Achieving Energy Independence: The U.S. Transportation System in the Age of Rising Oil Prices and Supply Disruptions

Background Report for Paul Brubaker
Research and Innovative Technology Administration
Final Draft White Paper — August 29, 2008

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Research and Innovative Technology Administration
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Notice

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Highlights

Introduction (Section 1)

- Addressing high oil prices and supply uncertainties is critical for several reasons:
  1. Economy
     - The United States pays more than $1 billion per day to import oil.
     - Oil prices affect where goods are produced and how they are shipped.
     - U.S. households, automobile manufacturers, air carriers, trucking companies, and others are hurt financially by high oil prices, in some cases leading to bankruptcy.
  2. Quality of life
     - High oil prices reduce mobility because they raise travel costs.
     - High oil prices also decrease trade because they raise freight costs.
  3. Equity
     - The financial impacts of high oil prices are not evenly spread across society.
     - Poor Americans in rural areas are hit hardest by high oil prices because they frequently must travel long distances and their transit options are limited.
  4. Environment
     - There is growing awareness and concern about climate change and other environmental issues related to consumption of oil and other fossil fuels.
     - CO_2 emissions and other environmental impacts should be considered when assessing alternative fuels and vehicles.
  5. Security
     - The United States has a strategic interest in ensuring steady oil supply from the Persian Gulf and other oil-rich regions, in part because the U.S. military relies primarily on oil for its combat operations and logistics support.

Oil Market Status and Outlook (Section 2)

- The United States imports about 60 percent of the oil and refined products that go into its total liquid fuel supply, and transportation consumes about 70 percent of U.S. liquid fuel.
- The recent increase in oil prices could be a price spike that soon subsides, or it could mark the beginning of an age of high oil prices. The U.S. Energy Information Administration projects that prices will fall to about $80 per barrel in 2009, but the International Energy Agency has expressed concern about a near-term "supply-side crunch…involving an abrupt run-up in prices" caused by inadequate investment in maintaining production capacity at existing oil fields and developing new fields.
- The United States holds only 2 percent of the world's oil reserves, while OPEC and countries with national oil companies control more than 90 percent of reserves. Many oil market observers believe the chance of a major oil supply disruption is high in light of geopolitical risks and vulnerable shipping routes.
- Saudi Arabia, Venezuela, and Nigeria are among the top five countries from which the United States imports oil and refined products.

Transportation Sector Energy Consumption (Section 3.1)

- Transportation represents about 28 percent of U.S. energy consumption, and petroleum represents about 98 percent of transportation energy.
- Transportation energy consumption is growing rapidly compared to other sectors.
- Road transportation dwarfs other modes and has been most responsible for growth in transportation energy use.
- Light-duty vehicles account for 58 percent of transportation energy consumption, freight trucks 17 percent, and air 10 percent.

Passenger Transportation Energy Consumption and Recent Developments (Section 3.2)

- Transportation fuel expenditures now consume about 8 percent of median household income (twice as much as in 2001).
- Recent empirical evidence indicates that people are driving less. Total vehicle-miles traveled (VMT) by light-duty vehicles has leveled off and is declining for the first time in decades. VMT was 4.7 percent lower in June 2008 than one year earlier.
- Public transit ridership nationwide has increased by 3 percent over last year, with increases over 15 percent in some areas. In 2007 the total number of passenger trips in light-duty vehicles was about 300 billion; the total number of transit passenger trips was about 10 billion or 3 percent of total trips.
- The mode share of private passenger transportation is a strong function of population density and gross domestic product per capita. At the same income per capita the modal share of private light-duty vehicle transportation ranges from a high of nearly 95 percent in Houston and Atlanta to a low of 30 percent in Amsterdam.
- In response to increasing fuel prices and emission constrictions, the share of transit buses running on diesel has decreased from about 95 percent in 1997 to less than 80 percent in 2007. Many of the nation's 80,000 transit buses are now powered by natural gas, electricity, and hydrogen.

Air Transportation Energy Consumption and Recent Developments (Section 3.3)

- Fuel costs are absorbing a large share of airline revenues. As a result, airlines are facing increasing financial difficulty and in some cases even bankruptcy. To remain solvent the airlines are significantly increasing ticket price, charging for checked baggage, cutting back their workforce, and retiring older and less fuel efficient aircraft. The cutbacks are having a significant impact on intercity mobility.
- The nation's intercity rail passenger systems would be hard-pressed to pick up the slack. In 2007 Amtrak ridership was 27 million passengers, compared to nearly 700 million domestic passengers by air carriers.

Freight Transportation Energy Consumption and Recent Developments (Section 3.4)

- Trucking accounts for nearly 80 percent of freight energy use, followed by rail at 10 percent, marine highways at 4 percent, and international shipping at 6 percent.

- U.S. logistics costs have reversed a previous downward trend and now exceed 10 percent of GDP. To reduce costs, logistics chains are being shortened, and in some cases manufacturing facilities are being relocated from overseas back to the United States.
- Trucking has the lowest fuel efficiency of the freight modes, which makes its fuel costs per ton-mile most sensitive to fuel prices. The challenge in shifting freight movement from highways to the more fuel efficiency rail and marine modes is the lack of required capacity.

Progress and Prospects for Alternative Energy for Transportation (Section 4)

- Alternative energy sources for transportation include natural gas, electricity, hydrogen, biofuels, and nonconventional oil.
- There is widespread interest in alternative energy now because of high fossil fuel prices, but large-scale deployment of alternative energy will take time.

Policy Options (Section 5)

- The United States already has several policies and programs in place to reduce oil consumption and address supply security.
- There are many policy options for mitigating the impacts of oil price spikes and reducing U.S. oil consumption. A list of approximately fifty policy options appears in Table B-1 in Appendix B. The following ten selected options are assessed in Section 5.2:
  1. Price floor on oil or liquid fuels
  2. Carpooling, teleworking, and shorter work weeks
  3. Increased fuel economy standards
  4. Tax credits for purchasing advanced vehicles
  5. Accelerated vehicle scrappage
  6. Investment assistance for vehicle remanufacturing and assembly plants (e.g., bonds)
  7. Modified driver behavior
  8. Public transit vouchers or reimbursement
  9. Expanded rail and marine networks
  10. Energy-related research, development, demonstration, and deployment (RD3) and policy analysis
- Policy options differ from one another in the scale, speed, and costs of reductions; technological, political, and administrative feasibility; possible unintended consequences; and other factors. Table 2 summarizes the assessment of the ten selected policy options.
- No policy option appears optimal with respect to all evaluation criteria. Ranking the policy options would depend on which evaluation criteria are most important (for example, whether it is more important to have large reductions or fast reductions).
- The selected policy options for DOT consideration would require interagency coordination and outreach to stakeholders to build consensus, as well as Congressional approval and regulatory impact analysis (RIA) before they could be translated into action.

Conclusions and Recommendations (Section 6)

- Given the uncertainty in future oil prices and their economic and social consequences, it is most prudent to significantly reduce U.S. vulnerability to high oil prices and supply disruptions.

- No single policy measure by itself will enable the United States to achieve energy independence in the near term, but a package of measures could substantially reduce its dependence on foreign energy sources in the long term.
- Most policies have long lead times, which makes near-term action critical to set the country on a path toward secure and sustainable energy.
- Each policy option has its pros and cons. Increased fuel economy standards, for example, could achieve large reductions in U.S. oil consumption but take effect slowly. Providing transit vouchers or reimbursement could reduce oil consumption immediately but may not result in large reductions unless transit capacity is expanded. Achieving large reductions would require combining this policy option with others, such as tele-working.
- The choice of specific policy options will depend on how large the reductions in oil consumption should be, how fast they should occur, how much money should be spent, and similar questions.

Goals and Challenges

Passenger Transportation: Light-Duty Vehicles and Transit (Local Travel)

- Fuel costs per mile have increased steeply
  - **Goal**: Reduce both fuel costs per mile and carbon footprint
  - **But**: Advanced vehicle technologies are not yet ready for "prime time"
- High fuel prices also reduce local mobility
  - **Goal**: Maintain local mobility (for example, through shift to public transit)
  - **But**: Inadequate transit infrastructure for large increase in ridership (only about 2 percent of local trips are by transit)
- **Actions/policies**: Increase fuel economy, hasten deployment of advanced technologies, expand transit operations and infrastructure

Passenger Transportation: Rail and Air (Intercity Travel)

- High fuel prices cause financial stress for both intercity operators and passengers
  - **Goal**: Maintain intercity mobility (for example, through shift to rail)
  - **But**: Inadequate rail infrastructure for large increase in ridership (only about 1.5 percent of intercity trips are by rail)
- **Actions/policies**: Assess alternatives for maintaining financial viability of intercity transportation systems

Freight Transportation: Shifting Modal Splits

- Trucking accounts for approximately 80 percent of freight energy use but is least fuel efficient
  - **Goal**: Reduce fuel costs per mile and carbon footprint
  - **But**: Advanced heavy-duty vehicle technologies are not yet ready for "prime time"

- High energy prices are raising total freight prices and reducing profits for trucking, rail, and marine systems
  - **Goal**: Facilitate shift from trucking to more-energy-efficient rail and marine highway
  - **But**: Inadequate rail and marine infrastructure for large increase in freight volumes
- **Actions/policies**: Increase fuel economy, diversity transportation fuels and hasten deployment of advanced technologies to improve vehicle fuel-efficiency, expand rail and marine infrastructure

Summary of Goals and Challenges

- The major national challenges for passenger transportation are to preserve our economic vitality and maintain social equity in the face of increasing cost of mobility.
- The major national challenge for freight transportation is to mitigate the economic impact of increasing transportation costs through modal shifts (i.e., from trucking to rail systems and marine highways) in the face of limited capacity for freight movement and intermodal transfer.
- The major technological challenges for electric vehicles (from hybrid-electric, plug-in hybrids to fully electric) include:
  - Development and supply of high-energy-density batteries
  - Low-carbon electricity grid to power the vehicles.
- The major technological challenges for hydrogen vehicles include:
  - Low-cost hydrogen fuel cells
  - National hydrogen production, delivery and fueling infrastructure development and deployment.
- The overall impediment to maintaining the nation's mobility and competitiveness in the face of increasing fuel prices is a large existing motor vehicle fleet (250 million vehicles with a normal annual turnover rate of about 5-7 percent) and a national freight infrastructure which is reaching its limit from growth in global trade.

1 Introduction

The U.S. transportation system is currently highly dependent on liquid fuels derived from oil. The sharp increase in oil prices over the last two years has highlighted the vulnerabilities inherent in this dependence and has stimulated widespread interest in alternative energy for transportation. Uncertainty about future oil prices and the possibility of a sudden supply disruption make reducing U.S. vulnerability to oil market volatility all the more urgent.

The U.S. transportation system's dependence on liquid fuels has negative consequences related to the economy, mobility, quality of life, the environment, and national security. When oil costs $110 per barrel and U.S. oil imports are 10 million barrels per day, the United States spends $1.1 billion per day or $400 billion per year to import oil. High oil prices increase freight costs and thus dampen trade. They also increase travel costs, which reduces mobility and constricts markets for motor vehicles, air travel, and other transportation services. Poor Americans in rural areas suffer most from high oil prices because they frequently must travel long distances and their transit options are limited. The environmental impacts of fossil fuel consumption are receiving increased attention, particularly with regard to climate change. Oil consumption is also a national security issue because hostile countries or groups could use oil as a weapon against the United States.

As American households, vehicle manufacturers, air carriers, public transit agencies, and others struggle to adapt to high oil prices, they are turning to transportation policy makers for economic assistance and policy leadership. This white paper presents information and analysis in support of federal policy making to reduce U.S. dependence on foreign oil while maintaining economic prosperity, trade, mobility, quality of life, and environmental well-being.

The remainder of this white paper is organized as follows. Section 2 discusses world and U.S. oil production and consumption, recent and projected oil prices, and supply security. Section 3 presents data on energy consumption by transportation mode and summarizes recent developments in passenger, air, and freight transportation resulting from high oil prices. Alternative energy for transportation is discussed in Section 4. Section 5 provides an assessment of ten selected policy options for reducing U.S. oil consumption, particularly in transportation. Conclusions and recommendations appear in Section 6. Appendix A presents detailed data on world and U.S. oil production and consumption. Appendix B contains a more comprehensive list of policy options than those in Section 5. Appendix C describes an analysis of petroleum consumption and CO_2 emissions in the light-duty vehicle fleet, which permits quantitative assessment of potential policies to hasten the deployment of advanced fuels and vehicles.

2 Oil Market Status and Outlook

2.1 World and U.S. Oil Production and Consumption

When U.S. oil production peaked in 1969, the United States accounted for 21 percent of world oil production and imported 20 percent of its total liquid fuel supply.[1] The U.S. share of world oil production is now 6 percent, and 60 percent of U.S. liquid fuel supply is now imported.[2] Over the last four decades, the U.S. share of world oil production has decreased roughly threefold and U.S. dependence on imported oil and liquid fuels has tripled. The United States is thus less able to influence world oil supply and more vulnerable to international supply disruptions than it was during the oil crises of the 1970s.

World oil production is currently about 84 million barrels per day, of which the United States produces about 5 million barrels. Total U.S. consumption of gasoline, diesel, jet fuel, and other liquid fuels is about 21 million barrels per day. The United States meets its immense liquid fuel demand by exporting only a negligible quantity of oil, importing about 10 million barrels of oil per day, and supplementing its oil supply with natural gas plant liquids, blending components such as ethanol, and imported refined products. Additional information on world and U.S. oil production and consumption appears in Appendix A.

Increasing U.S. oil production by opening new areas to exploration and development has been proposed recently as a policy response to high oil prices. The potential oil price impacts of this policy would depend on the increase in U.S. production relative to world oil supply, as oil is a global commodity whose price differs somewhat across regions and oil varieties but is largely set in a global market. Since U.S. oil prices rose sharply during the oil crises of the 1970s even though the United States was less dependent on imported oil, the increase in U.S. oil production from new areas would have to be large to significantly lower oil prices or mitigate the effects of possible supply disruptions in the future. Moreover, it is unclear whether the United States could rely on domestic producers to provide it with oil during international supply disruptions unless domestic producers were prohibited from trading in the global market.

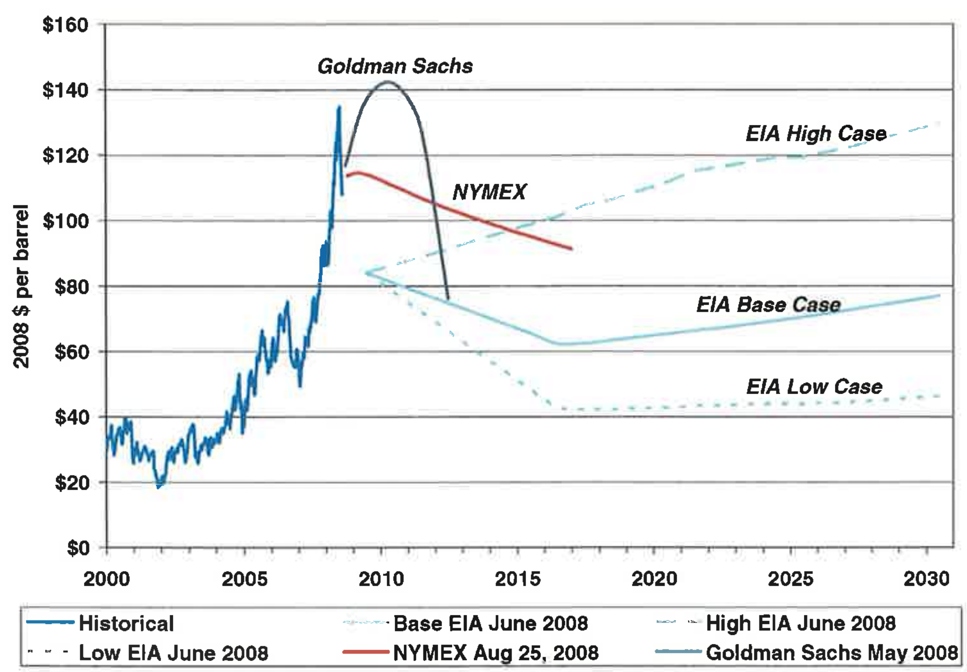
The U.S. Energy Information Administration (EIA) – the independent statistical and analytical agency within the Department of Energy – has evaluated the potential energy market impacts of opening the Outer Continental Shelf or waters off the Arctic National Wildlife Refuge (ANWR) to exploration and development. Both areas are believed to contain large quantities of oil and natural gas, but production could not start for ten years and even then the effects on oil prices would be small, according to EIA. In its analysis of the Outer Continental Shelf, EIA found that "access to the Pacific, Atlantic, and eastern Gulf regions would not have a significant impact on domestic crude oil and natural gas production or prices before 2030. Leasing would begin no sooner than 2012, and production would not be expected to start before 2017."[3] EIA estimates that if the federal government authorized oil and natural gas activities off ANWR, oil would begin flowing in 2018 and production would peak at 0.78 million barrels per day in 2027. This production level represents about 15 percent of current U.S. production and 0.9 percent of world production. Oil prices would most likely be reduced by $0.75 per barrel.[4]

The United States is such a large consumer in the global oil market that it might influence prices through its consumption, though probably only slightly. A recent study estimates that reducing U.S. oil imports by 1 million barrels per day would most likely lower world oil prices by less than $1 per barrel.[5] Although the United States probably cannot reduce world oil prices significantly through feasible changes in either its production or consumption, lowering U.S. liquid fuel consumption would still have the positive effects of reducing U.S. oil payments to other countries and dampening the impacts of any future supply disruptions.

