Chapter 26
Transportation

Introduction

The rapid and dependable transportation of people and materials from place to place is essential to modern American society and to Texas.

Since Henry Ford perfected the assembly line process for manufacturing in 1908, making autos affordable for the average person, Americans have come to rely on personal vehicles, freight systems, and air travel to meet transportation needs. In 2005, the U.S. accounted for 21.5 percent of the cars and 42.7 percent of the trucks and buses registered worldwide.[1]

In that year, Americans owned more than 240 million cars and light trucks.[2] Texans accounted for just over 20 million of these vehicles.[3] In addition another 5.2 million commercial vehicles — those weighing more than 10,000 pounds — use American roadways to transport people and goods. And Americans rely on more than 224,000 aircraft, about 53,000 boats and ships and hundreds of thousands of locomotives and railcars to reach places not served by roadways.[4]

Nearly all of these vehicles are powered by gasoline or diesel derived from oil.

Fuel Sources and Usage

As America has become more reliant on personal vehicles for transportation, commercial air travel for personal and freight movement and trucking for freight, more and more of the nation's energy has been devoted to transportation. In 2006, the U.S. expended 28.4 quadrillion British thermal unit (Btu), or about 28.5 percent of all energy used nationwide, for transportation.

Transportation's share of the nation's total energy usage has risen steadily since 1973.[5] More than half of this increase can be attributed to a significant expansion in vehicle miles traveled (VMT). VMT per capita has risen substantially for travel other than the trip to work — increased highway travel, non-work trips and airline mileage.[6]

In 2005 (the most recent data available for both the U.S. and Texas), Americans used nearly 28.3 quadrillion Btu of fuel to transport people or goods from one place to another (**Exhibit 26-1**).[7]

Exhibit 26-1

U.S. and Texas Transportation Fuel Sources, 2005 (Trillion Btu)

Fuel Source	U.S. Amount of Fuel Used	Percent	Texas Amount of Fuel Used	Percent
Petroleum Products	27,301.6	96.5%	2,640.9	96.8%
Natural Gas*	626.3	2.2	85.4	3.1
Ethanol**	342	1.2	2.4	0.1***
Electricity	25.7	0.1	0.3	
Total	28,295.6	100.0%	2,729	100.0%

*Natural gas used in the transportation sector is consumed in the operation of pipelines, primarily in compressors and gas consumed as vehicle fuel.
**On the original EIA document, ethanol is listed twice: once as blended into motor gasoline and also separately, to display the use of renewable energy by the transportation sector.
***Ethanol and electricity used for transportation in Texas together account for 0.1 percent of all transportation fuel used in the state.
Source: U.S. Energy Information Administration.

Transportation's share of the nation's total energy usage has risen steadily since 1973.

Approximately 80.5 percent of all energy devoted to transportation in the U.S. was used on local roadways and highways; the other 19.5 percent was used for other forms of transportation, including air, water, railroads and other non-road vehicles (**Exhibit 26-2**).[8] Data on the amount of energy used on transportation modes in Texas was not available.

While motorized transportation helped build the U.S. into a global industrial power, its evolution has not been without drawbacks. The fuels used by most vehicles have an effect on human health and the environment, as discussed in previous chapters.

Oil Production and Consumption

As **Exhibit 26-1** illustrates, fossil fuels supply almost all of the energy used for transportation.

The U.S. Energy Information Administration (EIA) forecasts continued growth in U.S. demand for petroleum (**Exhibit 26-3**).

The nation's total petroleum consumption averaged 20.7 million barrels per day (bbl/d) in 2007, up 0.2 percent from 2006. For 2008 as a whole, EIA expects total U.S. oil consumption to average 20.6 million bbl/d. EIA expects gasoline consumption to increase by 0.9 percent in 2009.[9]

As consumption continues to climb, domestic production is expected to continue declining. In 2007, EIA estimates domestic crude oil production will average 5.1 million bbl/d, down from 5.14 million bbl/d in 2006 (**Exhibit 26-4**).[10]

While the early 1980s saw a brief increase in total U.S. oil production, Texas production has declined steadily since the 1970s (**Exhibit 26-5**).[11]

Declining production, along with supply disruptions due to regional conflicts around the world, weather and operating margins at U.S. refineries, all have pushed gasoline prices higher. EIA reports that regular grade gasoline prices averaged $2.81 per gallon in Texas in 2007 and they are expected to average $3.07 and $2.97 per gallon, respectively, in 2008 and 2009.

