts to deliver new supply in the atmosphere of the week-long strike. Although officials in the Blair administration refused to reduce petrol taxes, they did concede at the end of the first week that they were

**Figure 89. Transportation Energy Consumption in Western Europe, 1990-2020**




Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

willing to look at reducing (or at least not raising) motor fuel taxes in the next budget talks.

There are other indications that European consumers are becoming dissatisfied with the costs of owning and maintaining motor vehicles in today's high oil price environment. London's *Electronic Telegraph* reported that the costs of running a car in the United Kingdom increased by 60 percent over the past 10 years—strongly outpacing inflation [***17***]. The cost of unleaded gasoline increased from 42.8 pence per liter (about $2.38 per gallon) to 84.9 pence per liter ($4.73 per gallon) between 1990 and 2000, and the cost of diesel fuel similarly rose from 37.8 to 83.2 pence per liter ($2.11 to $4.61 per gallon). In 2000, the Royal Automobile Club (RAC) called on the British government to cut the costs of gasoline, and several freight and motorist associations, such as the Association of British Drivers and the Road Haulage Association, supported a "Boycott the Pumps" day to protest the high prices of transportation fuels [***18***] before the trucker strikes began in mid-September. The protest began on August 1 and was slated to continue on every Monday thereafter in an attempt to force the government to either lower the fuel tax burden on consumers or to at least guarantee that the taxes would be used to improve the overburdened and aging transportation network.

Despite the new-found consumer dissatisfaction with high gasoline prices, oil demand in Western Europe has not been markedly affected. Demand did not slow in 2000 until the third quarter, mostly because of the buffer that high transportation fuel taxes provide consumers [***19***]. In addition, strong economic growth and rising employment levels in the late 1990s and into 2000 resulted in strong growth in new car registrations. In the first five months of 2000, new car registrations increased by 2.7 percent over the same period in 1999, and the level for May alone was 10.4 higher than in May 1999. Although higher employment levels in Western Europe may lead to more commuter vehicle travel, the effects should be less dramatic than in the United States, because of the mass transit infrastructure that has been established in many European cities.

In terms of fuel mix, European consumption of diesel fuel is projected to grow faster than motor gasoline use (unlike the mix in Canada and the United States). Diesel fuel is currently taxed less than motor gasoline, although the disparities between the two sources are lessening in most countries. Also, diesel fuel has more energy content than gasoline, which means that drivers may buy fuel for their diesel vehicles less often than drivers of gasoline-fueled cars. The *IEO2001* reference case projects that diesel consumption will overtake motor gasoline consumption in Western Europe by 2020.

### Industrialized Asia

The transportation sector of industrialized Asia (Japan, Australia, and New Zealand) is well established, and motorization levels are similar to those in other industrialized countries. The characteristics of the transportation infrastructure vary among the three countries, reflecting differences in population density and geography. Japan, which is more densely populated than Australia or New Zealand, has established extensive mass transit systems to accommodate commuters. Japan, roughly the size of California, has about 14,676 miles of railways, whereas Australia, only slightly smaller than the United States, has only about 24,840 miles of railways.

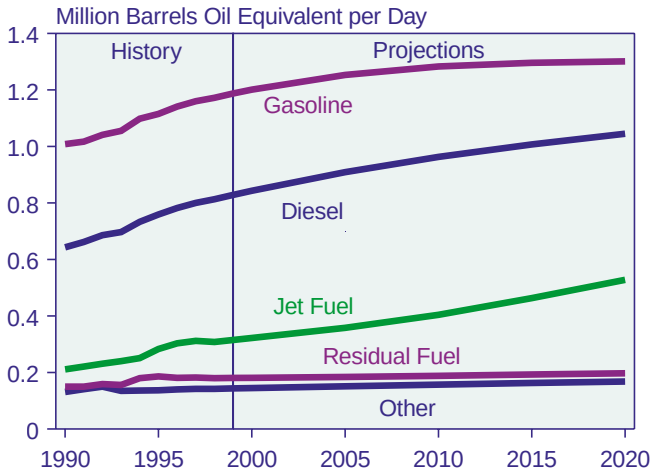
In Australia, the highest energy-consuming sector in the country is transportation, which currently accounts for 42 percent of total final energy consumption, compared with 35 percent for the industrial sector and 23 percent for the buildings sector [***20***]. Along with the nearly 25,000 miles of railways, Australia boasts some 503,010 miles of roads [***21***]. The country's current vehicle stock is estimated at 9 million, or about 637 vehicles per thousand persons.

Japan has a somewhat lower motorization level than does Australia, mainly because Japan relies more heavily on mass transit systems. Nevertheless, the share of energy consumption for transportation has been increasing in Japan, mainly due to rising demand for personal motor vehicles. Motor vehicle ownership rates in Japan grew by more than 50 percent between 1984 and 1998, and by 2020 they are expected to increase by another 13 percent as motorization reaches saturation levels. Most vehicles added at the end of the forecast are expected to be second or third family cars.

Japan's gasoline consumption currently represents 30 percent of the total Asian market (both developing and industrial Asia combined). Cambridge Energy Research Associates estimates that motor gasoline consumption in Japan grew by 2.0 percent in 2000, with very little impact from the increase in crude oil prices [***22***]. The average price for gasoline in Japan in the first half of 2000 was only 9 percent higher than in the first half of 1999, due to a combination of high gasoline taxes and vigorous competition among the liberalized Japanese retailers.