2.2 Oil Price Trend

Oil prices have been highly volatile for the past three decades. Most recently, the average U.S. oil price nearly tripled from early 2007 to mid-July 2008, climbing from about $50 per barrel to about $140 per barrel; by mid-August 2008 it had fallen slightly below $110 per barrel (**Figure 1**). Oil prices are now higher in real terms than during the oil crises of the 1970s or any other time since the nineteenth century. When oil costs $110 per barrel, the United States spends about $1.1 billion per day or $400 billion per year to import oil.

Figure 1. U.S. Historical and Projected Oil Price 2000 - 2030



Sources: EIA, "World Crude Oil Prices: Weekly," August 28, 2008; EIA, *Annual Energy Outlook 2008*, June 2008; New York Mercantile Exchange, August 25, 2008; news reports on Goldman Sachs announcement, May 2008

Liquid fuel prices track oil prices closely but not exactly. The cost of oil is approximately one-half of the price of gasoline; other components are refining costs and profits, distribution costs and profits, and taxes. Average U.S. gasoline prices rose from $2.17 per gallon in early 2007 to $4.16 per gallon in mid-July 2008 and then slipped back below $4 per gallon in August 2008.[6]

Oil market experts have attributed the recent price surge to various causes. The International Energy Agency (IEA) said in its *Oil Market Report* for June 2008 that "these abnormally high prices are largely explained by fundamentals…This is a case of supply and demand pulling in opposite directions to push prices higher." [7] Oil demand has been growing rapidly in China, India, and other large developing countries. Oil producers are increasing supply to meet demand but must use more expensive extraction technology to keep pace, which increases supply costs. Some oil market observers believe that financial speculation is also driving up prices, though economists are skeptical about this theory, as it would imply stockpiling and a different relationship between spot prices and futures prices than the observed relationship.[8] High oil prices also reflect the weak dollar and perceived geopolitical risks. OPEC has asserted that increased biofuel production is an additional factor behind the recent price surge.[9]

2.3 Oil Price Forecasts

There is wide variation in oil price forecasts, even for the near term (**Figure 1 above**). This reflects the uncertainty in world markets. Many oil traders apparently believe prices will remain near current levels for several years, based on futures prices in the New York Mercantile Exchange. Goldman Sachs also predicts high oil prices for the near term. EIA and IEA, on the other hand, predict prices using detailed supply and demand information and believe prices will soon decline unless geopolitical risks and financial market effects keep oil prices above their natural level. EIA has raised its long-term base case forecasts, however, and gives the following explanation for higher projected prices:

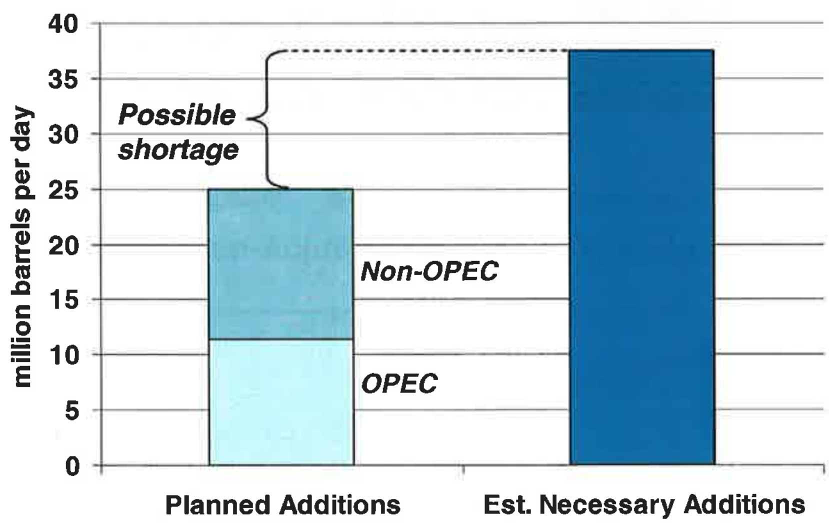
> The *AEO [Annual Energy Outlook] 2008* reference case outlook for world oil prices is higher than in the *AEO 2007* reference case. The main reasons for the adoption of a higher reference case price outlook include continued significant expansion of world demand for liquids, particularly in non-OECD countries, which include China and India; the rising costs of conventional non-OPEC supply and unconventional liquids production; limited growth in non-OPEC supplies despite higher oil prices; and the inability or unwillingness of OPEC member countries to increase conventional crude oil production to levels that would be required for maintaining price stability.[10]

IEA has similar oil price projections to EIA but has begun expressing concerns about whether world oil supply will be able to satisfy increased demand over the next decade and make up for declining production at mature oil fields (**Figure 2**). In its *World Energy Outlook 2007* published in November 2007, IEA predicted that 37.5 million barrels per day of new world oil production capacity would be needed by 2015. Its forecast for capacity additions by 2015 is only 25 million

> "The Saudis say they can ramp up production to 12.5 million barrels a day. But a field-by-field breakdown obtained by *BusinessWeek* shows that's not likely…Saudi Arabia's ability to calm panicky oil markets has been waning for years…[I]t appears that for at least the next five years, and possibly longer, the Saudis are likely to produce less crude than promised."
>
> Steve LeVine, "Saudi Oil: A Crude Awakening on Supply," *BusinessWeek*, July 10, 2008

barrels per day. This potential shortfall could be larger if either demand growth or production decline rates are higher than expected. IEA concluded that "[i]n view of these uncertainties, a supply-side crunch in the period to 2015, involving an abrupt run-up in prices, cannot be ruled out."[11] IEA is examining this issue more closely for its *World Energy Outlook 2008* due out in November 2008.

Figure 2. World Oil Capacity Additions 2006 - 2015



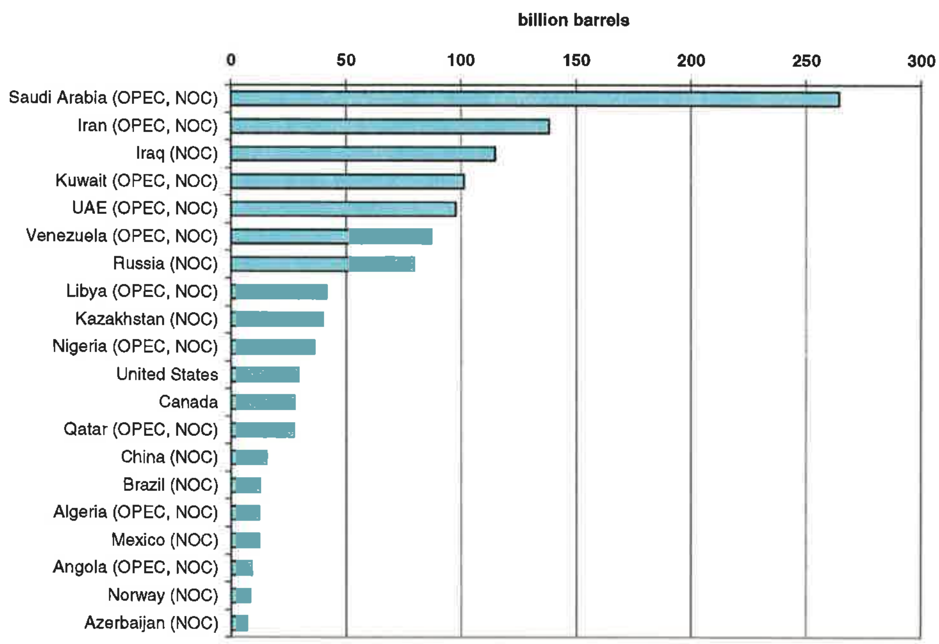
Source: International Energy Agency (IEA), *World Energy Outlook 2007*, November 2007, p. 84

World investment in upstream oil activities, consisting of exploration, new production capacity, and capacity maintenance at existing fields, amounts to about $300 billion per year (**Figure 3**). Investment is rising rapidly, but this does not necessarily mean much more oil in the future. Approximately 60 percent of investment goes toward maintaining capacity at existing fields, leaving 25 percent for new production capacity and 15 percent for exploration. Oil companies are moving out into the Arctic Ocean and other inaccessible regions where oil is expensive to produce. Exploration and production costs are also ballooning because the industry faces a shortage of rigs, other equipment, and skilled labor. After adjusting for industry-specific inflation, upstream oil investment rose by only 5 percent between 2000 and 2006 (**Figure 4**). Fatih Birol, the IEA's chief economist, has said, "That's almost nothing; it's inadequate."[12] The investment picture thus suggests that oil supply growth may be limited, which would put upward pressure on prices.

> "Projections that OPEC will increase capacity by an additional 10 to 20 million barrels per day in the next twenty years to meet rising demand…run counter to historical experience. OPEC's capacity has fallen, not increased, over the past 25 years, from 38.76 million barrels per day in 1979 to roughly 31 million barrels per day today."
>
> Amy Myers Jaffe, Testimony to the Select Committee on Energy Independence and Global Warming, U.S. House of Representatives, June 11, 2008

the United States and Canada do not have national oil companies. Other countries use their national oil companies as vehicles for government influence over oil activities to varying degrees. Given the political volatility of several oil-rich countries, including Iran, Venezuela, Libya, and Nigeria, there are many plausible scenarios in which civil or military unrest in any one of them would seriously crimp world oil supply. An interruption in shipping through the Strait of Hormuz linking the Persian Gulf to the Indian Ocean, the Strait of Malacca linking the Indian Ocean to the Pacific Ocean, or any other so-called world oil transit chokepoint could also disrupt the world oil market.

Figure 5. World Oil Reserves 2007, OPEC Membership, and National Oil Companies

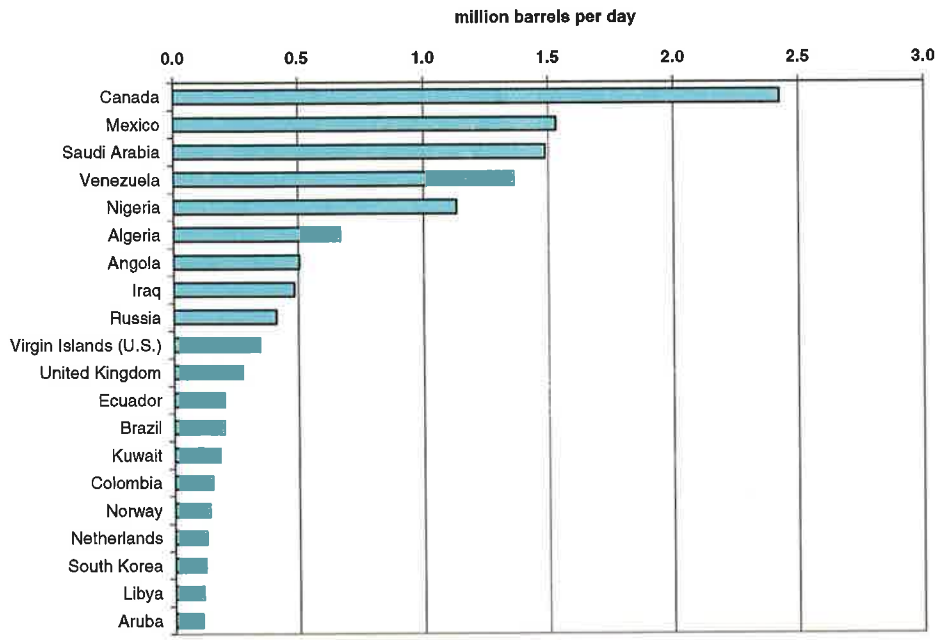


Source: BP, *Statistical Review of World Energy 2008*, June 2008

Note: "NOC" denotes a national oil company; some countries with national oil companies grant concessions to other companies as well; Iraq is in OPEC but does not have a production quota

As previously noted, the United States imports about 60 percent of its liquid fuel supply. The top five countries from which the United States imports oil and refined products are Canada, Mexico, Saudi Arabia, Venezuela, and Nigeria (**Figure 6**). The United States is particularly vulnerable in the short term to supply disruptions in any of these countries. Over the long term after a localized disruption, the United States could import more oil from other countries, but world oil prices could rise depending on the size of the disruption compared to world supply.

Figure 6. U.S. Imported Oil and Refined Products 2007



Source: EIA, "U.S. Imports by Country of Origin," July 2008

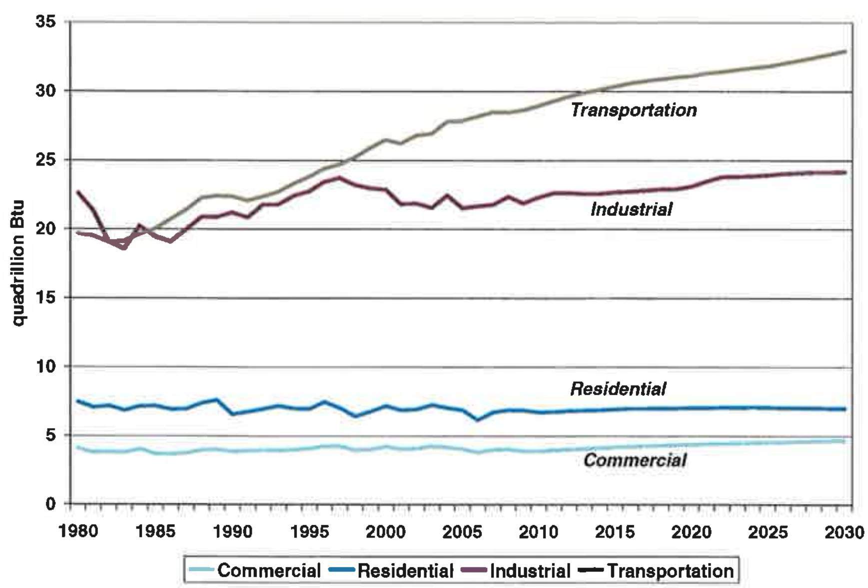
3 Oil Price Implications for Transportation

3.1 Transportation Energy Consumption

The U.S. transportation sector accounts for approximately 28 percent of total U.S. energy consumption. Ninety-eight percent of transportation energy consumption is liquid fuels derived primarily from oil; the small remainder is natural gas and electricity. The transportation sector consumes about 14 million barrels of liquid fuels per day, or about 70 percent of total U.S. liquid fuel consumption (**Figure A-2 in Appendix A**).

Primary energy consumption, which excludes electricity, is rising more quickly in transportation than in other sectors (**Figure 7**). Most of this growth comes from road transportation.

Figure 7. U.S. Primary Energy Consumption by Sector 1980 - 2030

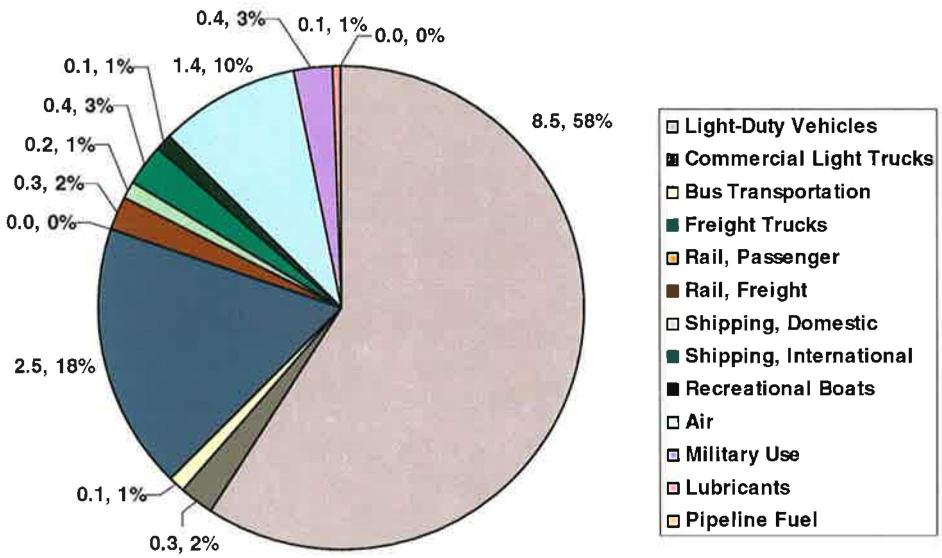


Source: EIA, *Monthly Energy Review*, June 2008, and *Annual Energy Outlook*, June 2008

Note: Electricity is omitted. Projections assume EIA base case scenario. The British thermal unit (Btu) is approximately equal to the amount of heat energy released by a match. A quadrillion Btu, or "quad" in energy parlance, is 10^{15} or a million billion Btu. Total U.S. energy consumption in 2007, including electricity, was 101 quadrillion Btu.

The three largest categories of energy consumption in the transportation sector are light-duty vehicles at about 58 percent, freight trucks at 18 percent, and air at 10 percent (**Figure 8**). The five freight categories – freight trucks, commercial trucks, freight rail, marine highways (domestic shipping), and international shipping – together make up about 25 percent of transportation energy consumption. Public transit accounts for about 1 percent of transportation energy consumption, and nearly all transit energy consumption is by buses.