EIA projects that U.S. consumption of gasoline and diesel fuel will continue to rise, as the total miles traveled outweighs efficiency improvements and the slow change of the vehicle market to more fuel efficient vehicles. This will spur increasing

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Exhibit 26-2

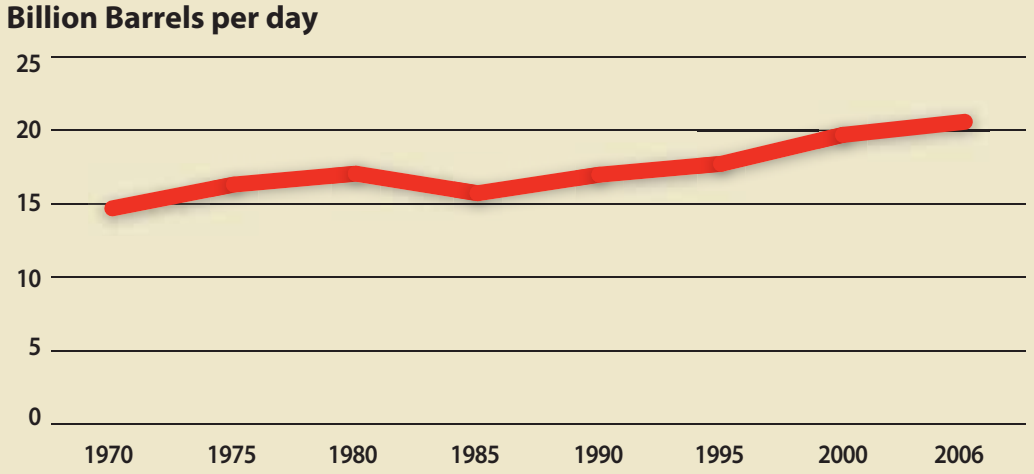
U.S. Transportation Energy Use by Mode*
In Trillions of Btu, 2005

Use by Mode	Amount of BTU Used	Percentage of Total
Highway	**22,042.7**	**80.5%**
Cars, Light Trucks & Motorcycles	17,275.1	63.1
Buses	190.7	0.7
Medium/Heavy Trucks	4,576.9	16.7
Non-Highway	**5,341.9**	**19.5%**
General, Domestic & International Aviation	2,476.6	9.0
Water	1,366.1	5.0
Pipeline	842.4	3.1
Rail	656.8	2.4
Highway & Non-Highway Total	**27,384.6**	**100.0%**

*Includes civilian consumption only.
Source: U.S. Department of Energy.