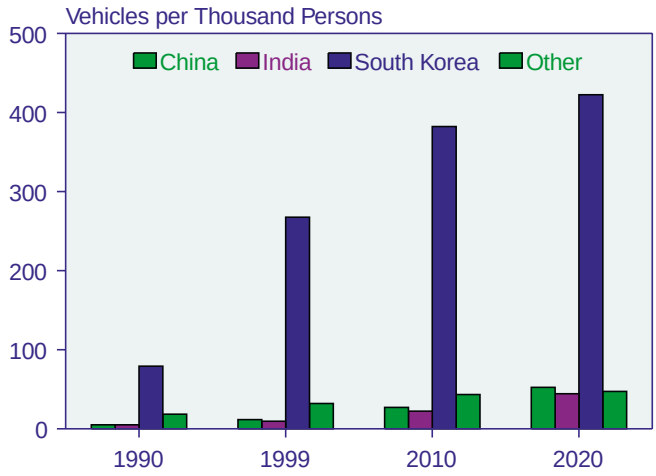
In all three countries of industrialized Asia, jet fuel consumption is expected to grow more rapidly than other transportation fuel use over the 21-year forecast period, by 2.5 percent per year, as compared with 0.4-percent annual growth projected for motor gasoline consumption and 1.1-percent growth for diesel consumption year (Figure 90). The importance of tourism to the economies

**Figure 90. Transportation Energy Consumption in Industrialized Asia by Fuel, 1990-2020**




Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

**Figure 91. Motorization Levels in Developing Asia, 1990, 1999, 2010, and 2020**




Sources: **1990:** American Automobile Manufacturers Association, *World Motor Vehicle Data* (Detroit, MI, 1997). **1999, 2010, and 2020:** EIA, World Energy Projection System (2001).

of both Australia and New Zealand is reflected in the expectations for growth in jet fuel use. Of the 44 airports operating in New Zealand today, 8 are international airports (Auckland, Wellington, Hamilton, Palmerston North, Christchurch, Dunedin, and Queenstown) [***23***]. Australia currently has 8 international airports as well, and the largest, in Sydney, handles almost 21 million passengers each year. The total for domestic air services at all of Australia's airports is only about 18 million passengers each year [***24***].

## Developing Asia

The transportation sector in developing Asia is a key indicator for the status of the region's economies. Motorization grew by double-digit percentages in the early and mid-1990s in many countries of developing Asia, as increasing prosperity resulted in more personal transport. The 1997-1999 economic recession in southeast Asia damped the trend, but in 2000 Malaysia posted a 22-percent increase in car sales and almost a 78-percent increase in car sales in Singapore [***25***]. In Thailand, sales of new cars jumped by 55 percent in 2000, as low interest rates sparked increased domestic demand [***26***].

### *China*

In China, per capita motor vehicle ownership remains low and, despite the robust average annual growth projected for automobile sales, motorization levels are projected to remain low relative to the industrialized world throughout the forecast. At present, most of the motor vehicles in China are owned by government or corporations, not by individuals. While personal motor vehicle ownership is projected to increase in the coming decades and per capita motorization to grow to more than four times the 1999 level, the projection for 2020 is only 52 vehicles per thousand persons by 2020—about one-fifteenth the 1999 U.S. level and only one-fifth the 1999 level in neighboring South Korea (Figure 91). Passenger cars are expected to be the fastest-growing mode of transportation in China, but mass transportation systems are expected to remain the most widely used form of motorized transport in the country throughout the projection period.

High world oil prices have also affected China's gasoline prices. Between May and June 2000 retail gasoline prices in Beijing rose by 9 percent [***27***]. The government is trying to bring gasoline prices more in line with the world crude oil market by allowing domestic gasoline prices to change on a monthly basis, and the result has been a fast-paced increase in gasoline prices. Angry taxi drivers in Beijing staged a one-day strike in early July 2000 to protest rising gasoline prices.

### *India*

Like China, India has not invested extensively in its transportation infrastructure, and its future economic expansion may be slowed as a result. India does not have a well-established interconnected transportation network. Rail accounts for the greatest share of interstate transportation. Although the country has an estimated 500,000 miles of paved roads, 38,000 miles of railways, and 11,000 miles of navigable channels, the roads and rail lines have not been maintained [***28***]. The railroad equipment is often outdated, and the poor condition of the roadways makes interstate motor travel difficult. Further, urban congestion is growing worse, causing air pollution problems in the major cities of India, along with a general difficulty in moving through the areas. India's airline infrastructure is similarly challenged

because there has been little investment to improve airports or runways over the past several years.

### *Other Developing Asia*

The main fear for the economies in other developing Asia is the potential impact of sustained high world oil prices on economies that have been in recovery since the southeast Asian recession. Malaysia and Indonesia have benefited from the high price environment because both are oil exporters, but both have also found it necessary to increase gasoline prices. In Indonesia—the last southeast Asian economy to show some recovery from the 1997-1999 recession—efforts to raise gasoline prices to reflect higher world oil prices were met by demonstrations from consumers after the first day of the rate increases.

The fast-paced growth in Malaysian car sales reflects a corresponding aggressive move by the government to enhance the transportation infrastructure of the country. The country's Seventh Malaysia Plan (1996-2000) made a priority of the development of roads, railways, ports, and airports [***29***]. Between 1995 and 1998, Malaysia's national road network grew by 6.1 percent, and privatized highways grew by 30 percent. Road construction has been particularly important to the Malaysian government in an effort to establish a link between the northern and southern parts of the country.

Malaysia has also established a major light rail transit (LRT) system and converted peninsular Malaysia's existing rail network from single to double tracks. LRT System I in Kuala Lumpur began operating in December 1996, and by the end of 1998 it was reportedly seeing 49,000 passengers each day [***30***]. A second LRT system came into operation in September 1998. Airports and ports have also been expanding because of a large influx of tourists and rising exports. In 1997, Malaysia reported that it had handled 30 million air passengers for the first time. In 1991, citing increased demand for air facilities to accommodate increasing tourism and commerce, the government decided to construct a new international airport facility. In September 1998, the Kuala Lumpur International Airport at Sepang was completed, with the ability to handle 65 to 67 planes per hour [***31***]. At present the airport is able to manage 25 million passengers each year.

Pakistan is working toward expanding its transportation infrastructure. The country has focused most of its effort on developing highways, which have doubled since 1980. Currently Pakistan has over 50,000 miles of paved roads and 8,000 miles of railways. Freight and passenger transport has been trending away from rail and toward road travel, and the result is that very little effort has been made to upgrade or expand the country's rail system. The country's main international airport, Karachi International, handles around 5 million passengers each year. Construction is underway on the expansion of Pakistan's Lahore International Airport. Lahore currently serves more than 2.5 million passengers each year, but the government expects the number to grow to 6.5 million by 2015 [***32***].