Figure 8. Transportation Liquid Fuel Consumption 2007 (million barrels per day)



Source: EIA, *Annual Energy Outlook 2008,* June 2008

Note: The U.S. transportation sector's liquid fuel consumption in 2007 was 14.3 million barrels per day

3.2 Passenger Transportation by Surface Modes

3.2.1 Energy Consumption

Light-duty vehicles consume about 8 million barrels of liquid fuels per day, and public transit consumes about 0.1 million barrels. Given that domestic oil production is about 5 million barrels per day, the United States must import oil just to satisfy demand from passenger vehicles. Liquid fuel consumption by light-duty vehicles is about 98 percent gasoline and 2 percent diesel and other energy sources, including some electricity. Liquid fuel consumption by public transit is mostly diesel.

As noted above, the historical trend for light-duty vehicle energy consumption through 2007 was steadily upward. The vehicle fleet grew in size over this period, annual vehicle usage increased, and average fuel economy changed little after the mid 1980s. The increased popularity of sport utility vehicles and other light trucks relative to passenger cars from the mid 1980s until a few years ago, when the oil price surge began, also contributed to the upward trend in light-duty vehicle energy

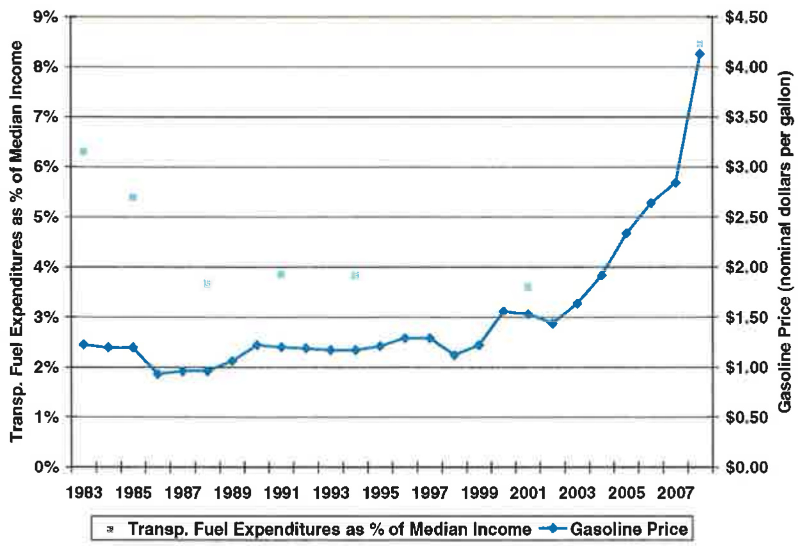
> "As American drivers groan over prices nearing $4 a gallon, the French are paying $8.67 for a gallon of super, compared to $7.10 in January, 2007…And in the U.K. diesel costs $11.50 per gallon, compared to around $3.90 in the U.S. Across the European Union, the average cost of a gallon of gas runs to about $8.70 — more than twice what Americans are shelling out to fill up."
>
> Bruce Crumley, "Think Gas Is High? Try Europe," *Time*/CNN, May 28, 2008

consumption, because light trucks generally have lower fuel economy than passenger cars.[13]

3.2.2 Recent Developments

American motorists know all too well that fuel prices have risen significantly and are changing their driving behavior in response. In a survey conducted in June 2008, 62 percent of Americans cited rising gasoline and home heating oil prices as their biggest economic worry.[14] Transportation fuel expenditures relative to median household income have doubled since 2001 from about 4 percent to about 8 percent (**Figure 9**).

Figure 9. Transportation Fuel Expenditure As Percentage of Median Income 1983 - 2008

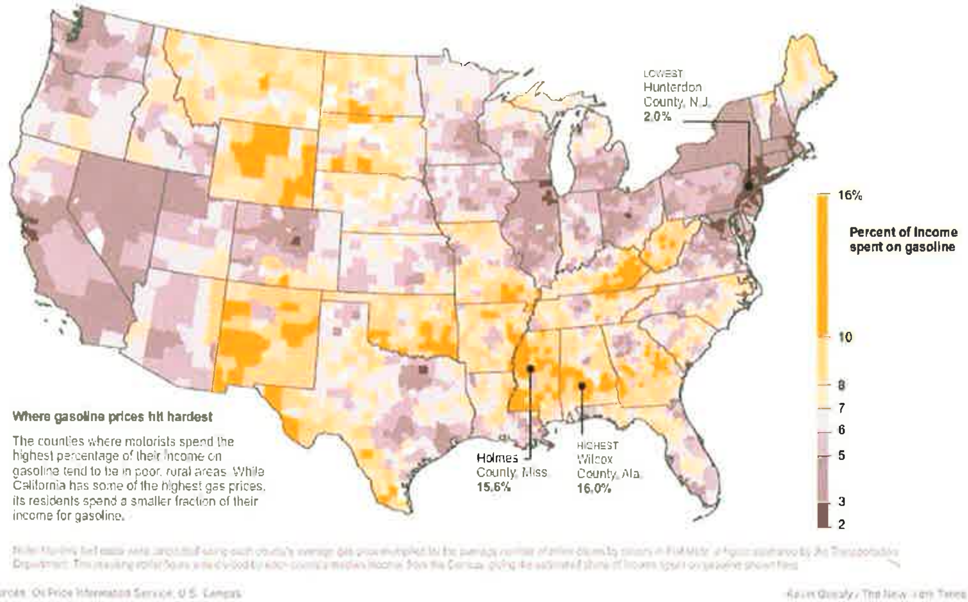


Source: EIA, *Residential Transportation Historical Data Tables* and gasoline price data; Census Bureau, *Current Population Survey*

Note: Transportation fuel expenditure value for 2008 is an extrapolation

The economic impact of high fuel prices is generally greatest in rural areas where low population density makes it necessary for people to drive long distances frequently (**Figure 10**). Average income in many rural areas is already low, and so high fuel prices have given rise to social equity concerns inasmuch as they hurt the poorest most.

Figure 10. Percent of Income Spent on Gasoline

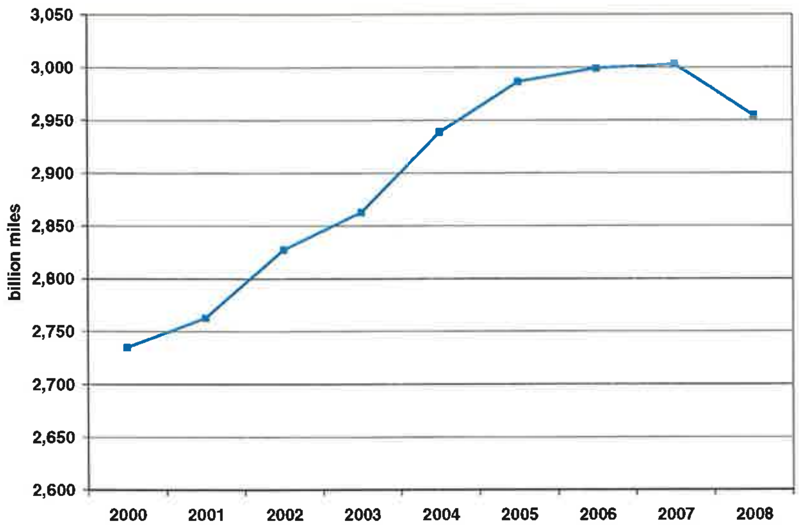


Source: Kevin Quealy, *The New York Times,* June 1, 2008

Empirical evidence indicates that Americans are reacting to high fuel prices by driving less and using public transit more. Vehicle-miles traveled (VMT) increased continuously from the last energy crisis through last year but is now declining appreciably (**Figure 11**). The Federal Highway Administration reports that VMT was 4.7 percent lower in June 2008 than one year earlier. Public transit ridership nationwide was about 3 percent higher in the first quarter of this year than in the corresponding period last year (**Figure 12).** The largest increases in public transit ridership have occurred in light rail and commuter rail. Ridership on the Miami Tri-Rail commuter train rose 13 percent in the first quarter of this year relative to last year, and on the Hiawatha light rail line around Minneapolis-St. Paul ridership rose 16 percent.[15] The American Public Transportation Association estimates that with gas prices near $4 per gallon, the average American city resident can save over $8,000 per year from taking public transit instead of driving.[16]

> "The number of people riding Amtrak surged 13.9 percent in July from a year earlier, as high gas prices caused more commuters to rely on intercity rail. But many Amtrak trains are getting overcrowded, and a backlog of infrastructure problems stands in the way of expanded service…'We're literally beginning to bump up against some of the capacity limits on Acela,' [Amtrak President Alex] Kummant said. 'We have basically no equipment left to start new services.'"
>
> Christopher Conkey, "All Aboard: Too Many for Amtrak – Surge in Ridership Leads to Crowding on Intercity Trains," *The Wall Street Journal*, August 8, 2008

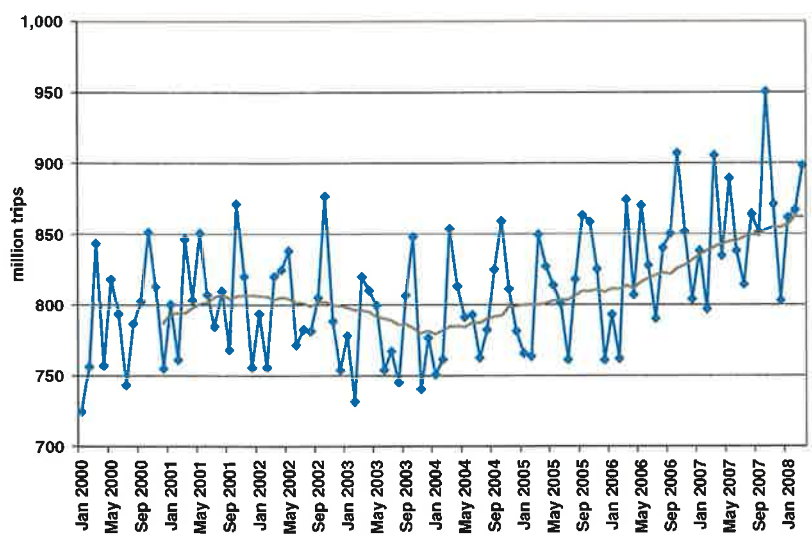
Figure 11. Vehicle-Miles Traveled 2000 - 2008



Source: Federal Highway Administration, *Traffic Volume Trends: June 2008*, August 2008

Note: 12-month moving average calculated in June of each year

Figure 12. Monthly Public Transit Ridership 2000 - 2008

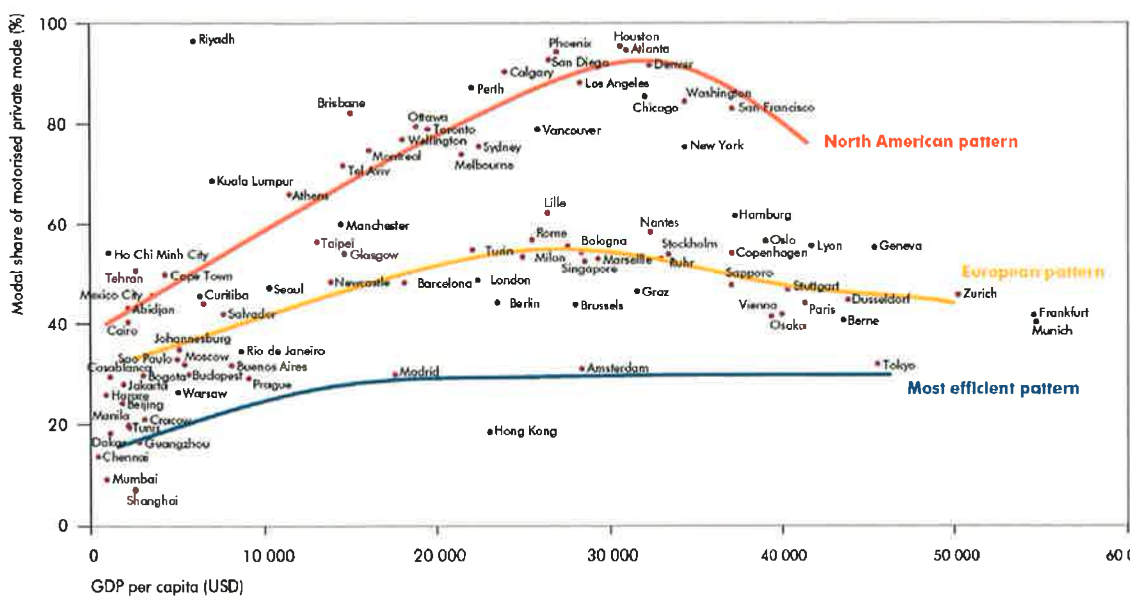


Source: American Public Transportation Administration, periodic transit ridership reports

Note: Trendline shows the average over the previous 12 months

Despite the decrease in VMT and increase in public transit ridership, nearly all passenger trips in the United States are still by private light-duty vehicle. Based on an average trip length of about 10 miles,[17] Americans make about 300 billion light-duty vehicle trips per year and about 10 billion public transit trips. High fuel prices could eventually bring U.S. private vehicle use down toward levels in Europe and elsewhere (**Figure 13**). For example, private vehicle use as a share of all local travel is more than 95 percent in Houston but only about 30 percent in Amsterdam, even though the two cities have approximately the same income per capita. Higher population densities and broader public transit networks in Europe and elsewhere make such limited private vehicle use possible. Effecting a large shift from private vehicle use to public transit in the United States would require large investments in public transit infrastructure.

Figure 13. Relationship between GDP per Capita and Private Vehicle Modal Share



Source: IEA, *Energy Technology Perspectives 2008*, May 2008, p. 448

The shift from private light-duty vehicle use to public transit reduces petroleum consumption because public transit requires less petroleum per passenger-mile. The difference in fuel efficiency is increasing as natural gas, electricity, and hydrogen gain ground on diesel for powering transit buses (**Figure 14**). The share of transit buses running on diesel has decreased from about 95 percent in 1997 to less than 80 percent in 2007. Advanced technology demonstration projects often use transit buses as a stepping stone to private vehicles. These demonstration projects include 23 hydrogen-fueled transit buses operating in the United States.

3.3 Passenger Transportation by Air

3.3.1 Energy Consumption

Air transportation consumes about 1.4 million barrels of jet fuel per day. Domestic air carriers account for about 54 percent of air transportation energy consumption, followed by international air carriers at 24 percent, freight carriers at 16 percent, and general aviation at 6 percent. Jet fuel typically costs about 75 percent as much as gasoline per gallon.[18]

Figure 14. Transit Bus Power Source Percentages 1997 - 2007

Source: American Public Transportation Association, *2008 Public Transportation Fact Book*, June 2008

3.3.2 Recent Developments

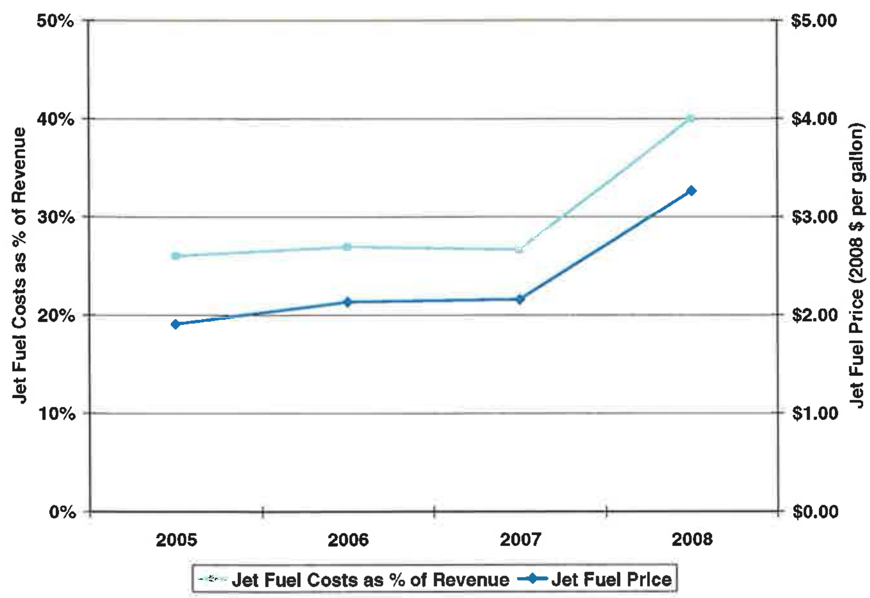
Increased jet fuel prices have already had a severe financial impact on the airline industry. Approximately 40 cents on each dollar of airline revenue must now go toward fuel costs, which is nearly double the level in previous years (**Figure 15**). Airlines use fuel price hedging to shield themselves from increased fuel costs, but this only provides partial protection. The airline industry is particularly vulnerable at present because it has operated with net losses for six of the last seven years and the current economic downturn has reduced demand. The Secretary General and CEO of the International Air Transport Association has said the industry faces not just "a crisis on the cost side" but also "a crisis on the revenue side." [19]

Airlines are attempting to cope with high fuel prices by raising air fares, introducing new charges, cutting back service, laying off employees, and in some cases reducing employee wages. A recent report by the Business Travel Coalition and AirlineForecasts estimates that major airlines must raise air fares by 20 percent to offset higher fuel prices. According to the report, the airline industry cannot raise fares this much without suffering a sharp drop in passengers because 60 to 70 percent of airline customers are leisure travelers with high price sensitivity. The report also estimates that at an oil price of $140 per barrel, airlines must reduce total flight capacity by 20 percent, which would result in more than 84,000 jobs lost across the country.[20] As examples of recent actions by specific carriers, American Airlines is laying off 7,000

"Despite more than a dozen industrywide fare increases in recent months, airlines are capturing only a sliver of the added cost of fuel. Some analysts believe the U.S. industry will lose more than $7 billion this year, on an operating basis. By comparison, in 2001, the industry posted a $10.3 billion operating loss. The chief culprit of the current woes is a fuel bill that could total $60 billion this year – a remarkable $18 to $20 billion higher than it was last year. The industry earned just $3.8 billion in net profit last year."

