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The Illusion of U.S. Energy Independence: An Assessment of the Current State of Energy Use

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Table of Contents

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Introduction

"What I have called Project Independence is…set to insure that by the end of this decade, Americans will not have to rely on any source of energy beyond our own."

Richard M. Nixon, Address to the Nation about National Energy Policy,
November 25, 1973

"Our growing dependence upon foreign sources has been adding to our vulnerability for years and years… I am recommending a plan to make us invulnerable to cutoffs of foreign oil."

Gerald Ford, State of the Union Address, January 15, 1975

"Beginning this moment, this nation will never use more foreign oil than we did in 1977—never."

Jimmy Carter, Crisis of Confidence Speech, July 15, 1979

"We must take steps to better protect ourselves from potential oil supply interruptions and increase our energy and national security. My goals in this area are to: maintain a strong domestic oil industry; increase our domestic stockpiles, which we can draw down in the event of a supply interruption; expand the availability of domestic oil and gas resources; continue conservation and progress toward diversification of our energy resources; and promote among our allies the importance of increasing their stockpiles."

Ronald Reagan, Message to Congress on Energy Security, May 6, 1987

"Over the next two decades, this strategy will make us more energy efficient without new energy taxes. It will mean savings for consumers in energy costs. And it will improve our energy security and reduce our vulnerability in the years ahead."

George Bush, Remarks at a Briefing on Energy Policy, February 20, 1991

"…the Nation's growing reliance on imports of crude oil and refined petroleum products threaten the Nation's security because they increase U.S. vulnerability to oil supply interruptions…."

William J. Clinton, Statement on Petroleum Imports
and Energy Security, February 16, 1995

"America is addicted to oil, which is often imported from unstable parts of the world…. By applying the talent and technology of America, this country can dramatically improve our environment, move beyond a petroleum-based economy, and make our dependence on Middle Eastern oil a thing of the past."

George W. Bush, State of the Union address, January 31, 2006

The call for the United States to significantly reduce its use of crude oil and move toward energy independence dates back to the 1970s. Beginning with President Nixon's demand for complete independence on imported energy by the end of the 1970s, to President Carter's bold assertion that the U.S. would never use more imported oil than it did in 1977, to President George W. Bush's claim that American is addicted to oil, presidential focus on "oil supply disruptions" and "dependence on Middle Eastern oil" have helped define U.S. energy policy for nearly 40 years. Usually the result of international events that cause the price of crude oil to spike, creating pressure on the American economy and the livelihood of the American people, these proclamations have generated little in the way of tangible improvement of the energy dependency "problem," which, at its core, is really an imported crude oil problem. Today's heightened international tensions and instability in the Middle East and other oil producing regions have precipitated renewed demands that the U.S. move down the path toward energy independence and energy security. The Congress has held numerous hearings, President Bush has stated that we must end our addiction to oil, and various interest groups are proposing policy alternatives designed to lessen our use of petroleum and petroleum products.

This scenario is not new. After the oil embargo of 1973, President Nixon launched Project Independence to end our dependence on foreign oil. President Carter created the Synthetics Fuel Corporation to pursue the same objective. While energy consumption patterns have responded to price and demand changes, the influence attributable to policy formulation or rhetorical appeals is marginal, at best. These past efforts floundered because oil is abundantly available, versatile in its uses, and its products are less expensive than alternatives, even in the context of today's higher prices.

Energy use patterns in the transportation and electricity consumption sectors are driven principally by market factors that government does not control or has chosen not to exert influence over. The price of energy, whether for transportation or electricity, is the main driver influencing consumer behavior and government policy. When the price is high, public demands for independence grow and when prices fall or remain low (as they have for much of the period since the 1970s), the demand for policies to seek independence wane.

This report is the result of an examination of recent calls for energy independence and associated policy proposals. The basic conclusion is that energy independence, as it is generally thought of, is economically, politically and technically impractical in the foreseeable future. Although government could take actions to reduce oil use significantly in the near-term, the political and economic consequences associated with those actions make them impractical. The report summarizes observed energy consumption and supply patterns, reviews projections of how those patterns may change, and outlines the policy choices facing the American public. The information provided in this report explains why oil will remain an important source of energy and why independence is an illusion.