Many countries of developing Asia are experiencing growing pains. Strong economic growth has increased the demand for personal motor vehicles, and transportation infrastructure has not always been able to keep pace with the growing demand. In the Philippines, for example, road transport accounts for nearly 80 percent of total transportation energy consumption, and new automobile sales—notwithstanding the sharp decline during the height of the Asian economic crisis—have increased at a steady rate [***33***]. Standard & Poor's estimates that current motorization in the Philippines is about 30 vehicles per thousand persons and expects that level to triple over the next two decades. The transportation sector currently accounts for only 20 percent of total energy consumption in the Philippines, and poor road upkeep and lack of expansion have kept the sector from growing more rapidly.

South Korea enjoyed exceptional growth in the number of passenger cars per person during the 1980s and through the 1990s, and the country is expected to continue the expansion of motorization, reaching saturation before the end of the forecast period. Motorization grew by 16.9 percent per year in South Korea between 1980 and 1999; but the growth rate is expected to slow considerably over the projection horizon to 2.2 percent per year between 1999 and 2020.

With the major increase in the number of motor vehicles on the roadway (the automobile fleet increased from 5.2 million vehicles in 1992 to an estimated 10.5 million in 1998 [***34***]), congestion and urban air pollution have become a major focus for the South Korean government. The Korean Ministry of Construction and Transportation Plans to introduce electric railways in major urban areas to alleviate the problem. There are additional, long-term plans to connect major cities with an electricity-fueled network of railways [***35***].

Another Asian country that is projected to reach motorization saturation levels over the forecast horizon is Taiwan. The country has already achieved car ownership levels estimated at 245 per thousand persons, similar to the levels of South Korea [***36***]. The Taiwanese government is concerned about the need to enhance the country's transportation infrastructure and, particularly, the need for mass transit options to counteract the potential for traffic congestion that will undoubtably occur over the forecast period. In Taipei, a rapid transit line was first opened in 1996, the so-called "Mucha Line" with 12 stations and 6.5 miles of elevated track [***37***]. Since then

the line has expanded by more than 20 miles and there are plans to add another 23 miles by 2005. The government has also been improving the road connections between islands and improving roads to major production centers [***38***].

After contracting by 10.2 percent in 1998, Thailand's economy substantially recovered with 4.2-percent economic growth in 1999 and an estimated 4.2 percent in 2000 [***39***]. Sales of motor vehicles in Thailand plummeted by nearly 60 percent in 1998, after a 38-percent drop in 1997 [***40***], but in 2000 the motor vehicle markets appeared to have regained the momentum lost during the southeast Asian recession. By the second quarter of the year, car sales were up by more than 50 percent and motorcycles more than 67 percent over 1999. Some analysts have noted, however, that consumer worries about persistent high oil prices might jeopardize the recovery of the Thai automotive industry [***41***].

The boom in personal motor vehicle ownership in Thailand began in the early 1980s when the government lowered import duties on automobiles. Unfortunately, efforts to improve and expand the transportation infrastructure have not, by and large, kept up with the fast-paced growth in motorization. Bangkok, the country's largest city, is notorious for its traffic jams and air pollution. To address the issue of commuter congestion, Thailand constructed an elevated electric rail system, called Skytrain, which went into operation at the end of 1999. The 14.6-mile rail consists of two routes: the Sukhumvit Route (from On Nut Intersection to Banthad Thong Road) and the Silom Route (from Mor Chit to Silom and Taksin Bridge). The country has plans for construction of another 160 miles of mass transit systems (trains and subways) over the next 5 to 6 years [***42***].

### Middle East

In the Middle East, transportation infrastructure has not been extensively developed. Motorization levels are relatively low and are expected to grow slowly, in part because many Middle Eastern countries actively discourage women from driving, ultimately limiting the population able to own automobiles [***43***]. Nevertheless, in the *IEO2001* reference case motorization rates are projected to increase by 3.8 percent per year, to 124 vehicles per thousand persons by 2020—still substantially lower than today's motorization rates in the industrialized world.

Since the end of the Iran-Iraq War in 1988, Iran has experienced substantial growth in its transportation sector energy use. Transport energy consumption has increased by about 6 percent per year as reconstruction of the oil refinery network has allowed the easing and eventually the removal of fuel rationing [***44***]. To accommodate growing demand in the transportation sector, the government is making the improvement of the transportation network one of the priorities of Iran's Third Five-Year Plan, which runs from March 2000 to March 2005 [***45***]. Between 1999 and 2000, the government spent more than 60 billion rial (about $34 million) to construct roads in Zahedar province alone.

There are also several highway construction projects underway within Iran. The government is attempting to improve the interconnections between cities. In 1999, the 62-mile Amir Kabir freeway was completed, connecting Qom Province to the city of Kashan in Isfahan Province. Amir Kabir was constructed to improve the connection between cities and ports in the southern and central parts of the country, allowing freight traffic to move more easily [***46***]. In August 2000, the Irani government announced plans to construct the 76-mile Tehran-Shomal highway in northern Iran to connect Tehran with northern Iranian cities Chaloos, Noshahr, and Clardasht [***47***]. The project, which is to be constructed through dense forest land, may take as long as seven years to complete and would require the excavation of an estimated 1.8 billion cubic feet of soil.

As in many other urban areas of the developing world, the expansion of the transportation sector has brought increasing concerns over air pollution in Iran. In June 2000, the country's Department of Environment recommended that Tehran Mehrabad International Airport be relocated from its present site because it is aggravating the air pollution problem in Tehran [***48***]. The Department of Environment estimates that the airport is responsible for 15 percent of the total air pollution in Tehran. Several mass transit rail projects have also been considered, in part, to address environmental concerns. In early 1999, the Tehran-Qom express railway became operational. The 85-mile railway is expected to transport 5.5 million passengers and 8 million tons of cargo each year [***49***].