EXHIBIT 26-3

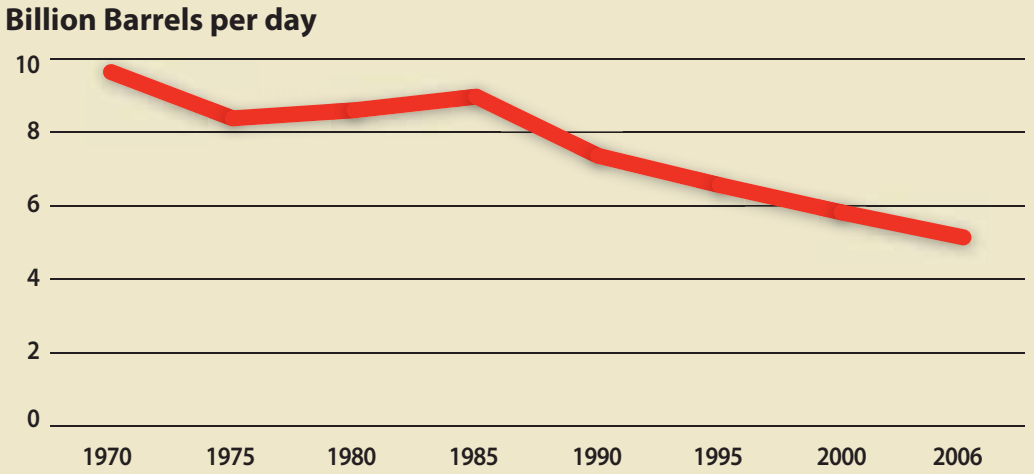
U.S. Petroleum Consumption



Source: U.S. Department of Energy, Transportation Energy Data Book.

EXHIBIT 26-4

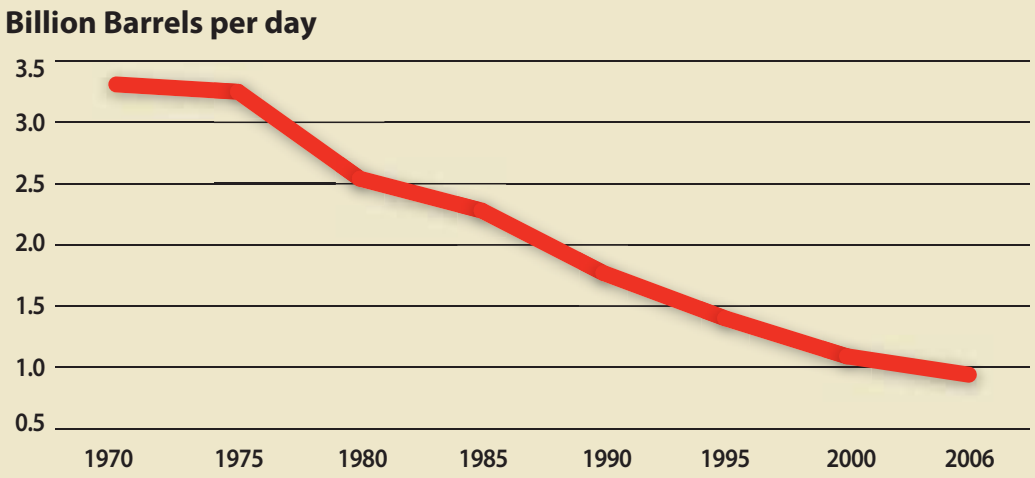
U.S. Crude Oil Production



Source: U.S. Department of Energy, Transportation Energy Data Book.

EXHIBIT 26-5

Texas Crude Oil Production



Source: Texas Railroad Commission.

The Energy Information Administration is projecting that energy use in the transportation sector will continue to grow at rates that are considerably larger than other sectors of the U.S. economy.

imports of crude oil and refined products over the next 25 years. EIA predicts that the current share of oil that is imported (60.3 percent) will rise to more than 61 percent by 2030.[12]

EIA is also projecting that energy use in the transportation sector will continue to grow at rates that are considerably larger than other sectors of the U.S. economy (**Exhibit 26-6**).

Light duty vehicle (cars and light trucks) travel is a significant contributor to this growth. EIA's 2008 projections assume that light duty vehicles' fuel economy standards will increase to only 30.0 miles/gallon, which is 4.7 miles/gallon above previous standards. Recent federal legislation, however, requires light duty vehicle standards to increase to 35 mpg by 2020, which could offset part of this growth.[13]