In evaluating the goal of energy independence, several factors require consideration. First, energy, as an input to production, is a means of creating economic value. In its use as a production factor, energy is comparable to the other main production factors, capital and labor, and, just like the use of those other production factors, the use of energy in production processes is determined by the relative cost of energy compared to the other input factors. This implies that, unless prices are artificially distorted, no factor of production is significantly wasted for an extended period of time, if adequate information is available to users. Although it is often asserted that the United States wastes significant amounts of energy, international data on energy intensity, adjusted for differences in demographics, indicates that U.S. efficiency is comparable to other developed countries.

Looking to the future, a larger global population will require significantly more energy to meet its economic needs than is being consumed today. The U.S. Energy Information Administration (EIA) and the International Energy Agency (IEA) estimate this to be as much as 50 percent more energy for the U.S. and world by 2025, even with aggressive improvements in energy technologies. This is especially true for the burgeoning populations and dynamic economies of China and India, which will require considerably more energy than they consume today to meet rising standards of living. Cost, technology, natural resource abundance and public policy will affect the mix of energy resources available to meet this demand.

Second, energy contributes positively to economic growth and is essential to increasing the living standards of a growing population. Continued growth of the latter is nearly impossible without increased use of the former. Changes in energy intensity, which is the relationship between energy use and gross domestic product (GDP), are an important indicator of how the structure of an economy is changing and how it uses energy. The United States and other industrialized nations will reduce their energy intensities as their economies evolve and embrace new technologies, continuing a long-established trend.

Third, oil-based products will remain the principal fuel for transportation needs for the foreseeable future. Absent significant and disruptive government intervention in the marketplace, gasoline and diesel will remain the fuels of choice in the transportation sector, even at relatively high prices. Alternatives simply have not reached the point of technological maturity or cost-competitiveness, nor will an infrastructure be in place, from either the supply or demand side, to provide supplies at sufficient quantities to displace petroleum.

Fourth, coal and natural gas will remain the principal fuels for electricity generation for most of the nation. Nuclear facilities, and in some areas of the country hydroelectric power, offer viable alternatives. Regulatory barriers to the expansion of nuclear and hydroelectric facilities remain formidable. Meeting the projected need for increased generating capacity will require more aggressive action by Federal, state, and local governments in siting new facilities and will limit their growth potential. Abundant stocks of coal and natural gas in the U.S. and a steady increase in the demand for electric power make it highly unlikely that a major shift away from coal toward renewable energy, nuclear power, or any other alternative will occur in the time frame covered by this report. This reality also has implications for greenhouse gas emissions from power plants.

Although electric power generation is an important component of national energy policy, the rhetoric of energy independence is about imported oil. In the early 1970s, the United States imported 30 percent of the oil used; today the U.S. imports about 60 percent.

Environmentalists, concerned about climate change and air pollution, have long championed alternatives to gasoline. Terrorism, the war in Iraq, and the continued instability in the Middle East have now caused some in the national security community to join environmental advocates in calling for an end to oil use, claiming that it can be done sooner rather than later. And now President Bush has set a goal to reduce Middle East oil imports 75 percent by 2025. As was the case with Project Independence and the Synthetic Fuels Corporation, political emotions and rhetoric are racing ahead of economic and technical realities.

While there are many reasons for producing more energy domestically, and we can, the fact remains that even if the U.S. did not import one barrel of oil, its economy and national security interests would remain intertwined with actions in global markets and the Middle East. A global economy links all nations and it is simply not possible to insulate the U.S. from what takes place in other countries and regions. Since the rest of the world will not turn away from oil, price shocks, disruptions, and geopolitical events in the Middle East will remain matters of concern for our well being, independent of how much oil we import or use. We can take, and indeed have taken, actions that mitigate the effects of potential oil shocks and so have other developed nations; for instance, all members of the International Energy Agency maintain strategic oil reserves for use in cushioning the shock of disruptions.

Energy, economic, and political realities should make it clear that the desire to become less dependent on oil, and especially foreign oil, is a wish that will not be realized anytime soon. Policies that do not reflect this reality are doomed to flounder and in the process do more harm than good. The public and national interest are better served if policy makers would temper their rhetoric with realism and pursue goals that have a reasonable chance of being achieved. In the coming decades, we will need all of the energy that can be produced economically from whatever sources are cost competitive. Creating false hopes and extravagant expectations will waste resources and create even more cynicism, neither of which makes us better off.