Another Middle Eastern country that has seen fast-paced growth in its transportation sector is Israel. The number of cars in Israel has increased rapidly since 1985, a result of increasing economic prosperity, and motor gasoline use has grown by an estimated 5 percent per year during the period [***50***]. The Israeli government estimates that over the next decade motorization levels will grow by 6 to 7 percent per year, and that the country's automobile fleet will grow from present levels of 1.4 million vehicles to 2.0 million [***51***]. One way in which the government plans to prepare for the growing traffic involves the construction of the 186-mile Cross Israeli Highway, which will span from the Galilee region to the Beer Sheba area. The first phase of the highway is expected to run parallel to the Tel Aviv metropolitan area and will be about 60 miles long. It is scheduled for completion by 2002.

Israel's Ben Gurion International Airport serves about 7.4 million passengers each year [***52***]. Increasing tourism and business travel are expected to drive growth in air travel in Israel, and the government has estimated that the airport will have to be able to handle as many as 16 million international travelers a year by 2010 [***53***]. With that in mind, the Israeli Transport Ministry has invested some $500 million in improving the infrastructure of the Ben Gurion Airport and expects to invest an additional $330 million in improvements before 2010.

Several road and airport projects are planned for the transportation sector development in the United Arab Emirates (UAE) [***54***]. The Ministry of Public Works and Housing started construction on 15 highway projects in 1997, as well as several maintenance projects. The country also has plans to construct a major inter-Emirate highway that would, at completion in 2005, link all seven emirates, from Abu Dhabi to Ras al-Khaimah and across to Fujairah. There are government plans to upgrade and expand the UAE's six international airports. By 2002, Abu Dhabi International Airport plans an additional runway and satellite terminal, and Dubai International Airport is also currently being expanded.

There are several plans for improving international road construction in the Middle East, including roads connecting Egypt, Israel, Jordan, and the Palestinian Authority; Haifa-Jordan highway; Amman-Jerusalem-Ashdod highway; and a future central corridor network that would link Syria, Lebanon, Jordan, Israel, Egypt, and the Palestinian Authority. No plans have been solidified yet, however, and in the current political atmosphere it is unlikely that anything will go beyond the planning stages for the time being.

## Africa

Africa's transportation sector has not expanded to the extent that it has in other developing regions, and the limited number of existing roadways have not generally been maintained. Low per capita incomes have kept the number of vehicles per person among the lowest in the world [***55***]. For example, in Nigeria—Africa's most populous country—there are only an average 12 vehicles per thousand persons, and even in South Africa—the region's most developed economy—there are only about 139 vehicles per thousand persons [***56***]. In much of the region, railways are primarily used to transport goods to the marketplace, but locomotives are old and outdated, and railway lines are in disrepair.

Most African governments subsidize petroleum products to protect consumers from higher oil product prices. (One reason for the subsidies is to encourage the population to use oil products rather than wood fuel, in an effort to limit deforestation.) When Ghana and Nigeria attempted to raise the prices of gasoline in 2000, the local populations were quick to protest [***57***]. In the case of Nigeria, the Nigerian Labor Congress threatened a general strike that quickly resulted in the government's rescinding the price increase [***58***]. Because higher oil prices result in stronger inflation, low-income Africans cannot afford to spend more for energy and for other products. Also, higher end-use prices might further encourage illegal trade rather than fostering energy efficiency and reducing consumption.

### *Nigeria*

In the 1970s, high world oil prices enabled oil-exporting Nigeria to construct an extensive transportation infrastructure to ease the shipping of the oil it produced to its marketing centers. The country currently has more than 20,000 miles of paved roads and about 2,000 miles of railways [***59***]. Unfortunately, political instability, government corruption, and low economic growth in recent years have made it difficult for the country to invest in repairs, and roads and rail lines have deteriorated over the past two decades.

Since 1999, when President Olusegun Obasanjo assumed office, the Nigerian government has announced plans for a number of road, rail, and airline infrastructure improvements. The country's Petroleum Trust Fund has pledged to invest nearly $1 billion in road network improvement [***60***]. Nigeria has also pledged to rehabilitate some 12,000 miles of surfaced road over the next 4 years [***61***]. The country is interested in co-financing development of a trans-Saharan roadway that would link Nigeria to its neighbors Algeria, Chad, Mali, and Tunisia, improving the ability to travel between the countries, as well as improving trade opportunities.

The World Bank is supporting efforts to establish a light rail project for Lagos, and the Nigerian government announced plans for eventually constructing 3,190 miles of rail to interconnect the country and take the pressure off shipping freight via roads alone [***62***]. The Nigerian government estimates that only about 0.05 percent of the country's freight is carried by rail. The Transport Ministry has made improving rail a priority, and the Nigerian Railways Corporation is scheduled to receive 55 percent of the total capital expenditure of the ministry in 2001, some $15 million, for this purpose [***63***].

Airlines in Nigeria have also fallen into disrepair, and airline travel has declined substantially over the past several years. This may, however, change with the privatization of the state-run airline, Nigeria Airlines Limited (NAL). The Nigerian government and the World Bank signed a pact to restructure NAL in October 1999 [***64***]. Further, the U.S. Export-Import Bank recently guaranteed $200 million in loans to assist Nigerian private airlines in upgrading their aviation equipment and aircraft [***65***].

### South Africa

Another African country with a fairly extensive transportation network is South Africa, where there are good interconnections among the country's industrial production centers. However, the transportation infrastructure has not kept pace with its needs. South Africa has more than 35,000 miles of paved roads, including highways, and more than 13,000 miles of railways [***66***]. The government allocated about $472 million in fiscal year 1993 and $489 million in fiscal year 1994 for road maintenance and repair, with another $500 million in 1995. In 1999, South Africa's Department of Transport began a 2-year, 20-road project (including toll roads) at a cost of more than 5 billion rand (about $635 million). The Department of Transportation estimated in 1995 that 170 billion rand ($22 billion) will be needed for road infrastructure expansion and maintenance over the next several years [***67***].