Susan Carey and Paulo Prader, "American Cuts Flights, Adds Fees As Airlines Face Crisis," *The Wall Street Journal*, May 22, 2008 employees, cutting flights by 8 percent, and charging $15 per checked bag, Continental is laying off 3,000 employees, and AirTran is trimming employee wages by an average of 10 percent.[21]

Figure 15. Jet Fuel Cost As Percentage of Airline Revenue 2005 - 2008



Source: EIA, *Annual Energy Outlook 2008*, June 2008; spot price for jet fuel in Los Angeles on August 26, 2008

Note: Baseline domestic yield per passenger-mile, load factor, and average aircraft fuel efficiency are assumed.

U.S. intercity rail passenger systems would be hard-pressed to pick up the slack from contraction in air services. In 2007 Amtrak ridership was 27 million passengers, compared to nearly 700 million domestic passengers by air carriers.[22]

3.4 Freight Transportation

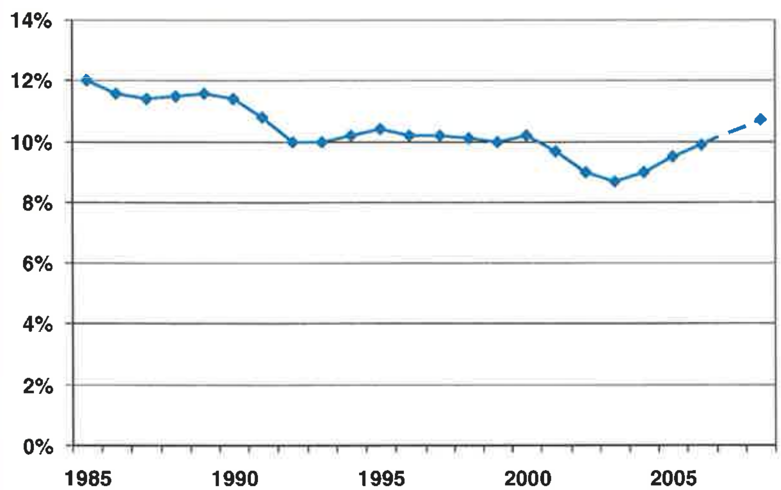
3.4.1 Energy Consumption

Freight modes use about 3.4 million barrels of liquid fuels per day, or about 25 percent of total transportation energy consumption. The largest freight category is trucking at about 2.5 million barrels of liquid fuels per day, or 80 percent of the freight total, followed by international shipping at 0.4 million barrels, rail at 0.3 million barrels, and maritime highways (i.e., domestic maritime shipping) at 0.2 million barrels. Trucks also carry the most freight as measured by tonnage and revenue,[23] though rail carries somewhat more freight than trucks do as measured by ton-miles.[24] Diesel provides most of the energy used for freight transportation, but there is also significant gasoline consumption by trucks and residual oil consumption by marine vessels. Until recently diesel prices were lower than gasoline prices per gallon. Over the last year diesel prices have risen above gasoline prices, and the price difference is now more than 40 cents per gallon.[25]

3.4.2 Recent Developments

In response to the needs of global markets and just-in-time distribution systems, U.S. logistics costs (i.e., freight transportation, inventory management, and administration) relative to GDP fell from about 14 percent in the 1970s to about 8.5 percent in 2003. More recently in response to high fuel costs, U.S. logistics costs have reversed the previous downward trend and now exceed 10 percent (**Figure 16**). To reduce costs, logistics chains are being shortened, and in some cases manufacturing facilities are being relocated from oversees back to the United States.

Figure 16. U.S. Logistics Costs Relative to GDP 1985 - 2008



Source: Council of Supply Chain Management Professionals, *18th Annual State of Logistics Report*, June 2007

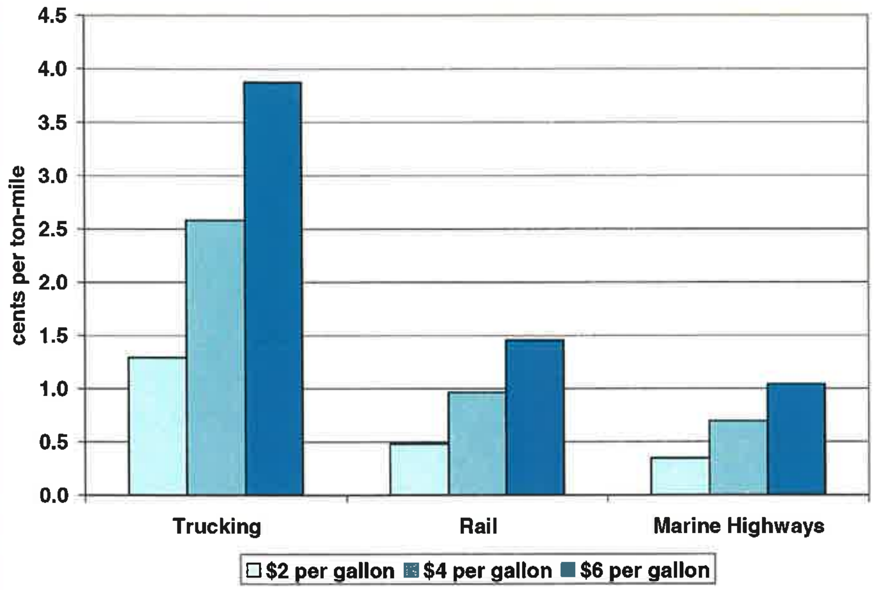
Note: Value for 2008 is an extrapolation.

Trucking has taken the hardest hit from high fuel prices because it has lower fuel efficiency than rail or marine highways (**Figure 17**). According to a report by the Texas Transportation Institute, trucking has a fuel efficiency of 155 ton-miles per gallon, while rail and marine highways have fuel efficiencies of 413 and 576 ton-miles per gallon, respectively.[26] The result is that when diesel prices rise from $2 to $4 per gallon, trucking fuel costs per ton-mile increase by about 1.3 cents (from 1.3 cents to 2.6 cents), and marine shipping fuel costs per ton-mile increase by about 0.3 cents (from 0.3 cents to 0.6 cents).

"Cheap oil, the lubricant of quick, inexpensive transportation links across the world, may not return anytime soon, upsetting the logic of diffuse global supply chains that treat geography as a footnote in the pursuit of lower wages…The cost of shipping a 40-foot container from Shanghai to the United States has risen to $8,000, compared with $3,000 early in the decade, according to a recent study of transportation costs. Big container ships, the pack mules of the 21st-century economy, have shaved their top speed by nearly 20 percent to save on fuel costs, substantially slowing shipping times…Until recently, standard practice in the furniture industry was to ship American timber from ports like Norfolk, Baltimore and Charleston to China, where oak and cherry would be milled into sofas, beds, tables, cabinets and chairs, which were then shipped back to the United States. But with transportation costs rising, more wood is now going to traditional domestic furniture-making centers in North Carolina and Virginia, where the industry had all but been wiped out."

Larry Rother, "Shipping Costs Start to Crimp Globalization," The New York Times, August 3, 2008

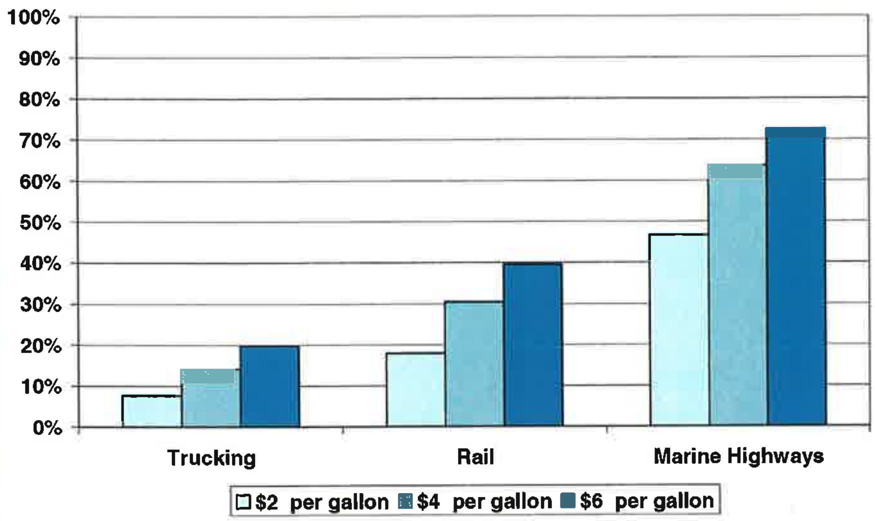
Figure 17. Estimated Fuel Costs per Ton-Mile



Source: Calculated from fuel efficiencies in Texas Transportation Institute, *A Modal Comparison of Domestic Freight Transportation Effects on the General Public*, November 2007

Fuel costs consume a larger portion of revenue for shipping than for trucking or rail, however (**Figure 18**). Marine shipping prices per ton-mile are therefore probably more sensitive to fuel costs than trucking or rail. Profits for each freight mode decrease if freight prices cannot rise to reflect higher fuel costs. As a case in point, 935 trucking companies went bankrupt in the first quarter of the year. This was the most bankruptcies in the trucking industry since 2001.[27]

Figure 18. Estimated Fuel Cost As Percentage of Revenue per Ton-Mile



Sources for revenue per ton-mile (in 2005):
Trucking: U.S. Census, *Statistical Abstract, 2008,* Table 1087 ($206 billion) and BTS, *National Transportation Statistics, 2008,* Table 1-46b (1.3 trillion ton-miles)
Rail: Association of American Railroads, *Class I Railroad Statistics, 2008*
Marine Highways: BTS, *National Transportation Statistics, 2008,* Table 3-17 (extrapolated from value in 2001)

Revenue per ton-mile (in 2005):

Trucking: 15.9 cents per ton-mile
Rail: 2.6 cents per ton-mile
Marine Highways: 0.8 cents per ton-mile

Note: Non-fuel costs and profit are assumed to remain at the same level in real dollars in 2008 as in 2005. Increased fuel costs are reflected in increased revenue per ton-mile. The estimation procedure is sensitive to assumed fuel efficiency and revenue per ton-mile, both of which have significant uncertainty.

4 Progress and Prospects for Alternative Fuels and Vehicles

The national goal is to substantially improve the fuel efficiency of transportation by modernizing and optimizing fuel-vehicle systems and by sustainably diversifying the energy base. This section discusses alternative fuels and vehicles that could replace conventional vehicles running on gasoline, diesel, and other liquid fuels derived from oil. The oil price surge has spurred more research and development in these alternative fuels and vehicles.

4.1 Natural Gas

Vehicles that run on natural gas have internal combustion engines like conventional vehicles but also must have high-pressure cylinders for fuel storage. The fuel can be either compressed natural gas (CNG) or liquefied natural gas (LNG). CNG and LNG transportation is well established abroad (for example, in Canada and Italy) and has been demonstrated in the United States for rail, bus, trucks, and personal vehicles. Commercial fleets have used CNG for decades. Because natural gas has a lower energy content than liquid fuels derived from oil, natural gas vehicles cannot travel as far on a given volume of fuel. There are currently fewer than 200,000 natural gas vehicles in use.[28] Approximately 15 percent of transit buses are now powered by natural gas (**Figure 14 above**).

There is less concern in the United States about natural gas supply than oil supply. U.S. natural gas consumption is approximately 23 trillion cubic feet per year, with approximately 19 trillion cubic feet (83 percent) produced domestically and 4 trillion cubic feet (17 percent) imported, primarily from Canada.[29] The United States has over 200 trillion cubic feet of natural gas proved reserves,[30] and it probably has more than 600 trillion cubic feet of undiscovered technically recoverable natural gas resources.[31] These values indicate that there should be enough natural gas in the United States for several decades to come. Even so, tight market conditions over the last few years have driven natural gas prices upward.[32] The billionaire businessman T. Boone Pickens has announced a plan to free up natural gas for vehicles by replacing natural gas-fired power plants with wind turbines.[33]

4.2 Electricity

There has been explosive growth and interest in electric vehicle technologies since oil prices began their climb earlier this decade. Electric drive vehicle types range from hybrid electric vehicles, which combine an electric motor with an internal combustion engine, to all-electric vehicles, which contain only an electric motor. Hybrid electric vehicles come in many different configurations. Most use a parallel configuration in which both the engine and motor provide power to the wheels. Others use a series configuration in which the engine keeps the motor charged and only the motor provides power to the wheels. Still other hybrid electric vehicles combine elements of parallel and series design. Hybrid electric vehicles are also often classified by whether they can run entirely on the motor ("full hybrids") or rely primarily on the engine ("power assist hybrids" and "mild hybrids"). Another important distinction is between grid-independent hybrids, which derive all their electric energy ultimately from liquid fuels, and plug-in hybrids, which can draw electric energy from the power grid. Grid-independent hybrids have been sold in the United States for several years now, with eight commercial hybrid models on the U.S. market, whereas plug-in hybrids are developmental and have not yet been introduced commercially.

There are about 1.4 million grid-independent hybrid vehicles on the road today, including the Toyota Insight and Prius.[34] GM plans to produce a plug-in hybrid in 2010 called the Volt, with a battery range of 40 miles. Hybrid buses and trucks are also being tested. All-electric vehicles with only a motor and no engine include the Tesla Roadster, a sports car released this year with a 220 mile range using a lithium-ion battery array.[35] Companies are working to lower the prices of electric vehicles and batteries to make this vehicle technology affordable for more motorists.

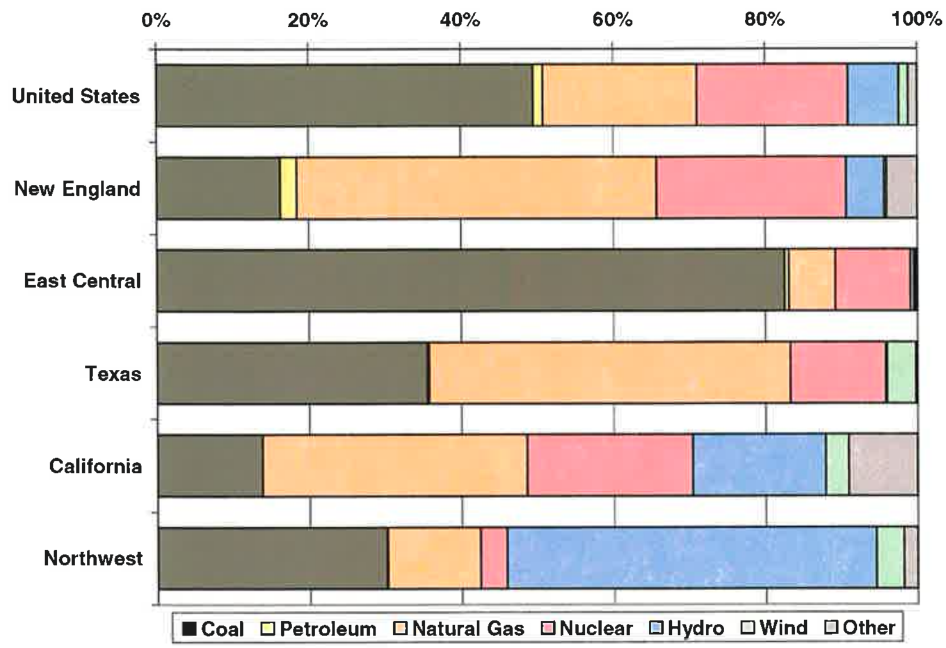
4.3 Hydrogen

Like other energy sources, hydrogen can be used in various ways to power vehicles and can be produced from various feedstocks. It can be stored on the vehicle either as a compressed gas or a cryogenic liquid in a pressurized tank. It can either be combusted much like liquid gasoline in an engine or combined with oxygen in a fuel cell to produce electricity to power a motor, with water as a byproduct. The hydrogen for the fuel cell could be produced from fossil fuels ("reformed") onboard the vehicle, thereby affording some energy efficiency improvements, but not lowering fossil fuel consumption.

> "Honda Motor celebrated the start of production of its FCX Clarity, the world's first hydrogen-powered fuel-cell vehicle intended for mass production…Honda will make just 200 of the futuristic vehicles over the next three years, but said it eventually planned to increase production volumes, especially as hydrogen filling stations became more common."
>
> Martin Fackler, "Latest Honda Runs on Hydrogen, Not Petroleum," *The New York Times*, June 17, 2008

Alternatively, hydrogen can first be produced at central or distributed plants, then delivered to refueling stations and stored onboard the vehicle in either gaseous or liquid form. Producing hydrogen from water via electrolysis is desirable as a renewable process, but if coal and other fossil fuels are used to generate the electricity there may be little or no reduction in "life cycle" CO_2 emissions along the energy supply chain from source to wheels (**Figure C-2 in Appendix C**). To minimize CO_2 emissions from producing hydrogen, the facility could have its own renewable electricity generation station, such as a wind farm, or it could be located in an area with a relatively clean generation mix, such as California or the Northwest (**Figure 19**).