The remainder of this report reviews current and projected U.S. energy patterns and documents the basis for our conclusions and the difficulties in making significant reductions in oil use in the pursuit of energy independence. The issue is not whether we could significantly reduce oil use over the next 20-30 years; we could. The issue is whether the costs of doing so and the economic consequences involved are acceptable to the American public. We believe that they are not and we explain why.

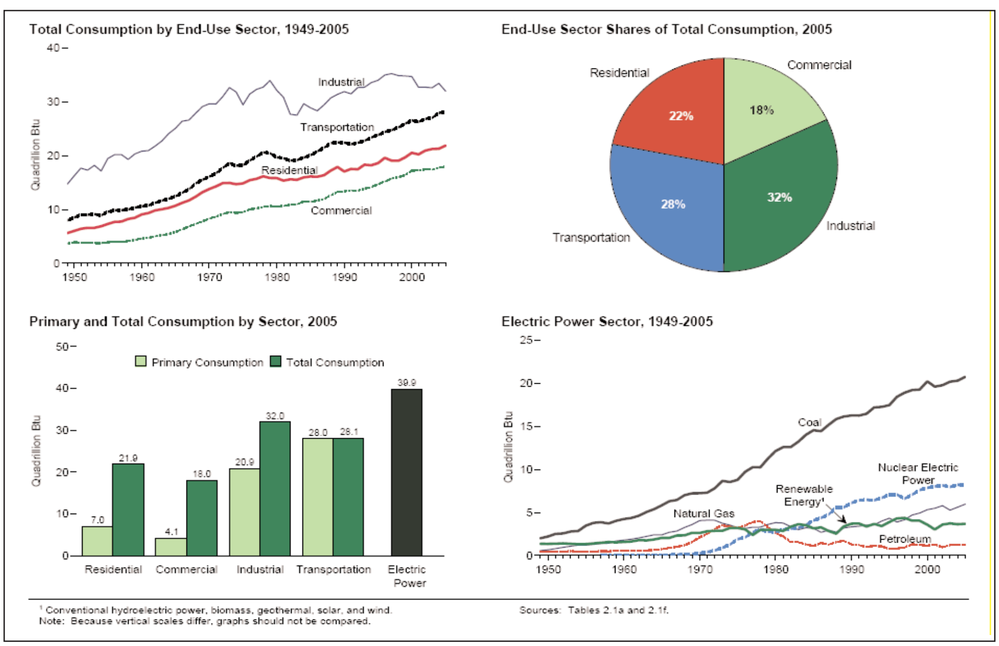
Energy in the United States Today

The rhetorical foundation of calls for energy independence focuses on imported oil and, by implication, concerns transportation and mobility. The energy system on which the U.S. economy and individual prosperity depends is, in fact, much larger and more complicated. If policymakers and the American public are serious about achieving energy independence and greater energy security, a comprehensive view of the entire energy system, not simply transportation, is required.

Figure 1 provides a summary from the U.S. Department of Energy's Energy Information Administration's (EIA) *Annual Energy Review 2005*. As can be seen from the graph on the top left in Figure 1, energy use in the transportation sector has more than doubled since 1950, but each of the other end-use sectors (Industrial, Residential, and Commercial) also show the substantial increases that would be expected from the growing, vibrant economy the U.S. has possessed over the same period. In 2005, the shares of total consumption were fairly evenly divided among the four end-use sectors. Transportation accounted for 28 percent, ranking second to the 32 percent consumed in the Industrial sector. Commercial and Residential uses account for the remaining 40 percent.