There is a substantial railway network in South Africa, serving the mining and heavy industries of the country along with those of neighboring countries. Spoornet is the largest heavy hauler and transporter of general freight in South Africa [***68***]. It was created in 1990 when the South African government decided to commercialize its transportation sector business interests and deregulate the transportation industry in the country. The railway system seems to be suffering from the poor economic conditions of the past 2 years, however. Spoornet went from making a profit of $76 million in 1998 to losses of $17 million in 1999 and $25 million in 2000.

The airline infrastructure of South Africa needs substantial improvement to be able to accommodate expected growth in tourism and business travel over the next decade. Already, the country's main international airport, Johannesburg International (formerly Jan Smuts International), handles around 5 million passengers each year, and the South African government estimates that the number of passengers traveling through the airport could reach 40 million by 2030 [***69***]. As a result, Airports Company South Africa (ACSA), the country's main airline services company, expects to invest some $150 million in major capital expenditures for expanding and improving the country's air infrastructure. Half the investment is designated for the Johannesburg International Airport. The ACSA operates nine of the country's major airports—Johannesburg International, Capetown International, Duban International, Kimberley Airport, Port Elizabeth Airport Bloemfontein Airport, George Airport, East London Airport, and Upington Airport—and in 1999 acquired Pilanesberg International Airport near Sun City.

### Morocco

Morocco has a more extensive road network than do most of the other African countries. Morocco is a natural transit point between Europe and Africa, and there are plans to expand the transportation infrastructure in the near future [***70***]. In terms of the road network, the north-south axis of the country is well established, with more than 36,000 miles of roads [***71***]. Highways link Casablanca to Tangier (in the north) and to Agadir (in the south). The country is currently developing its east-west axis. The Moroccan government has committed to connecting all the country's major cities with paved roads by 2002 [***72***].

Rail transportation under the control of the National Office of Railways, is also relatively well established in Morocco, with about 1,200 miles of rail lines [***73***]. A rapid commuter service is in operation linking Rabat, Casablanca, El Jadida, Marrakesh, and Agadir. Tourism is a growing part of the Moroccan economy, and air travel is of growing importance. The country currently has 11 international airports operating, and European tourists are also able to travel to the country easily via ferry.

### Algeria

Algeria has more than 64,000 miles of roads and around 3,000 miles of railways [***74***]. Most goods in the country are transported by rail, and modernization of the country's railways is considered a priority. In October 1999, Algeria reached a $2 billion agreement with French companies Spie Enertrance, RailTech, and Cogifer Travaux Ferroviaires on a 10-year contract for maintenance of existing rail lines and system expansion. The state-owned Societe Nationale du Transport Ferovier owns 200 trains that were acquired by Algeria in the 1970s and should be upgraded or replaced.

The Algerian road network is fairly extensive, although much of it has been established to support the shipment of oil, which is a major export of the country. The first phase of the trans-Saharan highway, linking Algiers to Lagos, was completed in 1985, and the project has now been extended. It will connect Algeria to Chad, Mali, and Tunisia when completed [***75***]. The European Investment Bank has approved a 45 million euro loan (about $48 million) to Algeria to finance the construction of a 50-mile section of highway to help integrate the road network of Algeria with Morocco and Tunisia [***76***].

## Central and South America

The transportation sector in Central and South America is projected to be one of the fastest-growing worldwide. While car sales fell during the recession that hit the region after the 1999 devaluation of the Brazilian real and the spillover impact from the Asian economic crisis, in 2000 new car sales began to recover. The *IEO2001* reference case expects transportation energy use to increase at an average annual rate of 4.6 percent between 1999 and 2020. Motorization rates are projected to

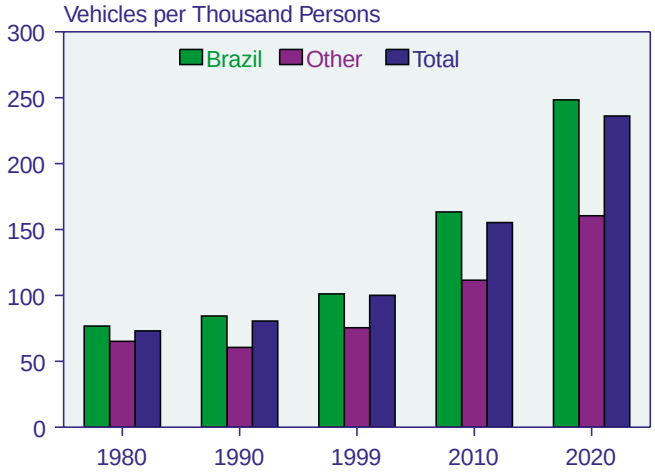
expand by 4.2 percent per year, from 100 vehicles per thousand persons in 1999 to 236 in 2020 (Figure 92).

### Brazil

Brazil, the region's largest economy, in 2000 showed clear signs of full economic recovery from the 1999 devaluation of the real and subsequent recession. The Brazilian economy grew by 0.8 percent in 1999 and by an estimated 4.2 percent in 2000 [***77***]. Automobile production, in particular, has made a strong recovery since 1999, increasing in August 2000 by nearly 27 percent compared to August 1999, and in July 2000 by nearly 23 percent compared to July 1999. Automobile exports and domestic sales have both been strong throughout the past year. High world oil prices have not yet had an impact on consumers in Brazil. The government sets fuel prices, and in September it announced that there would be no increases in prices for the rest of 2000.

Brazil has approximately 115,000 miles of paved roads, including 3,109 miles of the Trans-Amazonian Highway, which runs from northeastern Brazil to the Peruvian border and connects with the road networks of Colombia and Peru [***78***,***79***]. Expansion of the road infrastructure remained a priority in Brazil even during a slowdown in construction due to the brief 1999 recession [***80***]. The improvements to the country's road network have accompanied rapid expansion of personal motor vehicle ownership. Between 1994 and 1998, automobile sales in Brazil averaged 12.5 percent per year and, although they dropped in 1999, by mid-2000 they were averaging about 20 percent higher than in 1999 [***81***].