Figure 19. Electricity Generation Mix 2008



Source: EIA, *Annual Energy Outlook 2008*, supplemental tables, June 2008

Note: Not all regions of the country are shown; New England is ME, NH, VT, MA, RI, and CT; East Central is OH, KY, IN, western PA, western VA, and lower MI; Northwest is WA, OR, ID, WY, UT, western MT, and northern NV

Despite great research progress in hydrogen fuels and vehicles through federal programs and industry consortia such as FreedomCAR and the U.S. Council for Automotive Research (USCAR), significant deployment of hydrogen vehicles most likely will not come before 2015.[36] The National Research Council recently found that $200 billion in investment is needed between 2008 and 2023 to make hydrogen fuel cell vehicles cost-competitive with conventional vehicles.[37] The major barrier to deployment of hydrogen vehicles is the need for costly new fuel stations and other distribution infrastructure, such as hydrogen pipelines. Currently, pressurized or cryogenic rail or truck tankers are needed to transport liquid or compressed hydrogen to refueling stations; on-site production at "forecourts" refueling stations is being evaluated.

4.4 Biofuels

Biofuels harness the energy produced by living matter, such as sugars and starches produced by plants through photosynthesis. There are many varieties of biofuels, and current scientific research into biofuels is increasing their number. Probably the most well-known biofuel is ethanol, which in the United States is typically created from corn but can also be created from sugar cane, sugar beets, sweet sorghum, and several other plants. Researchers are developing methods of also producing ethanol from wood, grasses, and other non-edible parts of plants. This would be an important advance for biofuels because these feedstocks are abundant and do not involve trade-offs between food and fuel. Reformulated gasoline actually contains up to

10 percent ethanol by volume.[38] Slight modification to the vehicle fuel system allows vehicles to run on higher ethanol blends such as E85 (nominally 85 percent ethanol and 15 percent gasoline, though the ethanol percentage varies by season).

Another class of biofuels is biodiesel, which is created from vegetable oils, such as from soy or rapeseed, or animal fats, such as from beef or chicken. Diesel vehicles can run on a diesel blend of up to 20 percent biodiesel without modification to the fuel system. New varieties of biofuels under development come from algae or genetically engineered microorganisms. Research in this area is being conducted by small start-up firms, large energy companies such as Chevron, and the Department of Energy.[39]

Biofuel production in the United States is expected to increase rapidly in the coming years. The Energy Independence and Security Act of 2007 mandates production of at least 36 billion gallons of biofuels in 2022 (roughly a quadrupling of current biofuels production[40]), and 21 billion gallons of this must be other biofuel varieties than corn-based ethanol. The Act also has medium-term biofuel production mandates. About 6.5 million vehicles on the road in America today, or 3 percent of the total fleet, are flex-fuel vehicles that can run on either gasoline or ethanol blends up to E85. EIA projects there will be over 30 million flex-fuel vehicles on the road in 2020, nearly three-quarters of which will be trucks.[41]

Key issues related to energy-efficient and sustainable production, transportation, and utilization of biofuels, including food versus fuel issues, are under consideration by the Biomass R&D Board (BRDB), with active DOT participation.

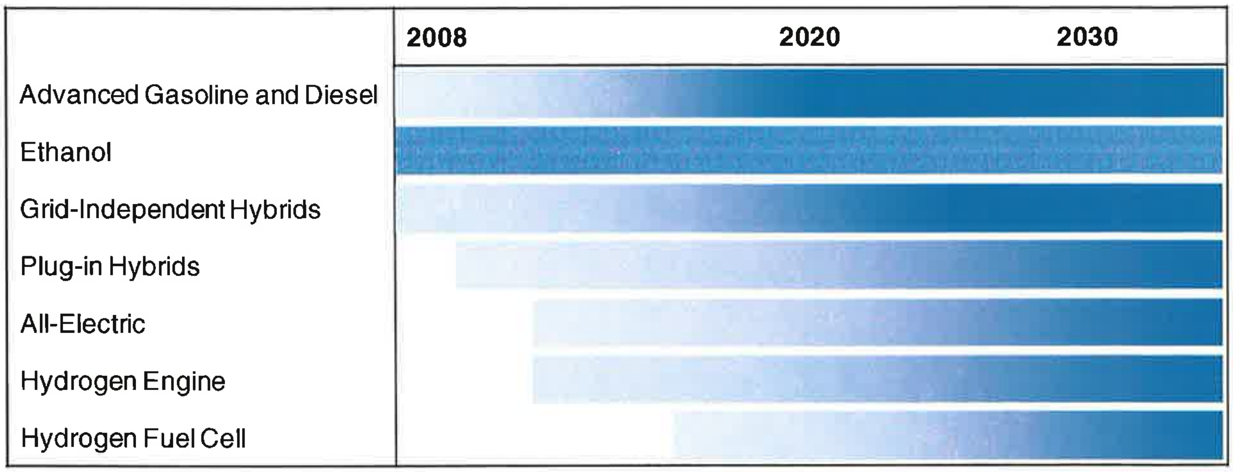
4.5 Nonconventional Oil

Nonconventional oil may be produced either from processing other hydrocarbons than oil, namely coal or natural gas, from tapping other sources than oil fields, or from applying enhanced recovery techniques at oil fields. Coal and natural gas can be converted to liquid fuel through a chemical reaction developed in the early twentieth century called the Fischer-Tropsch process. Other sources of oil besides oil fields include tar sands (also called extra heavy oil or oil sands) and oil shale. Tar sands are mixtures of sand or clay, water, and bitumen, a dense and viscous form of petroleum. Canada currently produces about 1 million barrels per day of oil from tar sands and has large remaining deposits.[42] Oil shale contains kerogen, an organic material that can be distilled to yield oil. The RAND Corporation estimates that U.S. oil shale reserves in Utah, Wyoming, and Colorado contain enough kerogen to produce 5 million barrels of oil per day for more than 400 years.[43] Producing oil from tar sands or oil shale is a more energy-intensive and costly process than conventional oil extraction, and it has various adverse environmental impacts on air, land, and water. An authoritative energy and emissions model developed at Argonne National Laboratory indicates that producing oil from tar sands results in five times more carbon dioxide emissions than conventional oil production.[44]

4.6 Assessment

Potential deployment timelines for alternative fuels and vehicles range from current availability for biofuels and grid-independent hybrids to minimal penetration before 2020 for hydrogen fuel cell vehicles (**Figure 20**). Table 1 below summarizes key issues regarding alternative energy for transportation.

Figure 20. Approximate Deployment Timeline for Advanced Light-Duty Vehicles



Source: Adapted from Anup Bandivadekar, *Evaluating the Impact of Advanced Vehicle and Fuel Technologies in U.S. Light-Duty Vehicle Fleet*, February 2008, p. 96

Note: Darker lines denote more potential deployment; advanced gasoline and diesel vehicles have turbocharging and other fuel-efficiency features; ethanol deployment is assumed to be limited by availability of ethanol feedstock (such as corn and woody biomass); natural gas vehicles are omitted because they do not appear in the source

Table 1. Assessment of Alternative Energy for Transportation

Alternative Energy	Status	Outlook	Costs	Infrastructure	Other Issues
Natural Gas 	~200,000 natural gas light-duty vehicles; ~10,000 natural gas transit buses (out of total fleet of ~80,000)	Penetration into transit bus fleets could speed adoption of natural gas for light-duty vehicle; large gas reserves in the United States	Natural gas vehicle costs ~$7,000 more than conventional vehicle*	New natural gas fueling stations needed; current natural gas pipelines reduce infrastructure challenges	Natural gas prices have also risen in recent years
Electricity 	~1.4 million grid-independent hybrid vehicles; Toyota Prius is 8th ranked car by sales	Plug-in hybrid is expected around 2010; supply chain difficulties could impede battery sales; development of a high energy-density battery entails high risk	Grid-independent hybrid costs ~$3,500 more than conventional vehicle*; plug-in hybrid is expected to cost ~$8,000 more*	Batteries could be rented from new stations; there is sufficient electric generation capacity for majority of fleet to be plug-ins[45]	Upstream energy consumption and emissions depend on local power mix
Hydrogen 	Very few hydrogen-powered light-duty vehicles; some bus demonstration projects	Significant deployment of hydrogen vehicles is not expected before 2015	Hydrogen fuel cell subcompact car currently costs ~$70,000*; price is expected to come down with more R&D	Entire new national infrastructure needed for hydrogen transportation and distribution	Upstream energy consumption and emissions depend on local power mix; hydrogen distribution and storage systems are still being developed
Biofuels 	~6.5 million flex-fuel vehicles; ~0.6 million barrels per day of ethanol, most of which is blended into gasoline; little E85 supply	Large growth is expected from biofuel mandates in Energy Independence and Security Act of 2007	Government subsidies lower biofuel prices; flex-fuel vehicle costs ~$300 more than conventional vehicle*	Expansion of biofuel transportation and distribution infrastructure would facilitate expansion of supply	Trade-off between food and fuel, but biofuels from non-food sources are under development; controversy over net greenhouse gases
Nonconventional Oil 	Little nonconventional oil supply currently (~3.7 million barrels per day) relative to conventional oil (~84 million barrels per day globally)	Large tar sand and oil shale reserves in Canada and the United States; also interest in coal-to-liquids	More expensive than most conventional oil production but perhaps economical given high oil prices	Some new pipelines could be needed	Production of non-conventional oil is very energy- and emissions-intensive relative to conventional oil

* U.S. Energy Information Administration, *Annual Energy Outlook 2008*, Table 60; all vehicle prices are rough modeling estimates

5 Policy Options

5.1 Current Policies and Programs

5.1.1 Fuel Economy Standards

The U.S. government already has several policies and programs in place to reduce oil consumption in transportation and other sectors. Foremost among them is the Corporate Average Fuel Economy (CAFE) program established in 1975 shortly after the Arab Oil Embargo. The CAFE program reduces light-duty vehicle fuel consumption by requiring that manufacturers meet minimum fuel economy levels for their passenger car and light truck fleets or pay a fine. The National Academy of Sciences has estimated that U.S. light-duty vehicle fuel consumption was 14 billion gallons less in 2000 than it would otherwise have been in the absence of the CAFE program. This reduction corresponds to 14 percent of actual fuel consumption in that year.[46] The Energy Independence and Security Act of 2007 mandates substantial increases in CAFE standards beginning with Model Year 2011 vehicles. The Act requires that the average fuel economy of the combined new passenger car and light truck fleets be at least 35 miles per gallon by 2020.

5.1.2 Biofuel Mandates, Driver Programs, and Other Light-Duty Vehicle Policies

The U.S. government encourages biofuel production for vehicle energy use through subsidies and production mandates. Biofuel policy was incorporated into President Bush's "Twenty-in-Ten" initiative announced in his 2007 State of the Union Address to reduce U.S. motor fuel consumption by 20 percent over ten years. This initiative envisions biofuels reducing motor fuel consumption by 15 percent and higher fuel economy standards reducing it by the remaining 5 percent.[47] Other policies and programs targeting light-duty vehicle transportation include carpooling programs, teleworking programs, gas guzzler taxes introduced in the late 1970s, tax incentives introduced earlier this decade for purchasing hybrids, and a multitude of research programs under the Department of Energy. Two researchers at the Harvard Kennedy School have found that state sales tax waivers and federal income tax credits for purchasing hybrids were responsible for 6 percent of hybrid sales between 2000 and 2006.[48] As part of its vehicle technologies program, the DOE announced in June 2008 that it would award $30 million to companies developing plug-in hybrids.[49]

5.1.3 Public Transit, Trucking, and Transportation Infrastructure Policies

Policies and programs targeting other categories of transportation than light-duty vehicles include public transit funding to support infrastructure and lower fares and the 21st Century Truck Partnership under the DOE to boost fuel efficiency in trucking. Most federal funding for rail, maritime, and air transportation systems has not typically been driven by energy policy but can contribute to reducing oil consumption nevertheless. Expansion of rail and maritime networks could reduce oil consumption by diverting freight away from trucking, as discussed in more detail below in Section 5.2.9.

5.1.4 Oil Supply Security Policies

Besides these policies and programs to reduce oil consumption, the U.S. government addresses oil supply security in a number of ways. The Strategic Petroleum Reserve was created in 1975 as a safeguard against a sudden supply disruption. It now contains about 700 million barrels of oil.[50] Based on current U.S. liquid fuel consumption of 21 million barrels per day, the Strategic Petroleum Reserve could satisfy U.S. demand for about 33 days if demand remained unchanged during the supply disruption. Oil supply security is also a factor in some U.S. military operations, particularly in the Persian Gulf region. Two researchers have recently estimated that if there were no oil in the Persian Gulf, U.S. military expenditures might be reduced in the long run by $27 to $73 billion dollars per year.[51]

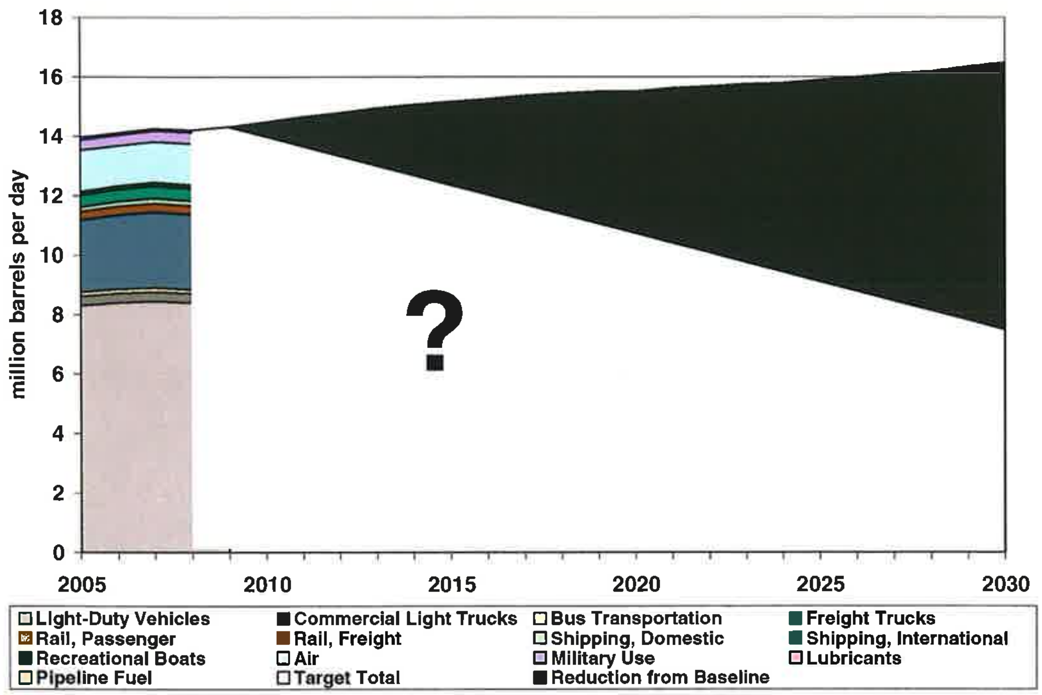
5.2 Assessment of Selected Policy Options

If the national goal were to completely eliminate oil imports by 2030, transportation liquid fuel consumption would need to decrease to about 7.5 million barrels per day based on its share of total U.S. liquid fuel consumption (**Figure 21**). This represents a 46 percent reduction from the current transportation consumption level of about 14 million barrels per day or a 55 percent reduction from the projected business-as-usual transportation consumption level in 2030 of about 16.5 million barrels per day. A reduction of this magnitude would mean revolutionary changes in transportation energy use. Any number of policies targeting light-duty vehicles, air, freight trucks, other freight modes, or any other transportation category could be used toward the goal.

This section provides an assessment of ten selected policy options to lower U.S. oil consumption, particularly in transportation. A more comprehensive list of policy options appears in Table B-1 in Appendix B. Policy options differ from one another in the scale, speed, and costs of reductions; technological, political, and administrative feasibility; possible unintended consequences; and other factors. This section serves as a high-level assessment by providing a brief discussion of the ten selected policy options in terms of some key factors and highlighting major obstacles or trade-offs to consider as more concrete policy ideas take shape.

The selected policy options for DOT consideration would require interagency coordination and outreach to stakeholders to build consensus, as well as Congressional approval and regulatory impact analysis (RIA) before they could be translated into action. In some cases, targeted interagency communication and cooperation would be needed for concerted action: e.g., with the Department of Energy (DOE) on advanced vehicle technologies and fuels; with the Environmental Protection Agency (EPA) for analysis of sustainability, climate change, air quality and other environmental impacts; and with the Federal Energy Regulatory Commission (FERC) on rapid pipeline permitting for biofuels and hydrogen distribution. DOT collaboration with non-profit organizations would also facilitate development of safety standards and vehicle design and operation guidelines.