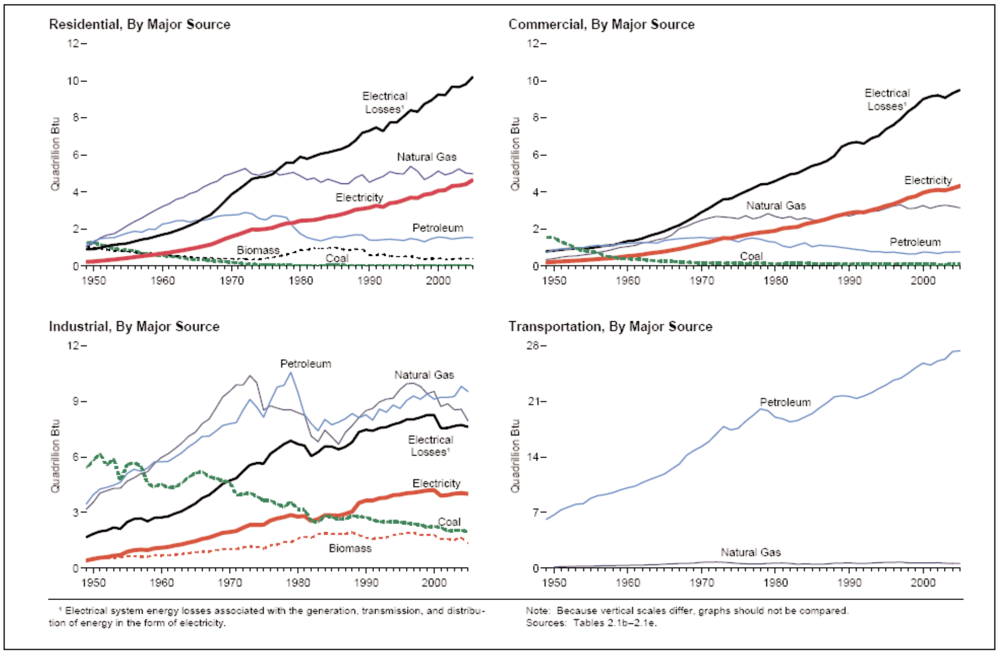
The graphics on the bottom of Figure 1 show additional information on consumption patterns.[1] The bottom right graphic provides context for evaluating electricity generation concerns which are considered in this report. The graphic shows the dominant position of coal as the fuel source for electricity generation. Coal accounts for more than double the energy produced by the next largest source, nuclear power.

Figure 1 – Overview of U.S. Energy Consumption, 2005



In Figure 2, the sources of energy for each major sector of the economy are identified. Also drawn from the EIA's *Annual Energy Review*, the four graphics show the relative differences in the use of fuel by type, ranging from the complete dependence of the Transportation sector on petroleum to diversity of sources used by the Industrial sector.[2]

Figure 2 – Energy Consumption in the U.S. in 2005, by Major Sector and Source



Energy Information Administration Economic Sectors: Definitions

Commercial sector: An energy-consuming sector that consists of service-providing facilities and equipment of: businesses; Federal, state, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments.

Industrial sector: An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing (NAICS codes 31-33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.

Residential sector: An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters.

Transportation sector: An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles. Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use.

http://www.eia.doe.gov/glossary/index.html

Energy and the Economy

Energy is an essential input to the productive capacity of the economy. As a key factor of production, energy is as valuable as any other, meaning that there are strong incentives to avoid waste, improve how it is used and produced, and increase its quality and reliability. Energy is embedded in every aspect of our lives. It is needed to grow crops, to operate factories, to ship goods, to heat, light and cool commercial buildings and homes, and to provide the mobility that Americans have long valued. This section evaluates the role of energy as a contributor to economic growth and individual prosperity. It also considers the broad question of how efficiently or intensely energy is used in the United States and elsewhere.

The use of energy in the United States reflects three characteristics. First, the United States possesses energy intensive capital stock reflecting resource abundance, the historical structure of its economy, and the absence of a punitive tax structure. Second, as the world's wealthiest nation, U.S. citizens consume more energy to support a high and growing standard of living. Third, over time, the cost and price of energy in the United States has been less than that paid in other developed nations. These three factors have had a large effect on the transportation system, personal consumption patterns, and the general structure of the U.S. economy.

Energy is an input into production which, combined with the factors of production, labor and capital, helps to accomplish work and create wealth. In theory then, more energy allows fixed amounts of labor and capital to produce more output. Just like with labor and capital, the amount of energy used in production as well as the overall structure of the economy are determined ultimately by the relative price of those input factors. The cheaper the input factor, the more of it will be employed in production.