**Figure 92. Motorization Levels in Central and South America, 1980-2020**




Sources: **1980 and 1990:** American Automobile Manufacturers Association, *World Motor Vehicle Data* (Detroit, MI, 1997). **1999, 2010, and 2020:** EIA, World Energy Projection System (2001).

Brazil has a unique fuel mix in its automotive sector in that the country's vehicle fleet uses not only gasoline and diesel but also smaller amounts of alcohol and natural gas. Alcohol fuel use is a legacy from the 1979 Proácool program, in which the government encouraged the consumption of ethanol to ease Brazil's dependence on foreign oil, allowing the country to expand its oil production and reserves. The government is currently considering a proposal to reduce the amount of anhydrous alcohol to be mixed with gasoline to 22 percent from 24 percent, mostly because sugar cane productions has been reduced by a drought and there is concern that there may not be enough sugar cane to meet the internal demand for alcohol fuel [***82***].

There are about 17,000 miles of railways in Brazil, however, the trend for moving freight and passengers has been shifting toward road transport and away from rail, and the rail system is not receiving the same fiscal emphasis as the road infrastructure. The rail network has suffered from lack of investment and maintenance over the past several years [***83***].

### Argentina

Most of the countries of Central and South America showed economic improvement during 2000, after the 1999 recession. Argentina, however, is among the few countries in the region where the recession lingered through 2000. After Argentina's economy shrank by 3.2 percent in 1999, it grew only by an estimated 1.5 percent in 2000 [***84***]. Political and social problems continued in Argentina, and the De La Rua administration has been unable to enact policies that would help to spur economic growth. Further, several political scandals (including a Senate bribery scandal that was followed by several high-profile suicides) and corruption charges have made the country unattractive to foreign investors.

Argentina has around 40,000 miles of paved roadways and 24,000 miles of railways. Motorization levels in the country are fairly high relative to much of the rest of the region, currently estimated at 179 vehicles per thousand people. The high economic growth enjoyed by Argentina for much of the 1990s resulted in increasing per capita incomes that have, in turn, resulted in strong growth in demand for personal motor vehicles. As a result, new automotive plants have been built in Argentina by the world's major car and truck manufacturers. In 1998, however, total car and truck production began to decrease and sales fell as the government and international creditors restricted access to credit, and demand from the rest of the Mercosur trading block[28] members slowed.

[28]The Mercosur trading block is made up of Argentina, Brazil, Paraguay, and Uruguay. Chile and Bolivia are Associate Members.

Argentina was particularly hard hit by the economic turndown in Brazil. Automobile exports to Brazil plummeted in 1999, and the domestic automotive market was severely weakened in 2000 when the government ended its "Plan Canje Plus," which subsidized consumer automobile purchases [***85***]. The economic troubles that began in 1999 caused a delay in finalizing the Mercosur automotive agreement on joint automobile regulations among Mercosur member countries (the "Politica Automotriz Mercosur"), but talks resumed in 2000 and the agreement was signed in Buenos Aires on March 23, 2000 [***86***]. The agreement includes a common external tariff of 35 percent on all vehicle imports into Mercosur nations [***87***]. Uruguay and Paraguay—which argued that the 35-percent tariff was unfair to them because neither country has a domestic automotive industry—agreed to a lower tariff of 23 percent, which will remain in force through 2005.

The restructuring of Argentina's air transport sector has slowed with the weak economy, political crises, and high unemployment. The De La Rua administration, which came to power in January 1999, suspended ratification of the air transport deregulation agreement that was signed by the previous administration until the problems with the country's major airline, Aerolíneas Argentinas, are resolved [***88***]. In 1990, Aerolíneas was one of the first Argentine public-sector companies to be privatized; however, its financial performance is among the worst [***89***]. The airline was sold to Iberia in 1990, clear of debt, but at the end of 1999 it was some $874 million in debt, and the Spanish holding company Sociedad Española de Participaciones Industriales (SEPI) had to come up with $208 million to keep it from declaring bankruptcy [***90***]. In October 2000, SEPI agreed to invest $650 million in Aerolíneas but stated that it plans to sell its interest in the airline once it has returned to financial health.

### *Other Central and South America*

The development of the transportation sector in other Central and South American countries varies considerably as a result of differences in political and social issues, geography, and levels of investment. Colombia's main political challenge continues to be the resolution of armed conflicts between the government and the various guerilla entities operating in the country. As long as the government is unable to establish a lasting peace, it will be difficult to attract foreign investment. The United States has granted Colombia $1.3 billion in military aid over the next 2 years for the purpose of fighting drug trafficking, but because the drug cartels operating in the country have well-known ties to the guerillas, it appears that the money will, at least indirectly, be used against the guerillas [***91***]. Colombia's oil pipelines continue to be popular targets for terrorists, and acts of violence in oil-producing parts of the country make it less attractive to oil companies than other countries in Central and South America.

Colombia's political problems compound its problems in expanding and maintaining transportation infrastructure. Mountainous terrain has always impeded the development of the transportation network, and the threat of terrorist attacks on roads and (more often) pipeline projects has made it nearly impossible to establish the transportation network required to support increasing economic growth. The country does remain an important connection for transporting goods and people through the Andean region [***92***]. A portion of the Pan-American Highway runs through the country and links to roads serving important Pacific ports [***93***]. However, only a small portion of Colombia's roads are paved—approximately 12 percent of the total of 72,000 miles of highways. There are plans to improve the road linkages with ports, and the Colombian government plans to invest $141 million in the port system's land access infrastructure.

In Chile there are around 6,800 miles of paved roads, and the country is connected to neighboring Peru by 2,200 miles of the Pan-American Highway (Figure 93) [***94***]. Road transport is the primary mode by which people and freight are moved. As a result, the government has placed an emphasis on road maintenance and development in its plans for transportation network support, awarding more than $1 billion in road concessions to allow private firms to construct and manage toll roads and to maintain the Pan-American Highway (the country's primary north-south route). Currently, private companies are constructing 16 road and tunnel projects in which the property will be owned by the public sector but road tolls and maintenance fees will be paid to the companies.