Figure 21. Reducing Transportation Liquid Fuel Consumption to 7.5 MMBPD by 2030



Source: Baseline oil imports and transportation liquid fuel consumption and EIA, *Annual Energy Outlook 2008*, June 2008

5.2.1 Price Floor on Oil or Liquid Fuels

Establishing a price floor on oil or liquid fuels would send a clear signal that the United States seeks to move beyond oil for the long term. This policy would continue and accelerate the shift away from liquid fuels that the oil price surge has prompted. Advocates for price floors or higher prices include Alan Greenspan, columnists Thomas Friedman and Charles Krauthammer, and Senator Richard Lugar.[52]

The price floor would encourage American motorists to purchase vehicles with high fuel economy because it would change how they weigh up-front vehicle costs against expected fuel costs over the vehicle lifetime. More consumers would choose energy-efficient vehicles if they knew that fuel prices would remain high. There would be a guaranteed market for energy-efficient vehicles, leading to increased research and development in this area. The price floor would also stimulate research and development in alternative fuels and energy sources by eliminating much of the market risk that clean tech businesses would otherwise face. In addition, the price floor would facilitate investment in public transit, rail networks, and marine networks because they would appear more attractive relative to highway transportation.

The government could apply price controls on oil or adjust federal excise taxes on gasoline, diesel, and other liquid fuels to ensure that prices follow a target trajectory. For example, to maintain gasoline prices above $4 per gallon so that consumer investments in advanced vehicles certainly pay off and companies allocate more money to research and development, the government could raise federal excise taxes on gasoline, which are currently 18.4 cents per gallon. Taxes would rise as oil prices fall and vice versa to keep gasoline prices at the target level. If oil prices remain high enough to keep the gasoline price above, say, $4 per gallon, taxes would not need to be adjusted, which would improve the political viability of this policy option. Taxes would only need to increase if oil prices crossed below a threshold. Revenue from increased taxes could shore up the Federal Highway Trust Fund. The price control could also apply to oil rather than liquid fuels, as Senator Lugar has proposed.[53]

> "[T]he energy economist Philip Verleger Jr. [proposes] a 'price floor' for gasoline: $4 a gallon for regular unleaded, which is still half the going rate in Europe today. Washington would declare that it would never let the price fall below that level. If it does, it would increase the federal gasoline tax on a monthly basis to make up the difference between the pump price and the market price. To ease the burden on the less well-off, 'anyone earning under $80,000 a year would be compensated with a reduction in the payroll taxes,' said Verleger. Or, he suggested, the government could use the gasoline tax to buy back gas guzzlers from the public and 'crush them.'"
>
> Thomas Friedman, "Truth or Consequences," *The New York Times*, May 28, 2008

This policy is similar in some regards to increased fuel economy standards but could reduce fuel consumption across all sectors rather than just light-duty vehicle transportation. The scale of the reduction would depend on the level of the price floor or tax increase. Costs could be relatively low, especially if target prices only changed gradually. The short-term effects might be small, especially if the price floor is below current oil prices, but the long-term effects could be quite large. Previously proposed "carbon taxes" and "feebates" to incentivize the market penetration of energy-efficient vehicles are also related to this option, although they could be considered a non-market intervention and an additional tax burden.

5.2.2 Carpooling, Teleworking, and Shorter Work Weeks

U.S. policy makers could perhaps reduce light-duty vehicle usage and oil consumption substantially by encouraging people to change their private transportation habits for work. The data on work-related vehicle usage suggest that encouraging carpooling, teleworking, and shorter work weeks could potentially have a large impact on U.S. oil consumption. Based on survey data from 2001, the typical American household drives about 5,700 vehicle-miles per year to and from work, about 1,700 vehicle-miles for work-related business, and about 21,200 vehicle-miles in total. Work-related travel is thus more than one-third of the typical household's annual travel measured in vehicle-miles. On average, vehicle occupancy is only 1.1 for trips to and from work. Based on the 2000 Census, more than 110 million Americans use a private vehicle to travel to and from work. Only about 14 million of them, or 13 percent, carpool. Since light-duty vehicles consume a large share of U.S. liquid fuel supply and much of light-duty vehicle usage is for work, it appears that policies aimed at work-related vehicle usage could have a big effect. IEA estimates that encouraging carpooling, teleworking, and shorter work weeks could together reduce U.S. liquid fuel consumption by about 10 percent.[54] Yet previous and current government programs to promote carpooling and teleworking have had limited success, as carpooling rates have fallen over the past twenty years and VMT has increased up to last year.[55]

To carry out this policy, the government could designate some highway lines as high-occupancy vehicles lanes for carpooling, create or designate park-and-ride lots, match potential carpooling partners, and launch informational campaigns about carpooling, teleworking, and shorter work weeks. The federal government could most easily influence carpooling, teleworking, and work week length for the federal work force, but the policy would need to reach state, local, and private work forces to have a larger impact. The costs of this policy could be relatively low, but it could require larger administrative resources than some other policies. The government would need to examine why previous and current programs have had limited success to improve the effectiveness of new efforts to encourage carpooling, teleworking, and shorter work weeks.

5.2.3 Increased Fuel Economy Standards

Increased fuel economy standards are a powerful means of reducing U.S. oil consumption because light-duty vehicles consume such a large part of U.S. liquid fuel supply. The slow turnover of the light-duty vehicle fleet limits the short-term effects of new vehicle fuel economy standards, however. In analyses for the fuel economy rulemaking, passengers cars are assumed to remain in use for up to 26 years and light trucks for up to 37 years.[56] It therefore takes several decades for the fleet to consist entirely of vehicles meeting the increased fuel economy standards. Vehicles with relatively low fuel economy stay in the fleet for a long time unless vehicle scrappage is accelerated, an additional policy option that appears in Table B- but is not discussed in this section.

The National Highway Traffic Safety Administration (NHTSA) is preparing new regulations on passenger car and light truck fuel economy for Model Years 2011-2015. The regulations would put the country on track to reach a combined average fuel economy of 35 miles per gallon across the new passenger car and light truck fleets by 2020, as mandated by the Energy Independence and Security Act of 2007. The "optimized" set of fuel economy standards under consideration, at which the marginal costs of fuel economy technologies equal the marginal benefits of reduced fuel use, would reduce passenger car and light truck fuel consumption in 2020 by about 7 percent, from 148 billion gallons to 138.3 billion gallons. The proportional reduction rises to 11 percent by 2060.[57]

Appendix B presents modeling results for hypothetical light-duty vehicle fleet scenarios with various fuel economy levels.

5.2.4 Tax Credits for Purchasing Advanced Vehicles

As mentioned above in Section 5.1.2, the U.S. government uses tax credits on federal income tax to encourage people and businesses to purchase or lease hybrid vehicles. The tax credit reduces federal income tax liability on a dollar-for-dollar basis and can eliminate tax liability altogether. The current policy, set by the Energy Policy Act of 2005, provides for tax credits up to $3,400; the amount depends on the fuel economy of the hybrid vehicle, its weight, and the number of vehicles that have already been sold. The tax credit is phased out after the manufacturer has sold 60,000 vehicles of the qualifying model.[58] Some states also waive sales tax on hybrid vehicles.

To achieve larger reductions in U.S. oil consumption from this policy, the tax credit could apply to more vehicles and the amount could be increased. The tax credit could be extended beyond hybrid vehicles to highly energy-efficient vehicles with conventional power systems. The main trade-off is that federal income tax revenue is reduced; in addition, the tax code becomes even more complicated whenever it is used to promote specific policy goals. Another potential constraint is manufacturers' ability to meet the increased demand for advanced vehicles induced by the tax credit. Since Toyota already has difficulty producing hybrid vehicles fast enough to fill its orders,[59] a sudden surge in demand due to tax credits could be too much for the nascent hybrid vehicle industry. If the tax credit is going to apply to many vehicles and be a large inducement, it would probably be necessary to give manufacturers adequate time to prepare for the increased demand, but then the reductions in oil consumption are delayed.

5.2.5 Accelerated Vehicle Scrappage

Alan Blinder, an economist at Princeton University, has recently proposed a "cash for clunkers" program in which the government purchases old cars with high pollution rates and then scraps them.[60] Blinder believes the program would perform a "public policy trifecta" by "stimulating the economy, improving the environment, and reducing income inequality all at the same time." Several areas in the United States have used similar programs to improve air quality, and President George H.W. Bush proposed a similar nationwide program in 1992.[61]

The United States has approximately 35 million light-duty vehicles fifteen years old or older,[62] most of which have relatively low fuel economy and relatively high emission rates compared to newer vehicles. The government could offer a premium over market prices, up to a maximum value, to the owners of old vehicles. Another possible program would target newer vehicles with low fuel economy, such as sport utility vehicles, but the price would then have to be higher because the vehicles are more valuable. Other possible inducements besides cash to accelerate vehicle scrappage are public transit passes and rebates or tax credits for a new energy-efficient vehicle.

> "Canada's Environment Minister, John Baird, today was joined by the Clean Air Foundation to launch a National Vehicle Scrappage Program, which will offer incentives to people who retire their 1995 or older model vehicles. This program will be fully operating by January 2009, and will encourage people to scrap their gas-guzzling vehicles and to turn to environmentally-friendly transportation. The incentives include public transit passes, bicycles, a rebate on the purchase of a new car, membership in a car-sharing program, or $300 cash."
>
> Environment Canada, "Government of Canada and Clean Air Join Forces to get Gas-Guzzlers Off the Road," June 4, 2008

This type of program would have to be designed carefully, for it would have a number of direct and indirect consequences. First of all, the types of eligible vehicles and payment methods must be determined. The government outlay per vehicle, whether in the form of cash, transit passes, sales rebates, or tax credits, must be high enough to take a significant number of vehicles off the road but not so high that the costs of the program exceed its benefits. Just as for the tax credit policy, the reduction in U.S. oil consumption from a "cash for clunkers" program would depend on how many vehicles are eligible for government purchase and how much the government offers to pay for each. In administering the program, the government should ensure that it does not pay for vehicles that would not be driven anyway, as this would provide no social benefits. Testing the roadworthiness of vehicles before purchasing them may not be sufficient to avoid this policy pitfall.

The economist Steven Levitt has pointed out some potential drawbacks to this policy from reasoning through its market impacts.[63] Suppose the government offered to pay 20 percent above market prices for vehicles at least fifteen years old. Some people who otherwise would scrap vehicles somewhat less than fifteen years old would instead continue driving them to receive the high government price when the vehicles became eligible. This effect arising from the perverse incentive to forego scrappage would offset program benefits. The program would also probably raise the price of used cars not yet eligible for government purchase. If people who sell their vehicles under the program look for other used vehicles as replacements, they might be worse off even with the generous government payment. If they cannot afford to purchase a replacement vehicle, their mobility may decrease under the program. This concern is particularly acute because old vehicles potentially eligible for government purchase are disproportionately owned by poor people.

5.2.6 Investment Assistance for Vehicle Remanufacturing and Assembly Plants

The government could hasten deployment of advanced vehicles by assisting vehicle manufacturers with assembly plant investments. A researcher at MIT has estimated that capital costs for converting an assembly plant to produce 200,000 hybrid vehicles per year would come to $330 million.[64] As roughly 14 million new light-duty vehicles are sold each year, the capital costs necessary for producing several million hybrids or advanced vehicles of other types could be several billion dollars.

The government could provide investment assistance in a number of ways. It could provide loan guarantees to lower loan interest rates. Paul Williamson at the University of Montana, Missoula has proposed a National Alternative Energy Bond Fund with a value of about $10 trillion collected from fees on fossil fuel production and consumption and on vehicles with low fuel economy. Companies and entrepreneurs could apply for low-interest loans from the fund to finance alternative and advanced energy projects with large capital costs. Alternatively, the federal government or a quasi-governmental organization could sell Energy Independence Bonds for the same purpose to individuals and companies. Bond interest would be paid through federal income tax credits. In other words, bondholders would be able to reduce their income tax liability by an amount corresponding to the bond interest. This would amount to a taxpayer subsidy for investment in alternative and advanced energy. Tax-credit bonds probably have higher administrative costs and larger fiscal effects than Treasury bonds. The Congressional Budget Office has concluded that "using tax-credit bonds to fund programs that could be funded through federal appropriations would cost the federal government more per dollar than it would have to pay if it used its conventional financing method of issuing taxable bonds through the Treasury." [65]

5.2.7 Modified Driver Behavior

An educational campaign to promote energy-efficient driver behavior could achieve significant and immediate reductions in U.S. oil consumption. The DOE and EPA already make information on energy-efficient driving available to the public online.[66] Techniques for maximizing gas mileage fall into three categories: driving more efficiently, keeping vehicles in good shape, and planning trips carefully. Driving more efficiently holds the largest potential benefits in terms of reduced fuel consumption. Drivers can improve their actual gas mileage

> "[Natural Resources Defense Council's] new analysis shows that real relief measures aimed at getting the greatest possible efficiency out of the cars on the road now hold great promise. For the driver of a vehicle with an average fuel efficiency rating, taking advantage of these options and utilizing alternative transportation once each week can save about $800 [200 gallons] per year. Further, these measures can be adopted immediately and at little cost."
>
> Natural Resources Defense Council, "Tune Up America: Real Relief for High Gas Prices," July 2008

by between 5 and 33 percent by keeping a steady speed, accelerating slowly, and braking as little as possible. Driving at the optimal speed can lower fuel consumption by between 7 and 23 percent. Other techniques in this category include removing excess weight, avoiding excess idling, and using cruise control. Vehicle maintenance for maximum gas mileage involves keeping the engine properly tuned (approximately 4 percent fuels savings), checking and replacing air filters regularly (up to 10 percent savings), keeping tires properly inflated (up to 3 percent savings), and using the right motor oil (up to 2 percent savings). Drivers can reduce their fuel consumption through trip planning by combining errands to lower the number of cold starts and by avoiding congestion.

David Greene, an energy analyst at Oak Ridge National Laboratory, has stated in Congressional testimony that typical drivers can reduce their fuel consumption by about 10 percent by practicing the techniques listed above.[67] The reduction may seem small, but it applies to all vehicles on the road and requires no lead time. The government can encourage energy-efficient driver behavior by providing the public with gas mileage tips, as DOE and EPA already do. To increase the number of people adopting energy-efficient techniques, the government could launch a more extensive educational campaign, perhaps with notices on television and in newspapers. It is difficult to change habits, however, and so a long-term educational campaign may be necessary for long-term effects.

5.2.8 Public Transit Vouchers or Reimbursement

As noted above, public transit ridership in the United States is miniscule compared to private vehicle usage. Americans make about 300 billion private vehicle trips per year and10 billion public transit trips. Based on the 2000 Census, only about 6 million Americans use public transit to travel to and from work, compared to 110 million who use a private vehicle. More than half of work-related public transit ridership is by bus. The number of Americans using public transit for work-related travel has stayed relatively constant over the last twenty years despite a sizeable increase in the U.S. work force.[68]

The government could raise public transit ridership by providing transit vouchers or reimbursement to many more people than currently are eligible to receive these benefits. For example, the government could provide these benefits to American households living below the poverty line or to residents of cities with high light-duty vehicle usage, such as Houston and Atlanta. In addition to reducing U.S. oil consumption, this would soften the economic impact of high oil prices on American households. Providing the benefits to poor Americans would address social equity concerns associated with high fuel prices.

The effectiveness of transit vouchers and reimbursement for reducing U.S. oil consumption might be constrained by transit capacity. There may be inadequate transit capacity to carry all the people wishing to use transit because the government is paying for the ride. Limited transit capacity would be an especially important issue for the rural poor who do not live near transit networks. This policy option could therefore perhaps be coupled with expansion of public transit networks. The costs of this policy option to the federal government would depend on how many people received the benefits and the maximum level of vouchers or reimbursement.

5.2.9 Expanded Rail and Marine Networks

Expanding rail and marine networks would reduce U.S. oil consumption by shifting freight transportation from trucks to more fuel efficient modes. According to the Texas Transportation Institute, the energy efficiency of freight trucking is about 155 ton-miles per gallon, compared to about 413 ton-miles per gallon for freight rail and 576 ton-miles per gallon for marine shipping.[69] Expanding rail and marine networks would probably be advantageous even without the reduction in U.S. oil consumption, as these networks are currently under stress as freight flows increase. A MARAD report notes that "to sustain expected growth, it is estimated the U.S. must expand its overall port capacity by 10 percent annually…The greater use of America's Marine Highways is one answer to congestion on our highways and railroads. The use of vessels could reduce major bottlenecks, such as bridges and tunnels, as well as congested interstates, such as I-95 which parallels the U.S. Atlantic coastwise routes. Properly developed, the Marine Highway can greatly relieve the increased stress on the overall transportation system…The use of Marine Highways can reduce overall fuel consumption and limit the amount of air pollution." [70] Further study would be necessary to evaluate the scale, speed, and cost of reducing fuel consumption through expansion of rail and marine networks.

5.2.10 Energy-Related Research, Development, Demonstration, and Deployment (RD3) and Policy Analysis

Increasing energy-related RD3 and policy analysis is a broad policy option that could take many forms. For example, it could range from increased federal funding for advanced vehicle research to expanded public-private partnerships to detailed analysis of specific alternative strategies. Although the DOE oversees most federal energy research, DOT has an important role to play as well for energy issues related to transportation. Possible DOT actions within RD3 and policy analysis include the following:

- Support for "low-cost / no-cost" transportation demand reduction
- "No regrets" and "building block" strategies to enable development, testing, and evaluation of advanced vehicles, such as hybrid, all-electric, and hydrogen vehicles
- Multi-modal coordination and cooperation across DOT administrations
- Expanded cooperation between federal agencies, state and local organizations, industry, and academia on demonstration projects for energy-efficient transportation
- Exploiting regional strengths using the University Transportation Research Center (UTRC) network as the nucleus for transportation expertise
- Drawing other administrations than FHWA and FTA into the UTRC network to leverage its funding and expertise

5.2.11 Summary

Table 2 summarizes the assessment of the ten selected policy options in terms of the scale, speed, and cost of reductions in U.S. oil consumption as well as their technological, political, and administrative feasibility. No policy option appears optimal with respect to all evaluation criteria. Ranking the policy options would depend on which evaluation criteria are most important (for example, whether it is more important to have large reductions or fast reductions). Conclusions and recommendations from this assessment are presented in the next section.