Shifting Dependencies

The relationships that govern patterns of energy use and determine the structure of an economy can change and indeed have changed. In the 1970s when the first oil shocks occurred, American industries and economic activity were oil driven. Sixty percent of economic activity was directly dependent on oil and products based on oil, such as plastics. In the intervening years, that dependency has dropped dramatically. Today, 60 percent of economic activity, instead of being dependent on oil-based products, depends on electricity generated principally from coal and natural gas.[3] The nation's transportation needs are still wholly dependent on petroleum, but productive economic activity elsewhere draws its energy from a variety of other fuel sources. This shift in the composition of our energy budget and structure of our economy helps to explain why the American economy weathered recent spikes in oil prices without commensurate reductions in economic growth. The shift also suggests that future energy policies should focus more on electricity generation and supply than our current rhetoric would imply they are.

The Limits of Energy Efficiency

Over the past several decades, technological progress and periods of high prices have brought about gains in energy efficiency. The amount of energy required to produce a dollar of national wealth has steadily declined and today is about 50 percent lower than in the 1970s. While some of this is due to changes in the structure of our economy, a large part is due to improved technology. Nonetheless, the amount of energy consumed has steadily risen. There is no escaping the fact that a growing economy and a growing population drive the need for greater amounts of energy.

While improvements in efficiency lead to reductions in energy intensity, it is debatable that they can lead to reductions in energy consumption, as long as the population and economy are growing. When energy efficient technologies effectively penetrate the market, economists argue, "the resulting lower cost of energy services elicits a rebound effect of increased energy service demand and thus greater energy consumption."[4] Mark Mills and Peter Huber observe that "efficiency fails to curb demand because it lets more people do more, and do it faster—and more/more/faster invariably swamps all the efficiency gains."[5]

The magnitude of the rebound varies, is difficult to measure, and is the subject of contention.[6] A study of personal vehicle use in the United States found that a 10 percent improvement in vehicle efficiency resulted in a 2 percent increase in vehicle use by the individual consumer.[7] A study of U.S. manufacturing put the rebound effect at 24 percent,[8] and rebound estimates for space heating at 10-30 percent, space cooling at 0-50 percent, lighting at 5-12 percent, and automotive transport at 10-30 percent.[9]

Efficiency changes the relative price of transportation, manufacturing, heating, and space cooling. Not only may the individual car owner drive farther when his car is more efficient, due to the increase in efficiency, transportation as a good has become cheaper and more people will therefore demand transportation, i.e., the commuter taking the train to work will rethink his decision and buy a car to commute to work, because it has become relatively cheaper.

As standards of living have risen, consumer demand for larger homes, more electronic products, and increased travel and vehicle ownership, for example, offset gains in the efficiency in which those products use energy. Rising personal incomes around the world will almost certainly lead to greater use of more energy efficient products, but the pursuit of energy efficiency is unlikely to produce the reductions in total energy consumed which some advocates claim.

China offers a stark example of the significant relationship between energy demand and economic prosperity. Over a two-year period from 2002-2004, China has added 52 gigawatts of capacity, or 500 megawatts a week, which is the equivalent of a medium-sized power station per week.[10] China's industrial sector, which is particularly energy intensive, has grown most rapidly. In 2002, energy consumption for the secondary industries (manufacturing of finished goods or products) was 69.3 percent of total energy consumption. In contrast, energy consumption for primary industry was 4.4 percent, and service industry was 14.9 percent.[11]