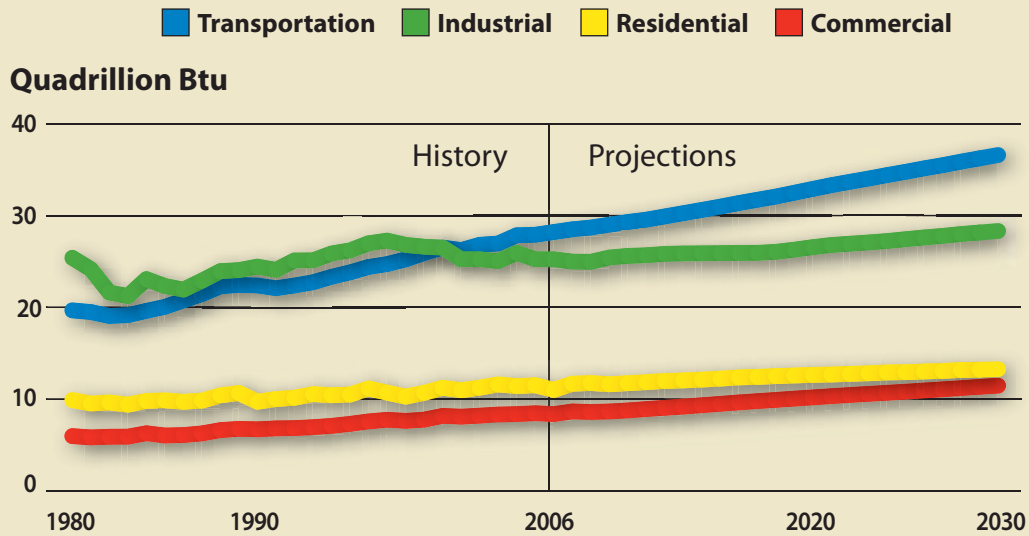
In 2004, world consumption of crude oil reached 82.6 million barrels a day. U.S. demand accounted for just over 25 percent of the total world demand. EIA estimates that total world oil consumption will rise by 1.4 million bbl/d in second-quarter 2007 (over the same quarter in the previous year). China and the U.S. remain the primary contributors to growth in world oil consumption. Preliminary data indicate that annual U.S. consumption rose by 200,000 bbl/d as of second-quarter 2007, while China's oil demand rose by an estimated 500,000 bbl/d over the same period. In all, EIA estimates that world oil consumption will rise by 1.3 million bbl/d in 2007 and 1.5 million bbl/d in 2008.[14] At present, about 68 percent of all petroleum consumed by the U.S. is used for transportation.[15]

TRENDS AND OUTLOOK

Increased demand for oil, tight oil supplies and increased oil prices have led the U.S. Government, consumers and automakers to seek alternatives to gasoline powered vehicles. Alternatives to gasoline powered vehicles are generally defined as vehicles that use non-petroleum fuels or other alternatives to conventional gasoline or diesel. Alternative fuels include natural gas, ethanol, methanol, electricity, hydrogen/fuel cells, propane, LPG, non-petroleum diesel (from vegetable and animal fats), and fuel blends such as biodiesel and gasoline/ethanol mixtures. They may also include hybrid vehicles that combine smaller gasoline or diesel engines with electric power.

EXHIBIT 26-6

Delivered Energy Consumption



Source: U.S. Energy Information Administration.

Of the 20.1 million registered vehicles in Texas, many are capable of using bio-fuels, such as ethanol/gasoline blends or biodiesel that can be made from a variety of plants or animal fats.[16] About 4.7 percent or about 966,000 of those vehicles are considered alternative fuel autos by the Auto Alliance because the vehicles run either partially or totally on a fuel other than gasoline. These vehicles include automobiles powered by hybrid technology, clean diesel, biodiesel, ethanol, hydrogen and compressed natural gas. (Hybrids supplement a conventional gasoline engine with power from electric batteries; flexible-fuel vehicles can use multiple fuels to power their engine, such as either regular gasoline or an ethanol-gasoline mix.)

A closer review of the 966,000 vehicles in Texas classified as alternative fuel autos by the Auto Alliance, shows that approximately 22,500 of the over 966,000 vehicles are hybrids and the remaining vehicles have the capability to operate on clean diesel technology, biodiesel, natural gas and flexible fuel.[17] Because clean diesel, biodiesel, natural gas and flexible fuel are not widely available in Texas most of these vehicles rely on the standard gasoline and diesel products.