Table 2. Assessment of Selected Policy Options

Policy Option	Large Reductions?	Fast Reductions?	Low Cost?	Tech. Feasible?	Pol. Feasible?	Admin. Feasible?
Price Floor on Oil or Liquid Fuels	✓ Shift away from oil across all sectors	~ Gradual shift, esp. if floor starts low	✓ Flexible market mechanism	✓ Full technological flexibility	✗ Unpopular, esp. when prices already high	✓ No major admin. issues anticipated
Carpooling, Tele-working, Shorter Work Week	~ Limited success so far from programs	✓ Reductions could begin immediately	✓ Low costs to gov. and private sector	✓ No tech. issues	✓ Generally popular	✓ No major admin. issues anticipated
Increased Fuel Economy Standards	✓ Potentially large change for LDV fleet	✗ Fleet turnover takes more than a decade	~ Inflexibility lowers cost-effectiveness	~ Manufacturers claim tech. challenges	~ Public support but industry opposition	✓ Rulemaking already underway
Tax Credits for Purchasing Ad-vanced Vehicles	~ Depends on vehicle eligibility and credit	~ Some acceleration in fleet turnover	~ Significant reduc-tion in tax revenue	~ Perhaps impossible to meet new demand	✓ Tax breaks are always popular	✓ No major admin. issues anticipated
Accelerated Vehicle Scrappage	~ Depends on vehicle eligibility and price	✓ Immediate reduction in vehicle fleet	~ Significant outlay by federal gov.	✓ No tech. issues	~ Concern about sellers' mobility	~ Gov. would need to check eligibility
Investment Assis-tance for Vehicle Plants (e.g., Bonds)	✓ Potentially large change for LDV fleet	✗ Fleet turnover takes more than a decade	✗ Large federal outlay (but public benefits)	~ Unclear which techs. to focus on	~ Skepticism about gov. in business	~ New admin. role for gov. involvement
Modified Driver Behavior	~ Approximately 10 percent	✓ Reductions could begin immediately	✓ Low costs to gov. and private sector	✓ No tech. issues	✓ No major political issues anticipated	~ Long-term driver education campaign
Transit Vouchers or Reimbursement	~ Reductions limited by transit capacity	✓ Reductions could begin immediately	✗ Large federal outlay (but public benefits)	✓ No tech. issues	✓ Generally popular, esp. for social equity	~ New admin. role for distribution
Rail and Marine Networks	~ Freight oil con-sumption rel. small	✗ Network expansion would take long time	✓ Investment needed anyway for trade	✓ No tech. issues	~ Public opposition can impede permitting	✓ No major admin. issues anticipated
RD3 and Policy Analysis	✓ Potentially large change across sector	~ RD3 may not yield results in short term	~ Some RD3 has low cost-effectiveness	~ Unclear which techs. to focus on	✓ Generally popular	✓ No major admin. issues anticipated

Notes: ✓ = Yes, ✗ = No, ~ = Moderate / Uncertain; RD3 is research, development, demonstration, and deployment

6 Conclusions and Recommendations

The recent increase in oil prices could be a price spike that soon subsides, or it could mark the beginning of an age of high oil prices. Although the EIA and other energy modeling organizations predict that oil prices will fall to around $80 per barrel in the near term, there are many reasons to believe that oil prices may well remain above $100 per barrel or rise further. Rapid growth in world oil demand, slow growth and potential decline in supply, the weak dollar, rising costs for upstream oil activities, geopolitical risks, and perhaps financial markets are putting upward pressure on oil prices. Given the uncertainty in future oil prices and the possibility of a supply disruption, it would seem most prudent to reduce U.S. vulnerability to the extent feasible. A long-term energy policy with particular focus on transportation could also mitigate the negative impacts of the current oil price surge.

High oil prices are having severe adverse effects on the U.S. transportation system because it relies almost exclusively on liquid fuels derived from oil. Mobility is decreasing as American motorists cope with $4 gasoline by driving less. The increased attractiveness of public transit relative to private vehicle usage is putting a strain on transit systems, which only have sufficient capacity to handle a small fraction of total passenger trips and are reluctant to raise fares to cover higher fuel costs. Poor Americans in rural areas are hit hardest by high oil prices because they frequently must travel long distances and their transit options are limited, but the economic burden is widely felt across the country. Transportation industries in trucking, air travel, and vehicle manufacturing are suffering from sudden and drastic changes in their business environment.

Federal policy makers have many options to reduce oil consumption in transportation and other sectors. Policy makers should consider Table B-1 in Appendix B as a menu of options from which to make multiple selections. No single policy measure by itself will enable the United States to achieve energy independence in the near term, but a package of measures could substantially reduce its dependence on foreign energy sources in the long term. Most policy options reduce oil consumption gradually, with large effects coming several years or decades after the policy is introduced. It is therefore critical that the government take action now to set the country on a path toward secure and sustainable energy.

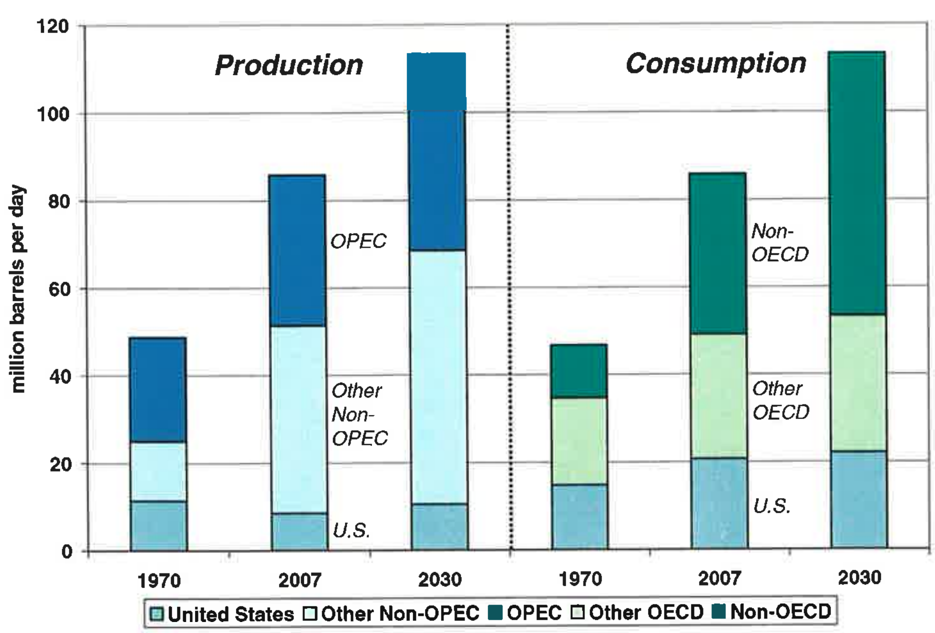
The assessment of ten selected policy options in Section 5.2, summarized in Table 2, indicates that each policy option has its pros and cons. Increased fuel economy standards, for example, could achieve large reductions in U.S. oil consumption but have long lead times. Providing transit vouchers or reimbursement could reduce oil consumption immediately but may not result in large reductions unless transit capacity is expanded. Several policy options have technological, political, or administrative issues that threaten their feasibility.

An ambitious and far-reaching energy strategy is vital to protect the country from high oil prices and potential supply disruptions in the future. More energy-related research, development, demonstration, and deployment (RD3) and policy analysis are certainly necessary, but not

Appendix A: Details on World and U.S. Oil Production and Consumption

This appendix provides additional information on world and U.S. oil production and consumption to supplement Section 2. Annual world oil production and consumption increased by nearly 70 percent between 1970 and 2007, and by 2030 they are expected to grow another 30 percent (**Figure A-1**). Note that neglecting any changes in oil stocks like the U.S. Strategic Petroleum Reserve, world production must equal world consumption at all times. OPEC production is projected to remain relatively constant between 2007 and 2030, while production in non-OPEC countries, such as Russia and Brazil, is projected to grow. U.S. production fell between 1970 and 2007 but is expected to rise somewhat in the coming decades. Most of the increase in oil consumption will likely come from non-OECD countries, such as China and India. The United States will have less influence in both world oil production and consumption in the future as its shares of the total decline.

Figure A-1. World Liquid Fuel Production and Consumption 1970 - 2030

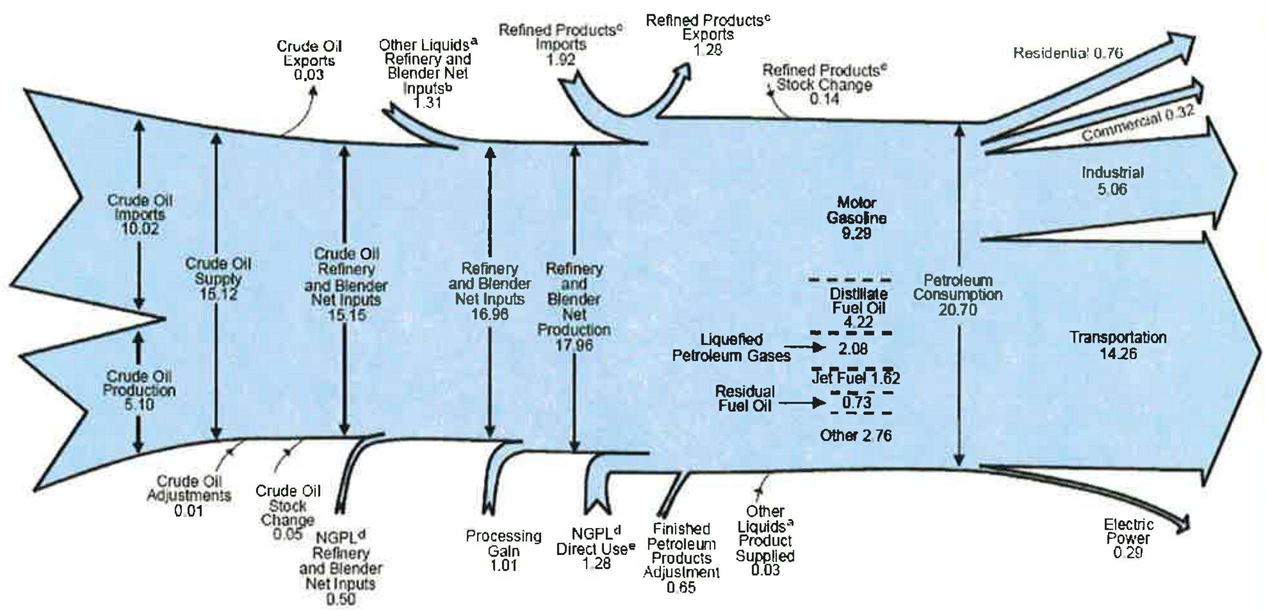


Source: EIA, *International Energy Review 2007*, June 2008 and *Annual Energy Outlook 2008*, June 2008

The United States has a daily oil supply of approximately 15 million barrels, of which 5 million barrels are produced domestically and 10 million barrels are imported (**Figure A-2**). The United States exports only about 0.03 million barrels of oil per day. Oil is not the only refinery feedstock to produce liquid fuels for consumption; other feedstocks include natural gas plant liquids and blending components, such as ethanol. The United States also imports nearly 2 million barrels per day of refined products to supplement its own domestic liquid fuel production. The total U.S. liquid fuel supply is about 21 million barrels per day, nearly half of which is gasoline. Transportation consumes about 14 million barrels of liquid fuels per day, or more than two-thirds of U.S. liquid fuel supply.

While petroleum is the key input in gasoline production, gasoline prices do not move in lockstep with petroleum prices. Disruptions or expected disruptions to the U.S. refining capacity can cause gasoline prices to spike, even when petroleum prices are steady or falling. Gasoline prices spiked in the face of Hurricane Ike in September 2008 while petroleum continued its steady three-month fall in prices, as shown in figure A-3. Hurricane Ike ended up having a less severe impact on refining capacity than expected and the gasoline price spike was short-lived.

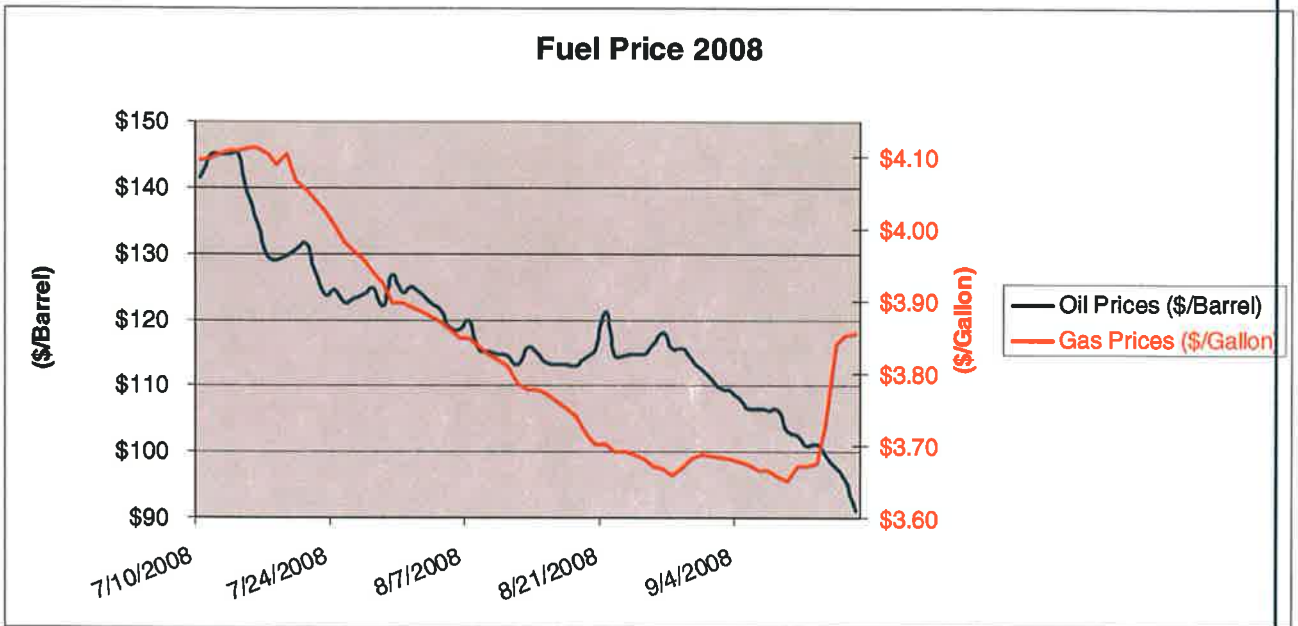
Figure A-2. U.S. Liquid Fuel Supply 2007 (million barrels per day)



Source: U.S. Energy Information Administration (EIA), *Annual Energy Review 2007*, February 2008

Notes:
(a) Unfinished oils, other hydrocarbons/hydrogen, and motor gasoline and aviation gasoline blending components
(b) Net imports (1.41) and adjustments (-0.05) minus stock change (0.02) and product supplied (0.03)
(c) Finished petroleum products, liquefied petroleum gases, and pentanes plus
(d) Natural gas plant liquids (hydrocarbons in natural gas that are separated from the gas as liquids through the process of absorption, condensation, adsorption or other methods)
(e) Production minus refinery input

Figure A-3. U.S. Crude Oil and Gasoline Prices



Appendix B: List of Policy Options

Policy options to address high oil prices and potential supply disruptions take as their objective either lowering oil prices or reducing oil consumption. Both types of policy option lessen the impact of price spikes because costs are the product of prices and quantities. The two objectives directly conflict with each other, however, as lower prices generally lead to higher consumption. Lowering oil prices may be the principal short-term objective when price spikes occur. Reducing oil consumption, on the other hand, may be the principal long-term objective to mitigate the potential impact of future price spikes. The United States becomes less vulnerable to price spikes and supply disruptions as U.S. oil consumption is reduced. Policy makers can seek both to lower oil prices and reduce oil consumption in response to price spikes but should recognize the interplay between the two objectives.

Table B-1 provides a more comprehensive list of policy options to lower oil prices and reduce oil consumption than those considered in Section 5.2. The table is broken down into several sub-tables with policy options for the world and U.S. oil markets and various categories of U.S. transportation. The table identifies broad policy goals for each level of policy options and then identifies specific policy measures, policy makers, and stakeholders for each broad policy goal.