Figure 3 – U.S. Energy Intensity Trends, 1949-2005

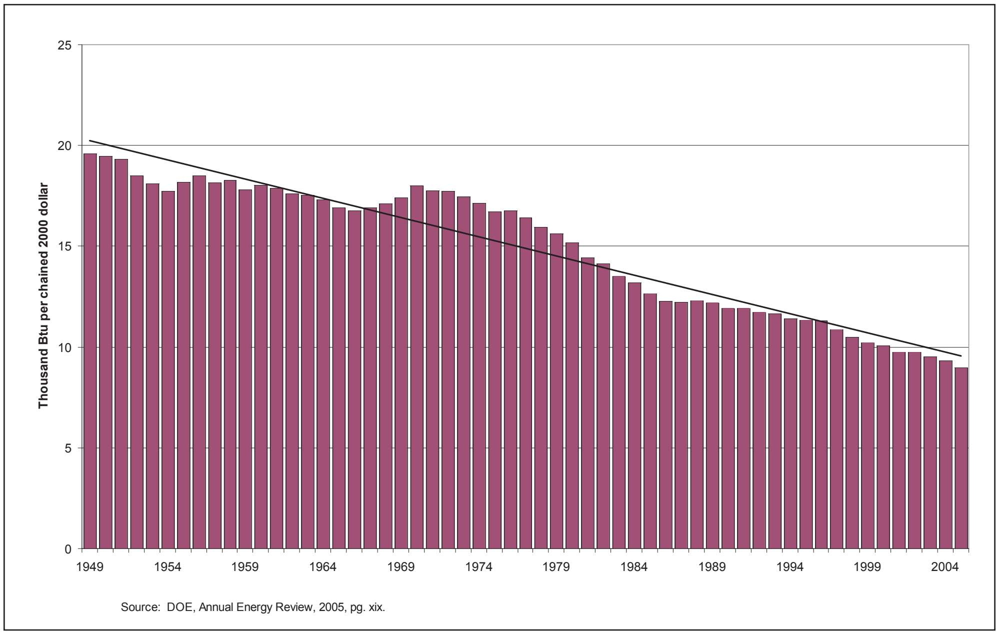
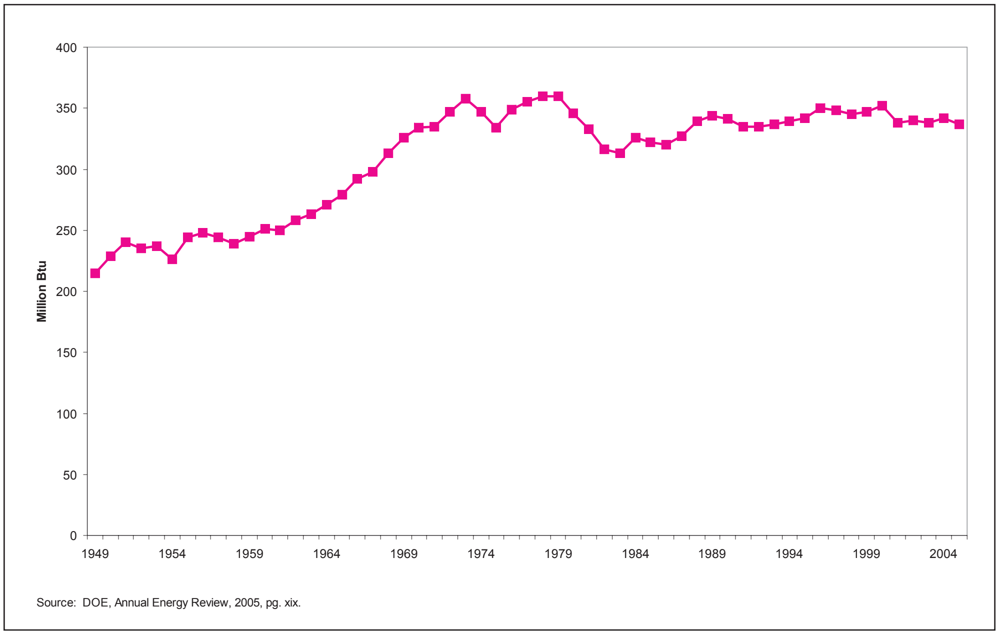


Figure 4 – Energy Consumption per Person, 1949-2005



Trends in Energy Intensity

Trends in the relationship of energy use to GDP — or energy intensity — over time offer important lessons for evaluating national energy policy and questions of independence. From the 1970s forward, the U.S. has consistently reduced its energy intensity ratio, as shown in Figure 3. This reduction is the product of the continuous introduction of new technologies which generate greater economic output for the same amount of energy use as well as structural changes in the economy, such as the movement away from heavy manufacturing to less-intensive service industries.[12] The widening gap between increases in GDP growth and energy use demonstrates that the economy is using energy differently than before. The trend reflects the technological transition which has occurred over the past several decades — the shift toward a silicon economy, the relative decline of hard manufacturing, and the growth of the service sector. Those increasingly important economic activities do not necessarily use less energy in total, but they are more productive in how they convert energy into economic growth, which has allowed for GDP to rise faster than energy consumption. There is also a degree of inevitability to the trends. As human activity has evolved from subsistence to industrialization to silicon, this transformation is aided, and it may be argued, driven, by discovery and utilization of improved power sources. The amount of energy used per unit of GDP consequently has been falling for thousands of years.[13]