According to the U.S. Department of Energy (DOE), alternative transportation fuels such as ethanol, biodiesel and natural gas currently account for the equivalent of about 1 percent of the nation's annual consumption of petroleum products. Under the most optimistic projections, DOE estimates that these technologies could displace the equivalent of 4 percent of the nation's annual U.S. oil consumption by 2015 and 34 percent by 2030, if the technological challenges facing these alternative approaches can be overcome.[18]

The Federal Energy Independence and Security Act of 2007 sets a goal of increasing the current 6.5 billion gallons of bio-fuels (primarily ethanol) produced in the U.S. annually to 15.2 billion gallons in 2012 and 36 billion gallons in 2022.[19] Increasing the use of alternative fuels will require significant improvements in the production and refinement of alternative fuels as well as the distribution network for these fuels. Ethanol production is not widely available in Texas or other areas outside the Midwest because ethanol cannot be transported by the current pipelines available to oil and gasoline. Ethanol absorbs water, which is present in all pipelines, and is corrosive to

the current type of pipelines used.[20] In effect, an entirely new distribution system of pipelines would be required to drastically increase ethanol consumption.

In addition, many alternative fuels have a lower energy content than traditional gasoline and diesel; in other words, it takes more fuel to provide the same or equivalent power. **Exhibit 26-7** shows the Btu content of different fuels and the number of units needed to equal a gallon of regular unleaded gasoline.[21]

Many alternative fuels have a lower energy content than traditional gasoline and diesel.

The goals set out in the Energy Independence and Security Act of 2007 to use alternative transportation fuels are ambitious and some observers note they have had some side effects. For example, the cost of corn has risen as demand for ethanol has increased. The rising cost of corn has, in turn, caused increases in food and feed prices.[22]

It took nearly 12 million acres to produce 6.5 billion gallons of corn based ethanol in 2007.[23] To meet the goals set out in the Act, it could require up to six times the current amount of land used or 72 million acres to produce 36 billion gallons of ethanol. In addition, corn-based ethanol production requires large amounts of water — between 2,500 gallons and 29,000 gallons per million Btu of energy produced.[24]

Before the general public can be expected to adopt alternative fuels, significant improvements in the production, refining and distribution network of these fuels must be made to make them both economically and environmentally attractive alternatives.

Government

Several U.S. governmental agencies are engaged in activities to encourage reduced oil consumption. For example, DOE funds research into alternative fuels and advanced vehicle technologies. The U.S. Department of Agriculture is collaborating with industry to identify and test the performance of potential biomass feedstocks and conducting research to evaluate the cost of producing biomass fuels.

The U.S. Department of Transportation (DOT), moreover, provides funding to encourage the development of bus fleets that run on alternative fuels; promote carpooling among consumers; and conduct outreach and education to encourage telecommuting. And DOT sets fuel economy standards for automobiles and light trucks sold in the U.S.[25]

Another significant step the U.S. government has taken in an attempt to reduce gasoline consumption is to adopt higher corporate average fuel economy (CAFE) standards. U.S. fuel efficiency

Exhibit 26-7
Fuel Equivalency Measures

Fuel Type	Btu Per Unit*	One Gallon of Gasoline is Equivalent to:	U.S. Average Price at Pump, per Gallon January 2008	U.S. Average Price of Fuel in Gallon of Gasoline Equivalents (GGE)** January 2008
Regular Unleaded Gasoline	115,400	1.00 gallons	$2.99	$2.99
Diesel	128,700	0.90 gallons	3.40	3.05
Bio-Diesel (B-20)	126,800	0.91 gallons	3.37	3.43
Compressed Natural Gas (CNG)	87,600	1.32 gallons	1.47	1.93
Liquefied Petroleum Gas (LPG)	83,500	1.38 gallons	3.12	4.31
Ethanol (E-85)	81,800	1.41 gallons	2.51	3.55
Electricity	3,400	33.53 kWh	n/a	3.47

*Btu values were rounded to nearest 100. Equivalency measures are based on current engine designs and abilities to convert fuel into energy.
**Average price equivalents for all fuels excluding electricity are based on January 2008 national average prices. Electricity numbers are based on December 2007 national average price per kWh for residential service. The Texas residential electric average per kWh for December 2007 was higher, (11.79 cents/kWh) than the national average, (10.31 cents/kWh).
Sources: U.S. Department of Energy, Clean Cities Alternative Fuel Price Report, National Association of Fleet Administrators, U.S. Energy Information Administration and Comptroller calculations.

standards for light duty vehicles, passenger cars and light trucks, are currently at 27.5 miles per gallon (MPG) but new legislation requires those standards to be increased to 35 MPG by 2020.[26] Vehicles in several other countries have higher MPG standards for new cars due in large part to the exceedingly high price of gasoline and diesel and government imposed regulations in those countries.