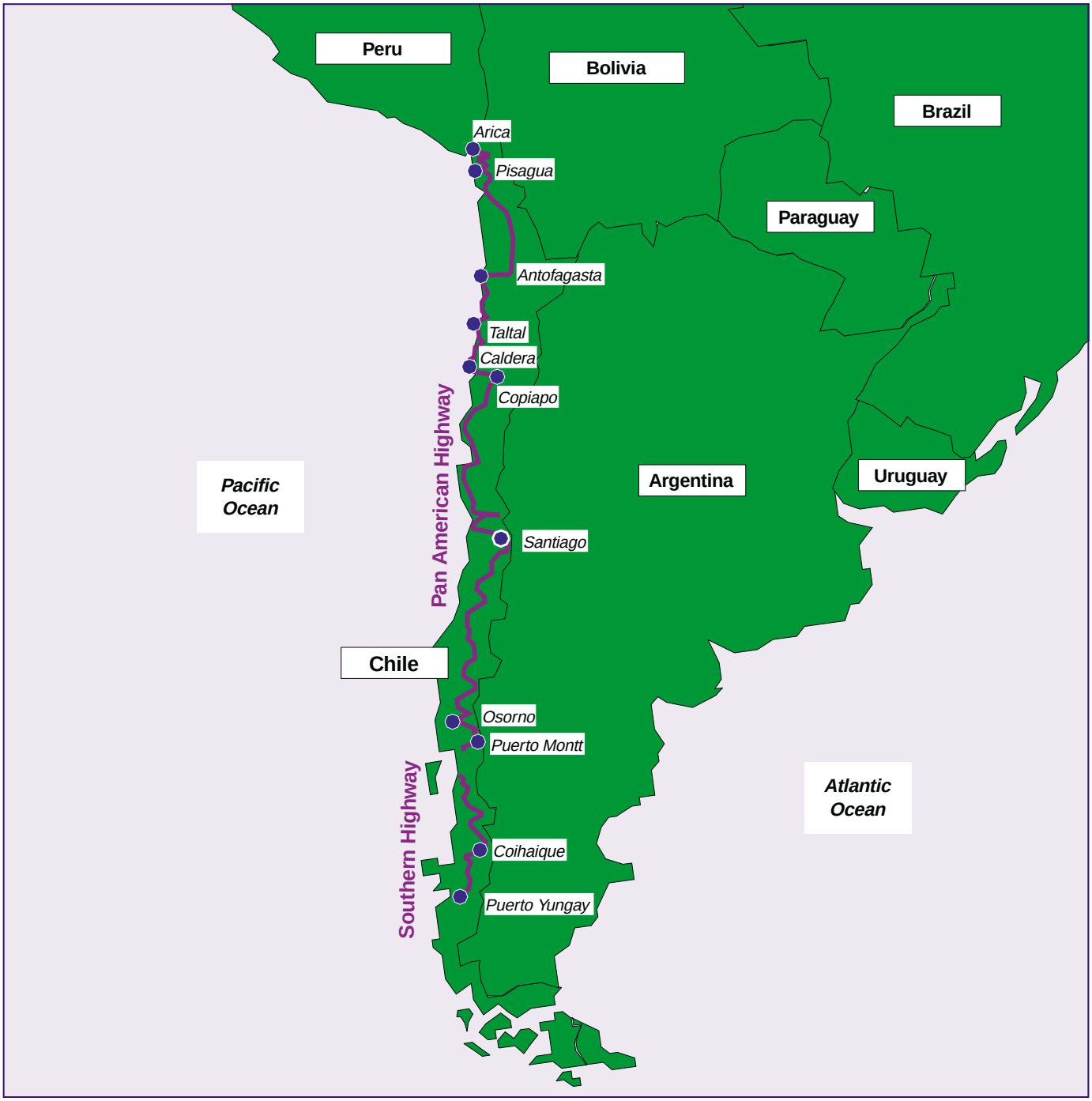
Air transportation in Chile is well established, and the country's main international airport, Comordoro Arturo Merino Benítez (in Santiago) handles an average 2 million passengers per year and is served by 18 international airlines. The country has 390 airports, but only 48 have paved runways. Air traffic increased dramatically in the early 1990s, by 56 percent between 1990 and 1993 alone. Línea Aérea Nacional de Chile (LAN-Chile), the largest domestic carrier, was privatized in 1989 and currently handles 46 percent of the country's domestic passengers and 84 percent of its international passenger movement.

Peru has been plagued by political problems over the past few years, but they do not appear to be impacting the country's economy, which grew by 3.8 percent in 1999 and an estimated 4.9 percent in 2000 [***95***]. In 2000, the Fujimori administration announced that new elections would be held in April 2001. The announcement was made after the April 2000 presidential election,

which was widely characterized by outside international observers as flawed. The move was precipitated by a video tape released to the press showing Fujimori's spy chief, Vladimio Montesinos, bribing an opposition congressman, Alberto Koury, in an effort to persuade Koury to change his party affiliation [***96***]. In July, after the Peruvian congress approved Fujimori for a third presidential term, new automobile sales fell by almost 20 percent from the previous year, and it now appears that political instability may be making consumers nervous.

Peru's transportation sector is among the smallest in South America. Mountainous regions, dense jungles, unpaved highways, and earthquakes have all worked to constrain development of the transportation sector. Although the government has eased import restrictions on both old and new cars, vehicle ownership remains low—40 vehicles per thousand persons, compared with the regional average of about 99 vehicles per thousand persons. The country is connected to Colombia and Chile by 1,550 miles of the Pan-American Highway

**Figure 93. Major North-South Highways in Chile**




Source: U.S. Department of Commerce, International Trade Administration, "Chile—Transportation Overview: Map of Chile's Transportation System," web site www.ita.doc.gov/td/transport/ci-oview.htm (not dated).

system, and it has approximately 4,740 miles of paved roads.