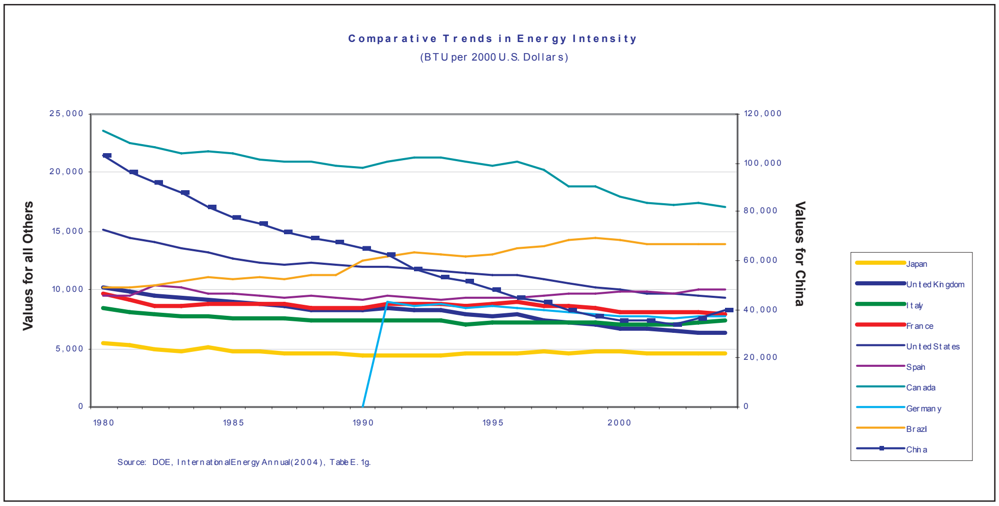
According to the Department of Energy's Energy Information Administration, "since 1992, the energy intensity of the U.S. economy has declined on average by 1.9 percent per year, and the share of total industrial production accounted for by the energy-intensive industries has fallen sharply, by 1.3 percent per year on average from 1992 to 2004."[14]

Figure 4 offers a different perspective. Portraying trends in per capita energy consumption in the United States over the same 1949-2005 period, Figure 4 shows that per capita consumption of energy in the United States has not changed appreciably since the late 1980s.

There is no question that the United States consumes more energy than any other nation. In 2004, from the most recent comparative data available, U.S. consumption of primary energy reached 100.4 British Thermal Units (BTU) quadrillion,[15] which equals approximately 17 billion barrels of oil.[16] The U.S. also happens to be one of the wealthiest nations in the world. U.S. GDP per capita reached $41,800 in 2005.[17] Compared to 1950, the United States uses only half as much energy to generate $1 of GDP (see Figure 3). Since 1980, total U.S. energy consumption increased by 28 percent, but at the same time U.S. GDP doubled. This translates into a 37 percent decline in energy intensity.

Comparing major industrialized countries, Figure 5 shows trends in energy intensity over time. Covering the period 1980-2004, Figure 5 presents trends for the top-10 leading economies according the World Bank's ranking of total GDP in 2005 (China is arrayed on the right axis, the remaining countries on the left).[18] China is the clear outlier among this group, posting a 2004 energy intensity nearly four times as large as the others.