High gas prices and government regulations such as fuel efficiency standards in these countries have contributed to the development and introduction of many more fuel-efficient cars. For example, a recent Civil Society Institute study, *Fuel-Efficient Car Gap*, noted that in 2005 there were 86 commercially available car models that could achieve 40 MPG in Europe and that number increased to 116 car models by 2007. By contrast, in the U.S. there were five car models sold in the U.S. that achieved 40 MPG in 2005 and by 2007 there were only two car models that could achieve that standard.

Many European car models cited in the Civil Society Institute report run on diesel, however, which is difficult to sell in the U.S. due to environmental concerns. On the other hand, several car models powered by gasoline could be sold here in the U.S., but they have not been offered here due to their size and perceived U.S. consumer preference.[27]

Auto Industry

Automakers have dedicated resources and time to developing vehicles that are more efficient and operate on alternative fuels.

In the near term, auto manufacturers are focusing on improving the performance of internal combustion engines through improved variable valve timing; improvements in power trains; more sophisticated six-speed transmissions; alternative fuels, including advanced diesel technology; and more efficient management of fuel use through cylinder cutoff (which allows engines to automatically stop using some of the cylinders in an engine when they are not needed to move the vehicle).

Some U.S. automakers are promoting flexible-fuel vehicles, which use E-85 a gasoline-ethanol blend of up to 85 percent ethanol. Some countries such as Brazil and Sweden require all new vehicles to be at least E-85 flex-fuel capable, and require fueling stations to devote at least a fourth of their pumps to flex-fuels. Diesel also is growing in popularity as an alternative to gasoline. According to auto giant DaimlerChrysler, if half of the current U.S. auto fleet used diesel, the nation could save about 8.5 percent of all auto fuel consumed, or about 12 billion gallons of fossil fuels annually.

Automakers also are developing hybrid electric technologies that employ both gasoline and electric motors for propulsion, as well as electric-only vehicles. Hybrids have distinct benefits over gasoline-only vehicles, including reduced oil consumption and exhaust emissions. Batteries which store energy on the hybrids contribute to the higher cost of the vehicles, one of the big factors holding them back. But automakers are striving to reduce their cost by increasing the volume of cars produced and educating consumers on the unique attributes of hybrids.

Automakers have dedicated resources and time to developing vehicles that are more efficient and operate on alternative fuels.

Not all hybrids are the same; varying widely in fuel economy and performance depending on their design. According to the DOE, hybrid vehicle miles per gallon (MPG) efficiency for 2008 models range from a high of 48 MPG in the city/45 MPG on the highway in a Toyota Prius to a low of 20 MPG in the city/20 MPG on the highway for a GMC Yukon hybrid. In general, hybrids provide better fuel economy in city driving, but less fuel economy on the highway.[28] Automakers are attempting to improve hybrid batteries and create smarter battery management so that they can run entirely on electric power in urban settings.[29] Plug-in hybrid vehicles, for example, store sufficient energy in their batteries to make most local trips (less than 40 miles), and then rely on a small gasoline or diesel engine for longer trips. Some drivers could almost entirely rely on home recharging of the vehicle. GM's Volt is an example of a recently announced advanced plug-in hybrid electric vehicle that will use lithium-ion batteries.

While most hybrid electric vehicles use nickel metal hydride batteries (NiMH) to store energy, electric vehicle designers would prefer lithium-ion batteries, the same technology used in laptop computers and cell phones. These batteries are lighter and recharge more quickly than other batteries. At present, however, lithium-ion batteries that are

powerful enough to propel an all electric car for any reasonable length of time are cost-prohibitive for mass production by automakers.