Venezuela has around 20,000 miles of paved highway and is interconnected to Guyana and to Colombia by 802 miles of the Pan-American Highway system [***97***]. It boasts the highest percentage of paved highways in the entire Central and South American region. As a major oil exporter, Venezuela used its profits in the 1970s to construct a relatively sophisticated transportation network. Most of the country's transport of goods and people are by roadway. Car ownership is estimated at 103 cars per thousand persons, higher than in neighboring Colombia and Guyana, and Venezuela is the third largest producer of cars in Latin America, after Brazil and Argentina. The government made road transportation its priority as early as the 1940s, when it began reducing investment in the Venezuelan railroads in favor of developing road infrastructure. There are only about 360 miles of rail operating in the country today, but in 1999 the government announced plans to upgrade and expand the rail system by increasing rail mileage to 2,500 miles by 2004, including construction of a link between Los Teques in Miranda State and Caracas.

## Eastern Europe and the Former Soviet Union

The economic and political upheaval that took place in Eastern Europe and the former Soviet Union (EE/FSU) in the early 1990s has had a negative impact on the upkeep and development of the region's transportation infrastructure, particularly in the former Soviet republics, where economic growth has largely lagged behind that in the countries of Eastern Europe. Railways and public transportation have suffered from a lack of investment for maintenance and upgrade, and roads have also fallen into disrepair in many of the FSU countries. In addition, the lack of economic growth has meant a stagnation in the demand for new automobiles.

The *IEO2001* reference case forecast expects that economies both in Eastern Europe and among the former Soviet republics will recover over the next two decades, with a corresponding recovery in demand for transportation fuels and personal motor vehicles. Motorization levels are projected to grow from 158 vehicles per thousand persons in 1999 to 218 vehicles per thousand persons in 2020 in the EE/FSU, an expansion of about 1.5 percent per year. Fuel use in the transportation sector is projected to grow by an average 2.8 percent per year.

### *Russia*

Russia, the largest economy in the EE/FSU region, relies on roads to move half its freight to market. The country has almost 590,000 miles of road, but only a little more than one-third are paved [***98***]. According to the U.S. Department of Commerce, Russia needs to add an estimated 900,000 miles of hard-surfaced roadways, and an estimated $3 billion will be needed to construct new roads and maintain the existing roadways [***99***]. The urgency of new road construction is apparent in Russia. Even in the wake of the August 1998 collapse of the ruble, road construction increased by 14 percent in 1998 and 3,300 miles of new road were built. However, the Russian Federal Road Fund, which had previously been used to pay for all road repair and development in Russia, faced major budget cuts after the 1998 monetary crisis, and as a result the government began to allow private toll roads to be constructed [***100***]. The World Bank has also begun to help the country finance road construction, allocating loans of $650 million for road construction projects between 1996 and 1998 and another $400 million at the end of 1998 for high-priority road network expansion in Siberia and Far East Russia, which should be completed by 2004 [***101***].

Russia's railroad infrastructure has also been neglected in the wake of the dissolution of the Soviet Union. In 1996, the European Bank for Reconstruction and Development (EBRD) approved a $120 million, 13-year loan to the Russian Ministry of Railways for "urgent improvements" to the country's rail network [***102***]. The funds were to be used to improve the tracks along high-density rail routes, particularly on the important routes of Moscow to St. Petersburg, Moscow to Nizhni Novgorod, and Moscow to Samara. In 2000, a second railway modernization loan was approved for $200 million to support further modernization of track and upgrades to freight and passenger cars and equipment [***103***]. Freight and passenger rail traffic have declined over the past several years as road transport has become a more important means of moving people and goods, and the Russian government hopes that the revitalization projects will strengthen the rail sector.

Although Russia has almost twice as many people as Germany, its new car sales in 1999 were only one-quarter of the number in Germany [***104***]. As the economy recovers over the projection period, personal motor vehicle demand is expected to increase, and the potential market is making Russia attractive to foreign car manufacturers. Currently Russia is the twelfth largest car producer in the world, and most of the demand for new automobiles is for domestic vehicles, such as the Lada and GAZ, which are much cheaper than western automobiles. Italy's Fiat, France's Renault, the Czech Republic's Skoda, and U.S. auto companies Ford and General Motors all have plans to invest in the automotive sector in Russia between 2001 and 2005.

### *Other Former Soviet Union Countries*

Other FSU countries are also trying to improve their transportation infrastructures in efforts to improve networks for moving freight and people. The EBRD has several loan projects slated throughout the former

Soviet republics to improve the transportation sector, including: rehabilitation of a 440-mile highway in Ukraine (100.5 million euro—currently about $94 million); multiple road maintenance and improvement projects in Azerbaijan (about $99 million); and upgrade and modernization of 75 miles of railway track in Lithuania (about $89 million) [***105***]. Similarly, the World Bank is providing $40 million in loans to Georgia for road maintenance and to improve the country's main road network, as well as $29 million to Uzbekistan to upgrade urban transportation (providing new buses and repairing existing ones) in projects that should be completed by 2004 [***106***]. In 1999, the World Bank approved a loan of $100 million to Kazakhstan to rehabilitate priority sections of national roads and to fund the construction of new road and maintenance of other key roads [***107***].

### *Eastern Europe*

With a greater pace of economic growth than in the FSU and greater proximity to Western Europe's markets, East European countries have generally fared better in terms of attracting foreign investment to build and maintain roads, as well as investment in their automotive sectors. Several car manufacturers have established automotive assembly plants, including Volkswagen, which invested in a plant at Bratislava, Slovakia, that in 2000 produced 200,000 cars for export to Western European markets [***108***]. Car exports have become a key element of the Slovakian economy, accounting for more than 20 percent of its total exports.

Other East European countries are also recognizing the importance of the transportation infrastructure in maintaining economic growth. Unless goods and people (tourism is becoming increasingly important to many East European countries) can be moved efficiently through a country and to the marketplace, economic improvement stagnates. Croatia is currently attempting to attract investment to improve its road infrastructure. The country has the potential to be a major thoroughfare linking Italy to Greece and Turkey by way of Slovenia, Croatia, Bosnia, Montenegro, and Albania [***109***], and a proposal for construction of an Adriatic-Ionian highway is currently being considered by U.S. company Bechtel. If approved, construction is slated to begin in 2003 and is estimated to cost between $5 and $12 billion.

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