Table B-1. Policy Options to Lower Oil Prices and Reduce U.S. Oil Consumption

Policy options in italics are discussed in Section 5.2

World and U.S. Oil Markets

Policy Goal	Policy Option	Policy Makers	Stakeholders
Increase world oil production	Encourage production from spare capacity across globe	Executive, legislative	Other countries
	Encourage investment in new capacity across globe	Executive, legislative	Other countries
Decrease world oil demand	Encourage energy efficiency across globe	Executive, legislative	Other countries
	Discourage energy subsidies across globe	Executive, legislative	Other countries
Reduce world price pressure from oil trading	Strengthen commodity market regulations	Executive, legislative	Oil contract traders
Enhance world and U.S. oil supply security	Add to U.S. Strategic Petroleum Reserve	Executive, leg., IEA	U.S. SPR
	Use U.S. diplomacy and military to prevent shocks	Executive, legislative	Other countries
	Require that U.S. oil producers not export their oil	Executive, legislative	U.S. oil producers
Increase U.S. oil supply	Release oil from U.S. Strategic Petroleum Reserve	Executive, leg., IEA	U.S. SPR
	Open new areas to production	Executive, legislative	U.S. oil producers
	Increase tax incentives for domestic oil production	Executive, legislative	U.S. oil producers
	Encourage nonconventional oil production	Executive, legislative	U.S. oil producers
Reduce U.S. oil consumption	Increase taxes on liquid fuels	Executive, legislative	U.S. oil consumers
	Establish floor on oil price (constant or rising level)	Executive, legislative	U.S. oil consumers
Replace U.S. oil with alternative energy	Increase biofuel mandates	Executive, legislative	U.S. biofuel producers
	Fund biofuel infrastructure	Executive, legislative	U.S. biofuel producers
	Reduce or eliminate biofuel tariffs	Executive, legislative	U.S. biofuel importers
	Increase energy-related RD3 and policy analysis*	Exec. (DOE, DOT), leg.	Energy product manuf.

* RD3 is research, development, demonstration, and deployment

Light-Duty Vehicles (57.8 percent of transportation energy consumption)

Policy Goal	**Policy Option**	**Policy Makers**	**Stakeholders**
Reduce vehicle miles traveled (VMT)	*Encourage carpooling*	Executive (DOT)	LDV drivers
	Encourage teleworking	Executive (DOT)	National workforce
	Encourage shorter work weeks	Executive, legislative	National workforce
	Establish VMT tax	Nat., state gov.	LDV drivers
	Change auto insurance to pay-as-you-drive	Nat., state gov.	LDV drivers
	Expand toll roads	Nat., state gov.	LDV drivers
	Establish congestion pricing	Nat., state, local gov.	LDV drivers
	Ration fuel (e.g., by license plate number)	Exec. (DOT), leg.	LDV drivers
	Increase residential density	Nat., state, local gov.	Planning agencies
Increase fuel economy of vehicle fleet	*Increase new vehicle fuel economy standards*	Exec. (DOT), leg.	LDV manufacturers
	Increase tax incentives for advanced vehicles	Executive, legislative	LDV drivers
	Increase gas guzzler tax	Executive, legislative	LDV drivers
	Establish feebate system	Executive, legislative	LDV drivers
	Mandate retirement of old vehicles	Exec. (DOT), leg.	LDV drivers
	Purchase old vehicles and then scrap them	Exec. (DOT), leg.	LDV drivers
	Establish government contracts for advanced vehicles	Exec. (DOT), leg.	LDV manufacturers
	Provide investment assistance for vehicle plants	Exec. (DOT), leg.	LDV manufacturers
	Express fuel economy as gallons per mile (not MPG)[71]	Exec. (DOT), leg.	LDV drivers
	Increase energy-related RD3 and policy analysis	Exec. (DOE, DOT), leg.	LDV manufacturers
Modify driving behavior	Set optimal speed limits for fuel economy	Nat., state, local gov.	Highway authorities
	Improve traffic flow around optimal speed	Nat., state, local gov.	Highway authorities
	Launch educational campaign on driving behavior	Nat., state, local gov.	LDV drivers

Appendix C: Modeling Analysis of Light-Duty Vehicle Fleet

Volpe Center staff created a light-duty vehicle fleet model specifically for this analysis. The model incorporates information from the EIA *Annual Energy Outlook 2008* and the GREET model on vehicle energy consumption and emission rates developed by Argonne National Laboratory. The model generates similar outputs to the VISION model developed by Argonne National Laboratory and the CAFE fleet model developed by the Volpe Center but is completely independent of these other models.

The present modeling analysis does not directly draw on or conform exactly to modeling for the ongoing CAFE rulemaking. There is consistency across the models, however. The "business-as-usual" baseline case for this modeling analysis reflects the assumption that average fuel economy across the new passenger car and light truck fleets will rise to 35 miles per gallon by 2020 as mandated by the Energy Independence and Security Act of 2007. In other words, the "business-as-usual" baseline case incorporates increased fuel economy standards consistent with the new standards NHTSA is developing in the CAFE rulemaking.

C.1 Modeling Methodology and Inputs

The fleet model estimates light-duty vehicle petroleum consumption and CO_2 emissions under hypothetical new vehicle mixes and vehicle retirement scenarios between 2010 and 2030. The fleet model handles ten types of vehicles for both passenger cars and light trucks: conventional gasoline vehicles, advanced gasoline vehicles, conventional diesel vehicles, advanced diesel vehicles, ethanol vehicles, grid-independent hybrids, plug-in hybrids, all-electric vehicles, hydrogen vehicles with internal combustion engine technology, and hydrogen vehicles with fuel cell technology. The model estimates light-duty vehicle petroleum consumption and CO_2 emissions for the vehicle fleet based on the number of vehicles with each technology in the fleet. Each new vehicle fleet between Model Year 2010 and 2030 has a different mix of vehicle technology, and the attributes of vehicle technologies change over time. The fleet model captures gradual changes in the vehicle fleet as new vehicles enter it and old vehicles are eventually scrapped. The composition of the vehicle fleet changes slowly because passenger cars are assumed to remain in use for 28 years and light trucks for 40 years. Retirement rates can be adjusted as modeling parameters but are constant across the modeling scenarios presented here.

Total vehicle miles traveled and vehicle usage per year are the same in all modeling scenarios as in the CAFE modeling analysis. These assumptions coupled with constant vehicle retirement rates imply that vehicle sales quantities and the total number of vehicles in the fleet are also the same across all modeling scenarios. Petroleum consumption and CO_2 emissions are calculated from rates per 10,000 miles and model results on total distance traveled by vehicle type per year. Petroleum consumption and CO_2 emission rates derive from the GREET model developed at Argonne National Laboratory. The rates reflect both upstream or "source-to-tank" energy consumption and vehicle or "tank-to-wheels" energy consumption. The GREET values indicate that alternative fuels and vehicles could greatly reduce life cycle petroleum consumption per mile traveled (**Figure C-1**). Reductions in CO_2 emissions per mile are significant but smaller than reductions in petroleum consumption (**Figure C-2**). Petroleum consumption and CO_2 emission rates are measured per 10,000 miles because this is roughly the distance an average vehicle travels per year.

Figure C-1. Passenger Car Petroleum Consumption per 10,000 Miles

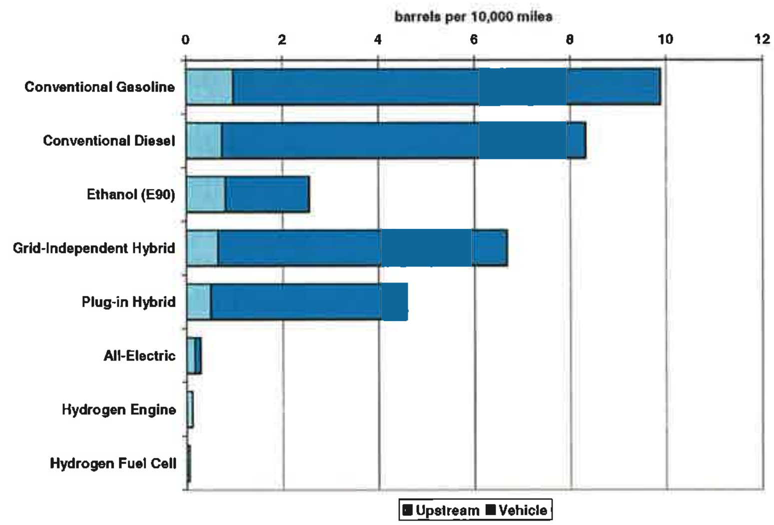
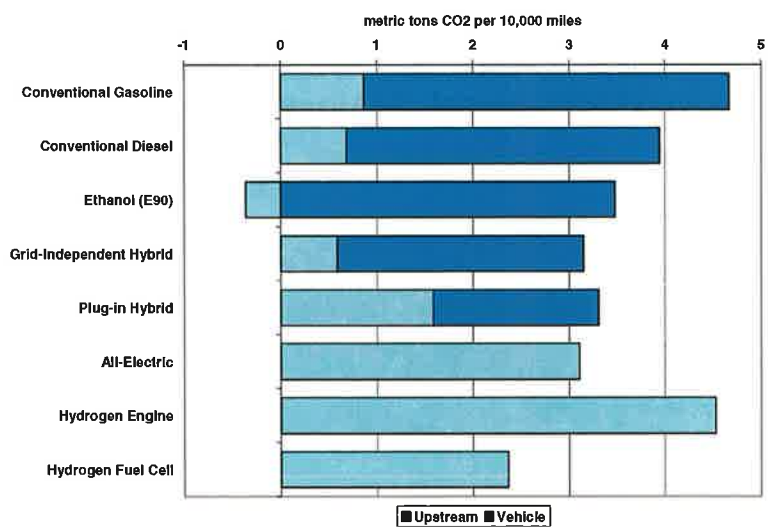


Figure C-2. Passenger Car CO_2 Emissions per 10,000 Miles



Source: GREET 1.8a

Note: Passenger cars in 2010; marginal and average electricity generation from U.S. power mix; hydrogen produced from natural gas; negative upstream CO_2 emissions for ethanol due to CO_2 absorption in crop feedstocks and soil

Figure C-3. Baseline Scenario: Light-Duty Vehicle Sales (left) and Fleet (right)

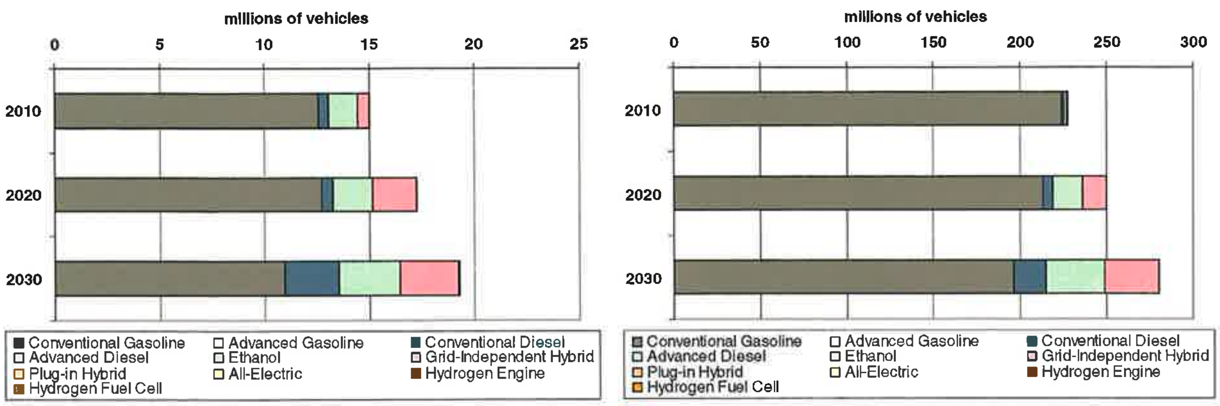
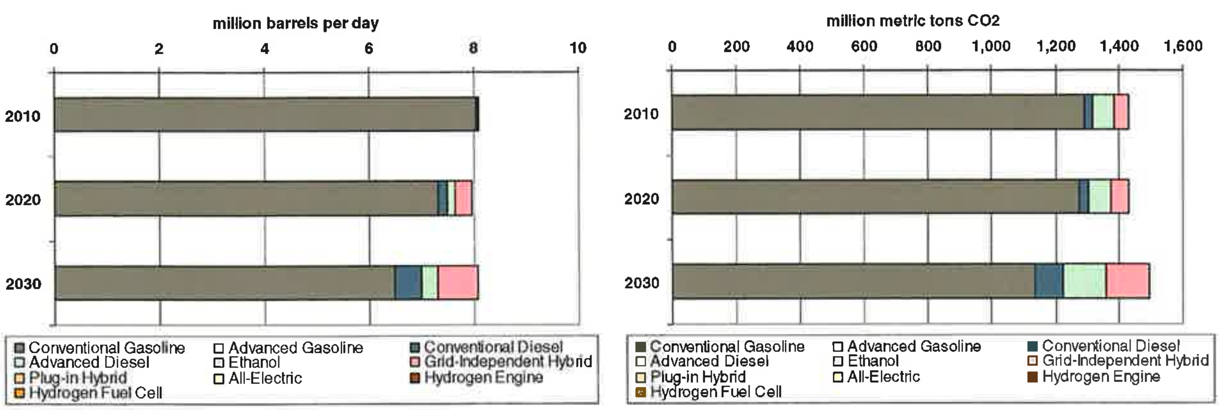


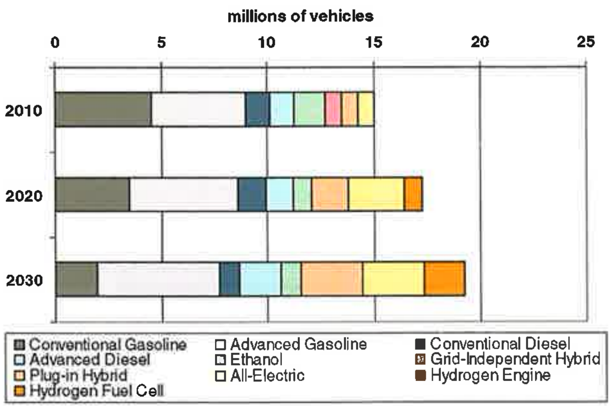
Figure C-4. Baseline Scenario: Light-Duty Vehicle Petroleum Consumption (left) and CO_2 Emissions (right)



Source: Volpe Center modeling as explained in text

Advanced vehicle sales far outnumber conventional vehicle sales in the "more rapid deployment" scenario, but the fleet is still dominated by conventional vehicles out to about 2020 because it has so many conventional vehicles from before 2010 (**Figure C-5**). Slow turnover in the fleet limits the pace at which light-vehicle petroleum consumption and CO_2 emissions can be reduced (**Figure C-6**).

Figure C-5. "More Rapid Deployment" Scenario: Light-Duty Vehicle Sales (left) and Fleet (right)



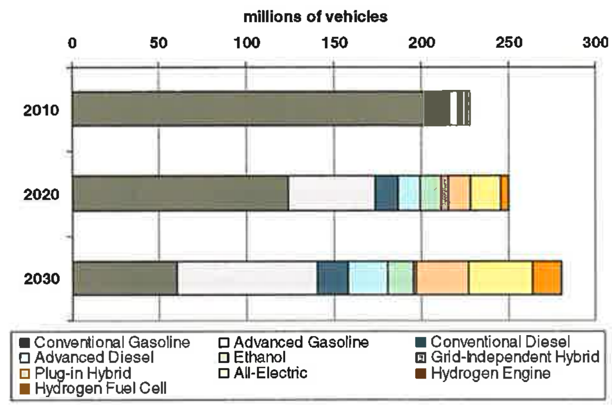
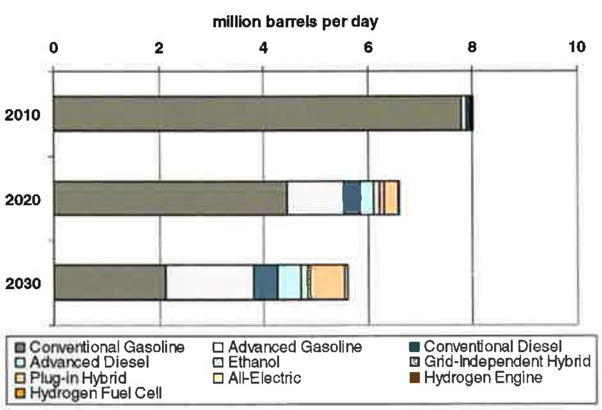
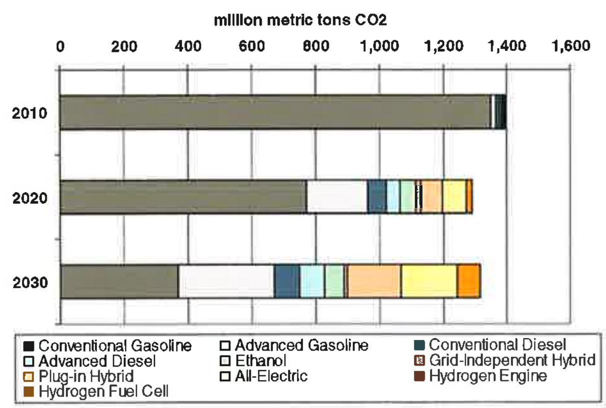


Figure C-6. "More Rapid Deployment" Scenario: Light-Duty Vehicle Petroleum Consumption (left) and CO_2 Emissions (right)





Source: Volpe Center modeling as explained in text

Even with so many more advanced vehicles being sold each year in place of conventional vehicles, petroleum consumption in 2030 is only 31 percent lower in the "more rapid deployment" scenario than in the baseline scenario (**Figure C-7**). CO_2 emissions in 2030 are only 12 percent lower. This modeling illustrates the immense challenge in effecting large changes in the near term to light-duty vehicle petroleum consumption and CO_2 emissions, no matter which policy options are adopted.

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