According to a recent *Wall Street Journal* article, some carmakers including France's Renault SA and Japan's Nissan Motor Co. and Honda Motor Co. have expressed skepticism about the economic wisdom of hybrids and are instead backing all-electric cars. They argue that all-electric vehicles make more sense, environmentally, politically and economically, than do hybrids, provided there are continuing advances in lithium-ion battery technology. Renault and Nissan believe that many major urban areas in Europe, such as London and Paris, will ban cars unless they have zero emissions. To meet the transportation needs of such cities, carmakers are actively researching and testing new and improved technologies for all-electric vehicles, and expect to have a significant number of them available to the public by 2012.[30]

Historically, American drivers have preferred performance to fuel economy, but high gasoline prices can prompt shifts in consumer preference.

For the longer term, several companies including General Motors, Toyota, Honda, Kia, and Chrysler are working on various designs powered by hydrogen fuel cells, and some of which will be tested in the U.S. in 2008. While the hydrogen fuel cell is a promising innovation, it entails many technical challenges, including an appropriate storage system for hydrogen.

In addition, some automakers are researching a biofuel-boosted turbo gasoline engine. The idea is to use smaller, turbo-charged engines that employ direct fuel injection to increase horsepower while allowing engines to be made smaller and more efficient — so much so that cars with these engines could rival hybrid vehicles in fuel efficiency.[31]

Consumers

Carpooling, telecommuting and simple measures such as proper tire inflation and slower driving speeds all can help reduce overall fuel consumption. DOE estimates that drivers could improve fuel economy by 7 to 23 percent by traveling no faster than 60 miles per hour. In addition, aggressive driving (speeding, rapid acceleration and braking) can lower gas mileage by 33 percent at highway speeds and by 5 percent around town.[32] The International Energy Agency estimates that telecommuting could reduce total fuel consumption in the U.S. and Canada by 1 to 4 percent.[33]

Historically, American drivers have preferred performance to fuel economy, but high gasoline prices can prompt shifts in consumer preference. The U.S. Congressional Budget Office (CBO) recently issued a report on the effects of gas prices on consumer behavior and purchases. The CBO report found that while consumer response to high gas prices have been relatively small with regards to driving habits (such as driving slower, reducing or combining trips, and increased use of public transportation) consumer purchasing habits are changing significantly. The report found that purchases of light trucks, SUVs and minivans have been in decline since 2004, purchases of smaller more efficient vehicles have increased during this same time, and purchases of mid-grade and premium grade gas products at the pump have been down since 2000. The study noted that partly as a result of consumers wanting and buying more fuel efficient cars, the average fuel economy of new vehicles has increased by more than half a mile per gallon since 2004.[34] In addition, purchases of hybrid vehicles rose by more than 130 percent from 1995 to 2004.[35]

Gasoline demand also rose more slowly in 2005 and 2006 — by 0.95 and 1.43 percent, respectively — than in the preceding decade, when gasoline demand rose at an average rate of 1.81 percent per year. In addition, EIA's February 27, 2008 edition of *This Week in Petroleum*, an online weekly update of petroleum production and demand, indicated that the 4-week moving average for gasoline demand was down 1.1 percent from the same time period in 2007. EIA attributed the decrease in demand to changing consumer behavior resulting from sustained high fuel prices and a struggling economy.[36] This pattern of decreased oil demand has occurred in the past as well; U.S. consumption of oil fell by about 18 percent from 1979 to 1983, in part because consumers purchased more fuel-efficient vehicles in response to high oil prices and fuel efficiency standards enacted in 1978.[37]

Continued high fuel prices, concerns about dwindling fuel supplies, government regulation and the environmental impacts of oil will all influence consumer choice and behavior. Consumers ultimately will determine whether more fuel-efficient vehicles

are built, whether alternative fuels achieve a significant market share, and how many resources auto manufacturers devote to developing alternatives such as gas-electric hybrid cars or fuel cells.[38]

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