Figure 5 – Comparative Trends in Energy Intensity



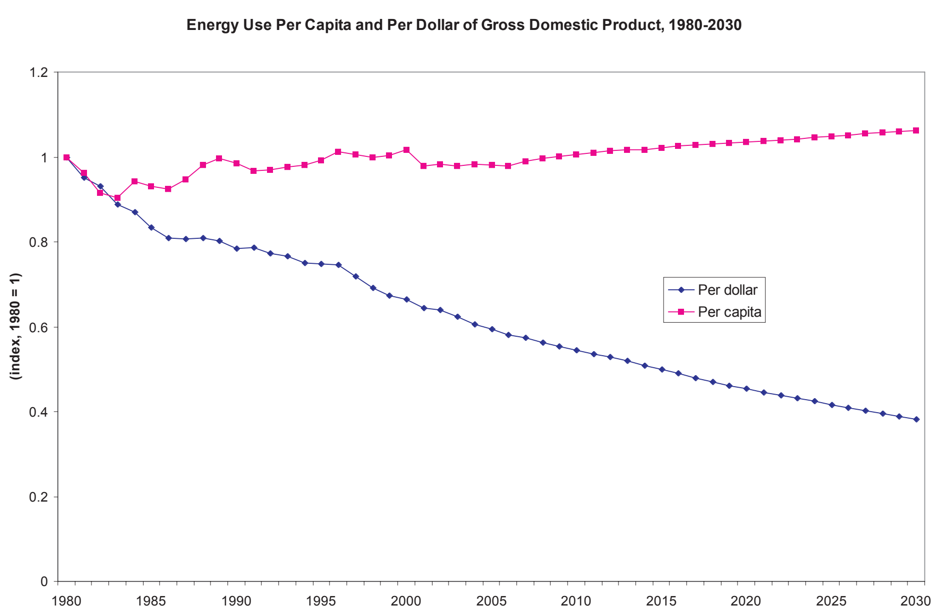
The pace of future improvement in energy intensity will be influenced by rates of macroeconomic growth, economic development and technology improvements. Various projections of anticipated worldwide energy intensities depend on each of these factors. The higher the rate of growth and development, typically the faster is the decline in energy intensity; for example, worldwide energy intensity in the EIA's *International Energy Outlook* high economic growth case "improves by 1.9 percent per year on average from 2003 to 2030, compared with 1.8 percent in the reference case. On the other hand, slower economic growth would result in a slower rate of decline in energy intensity. In the low macroeconomic growth case, world energy intensity declines by an average of 1.5 percent per year over the projection period."[19]

For the United States, the Department of Energy forecasts that energy intensity will "decline at an average annual rate of 1.8 percent from 2004 to 2030 in the 2006 reference case (Figure 6), with efficiency gains and structural shifts in the economy dampening growth in demand for energy services."[20] The figure referenced in the quote is replicated below. The projected trends continue the long established and observed trends shown in Figure 3 and Figure 4. Per capita energy consumption rises slightly under this projection by EIA, which is based on the agency's assumption that rising disposable income will increase consumption.[21] Measures of energy intensity per dollar of GDP in the forecasts continue the strong declines observed for much of the past 30 years in the United States.

The only industrialized country that saw per capita consumption decrease during the past 30 years was Germany. Germany's pattern is attributable to heavy capital investment during the early nineties. The new state-of-the-art production facilities that were built brought up the average energy efficiency of the production stock. The closing of East German power facilities also contributed to this trend.

Americans still use more energy per dollar of GDP than the Japanese or Germans, which is often interpreted as evidence that our use of energy is less efficient than theirs. Upon examination, it becomes clear that this difference in efficiency is mainly due to differences in demographics, transportation and home heating requirements. According to the United Nations Demographic Yearbook, the population density in the United States averaged 30 people per square kilometer in 2003. This is much lower than the population density of all major European countries: In 2003, Britain's population density averaged 245 people per square kilometer, followed by Germany with 231, Italy with 191, and France with 108 people per square kilometer or Japan, which had a population density of 338 people per square kilometer.[22] Due to this much lower population density, U.S. transportation requirements are much higher than those of most other developed economies.

Figure 6 – Trends in Energy Use Per Capita and Per Dollar



Source: DOE (2006), Annual Energy Outlook 2006 with Projections to 2030, Figure 4.

U.S. Energy Use in the Transportation Sector

In the early 1970s, the United States imported 30 percent of the oil used; today it imports about 60 percent. Since the 1970s, the U.S. economy has more than doubled, but oil use is only about 17 percent greater. Growing imports, fueled by consumer demand and government restrictions that limit the expansion of domestic capacity, have produced demands for development of alternative fuels and introduction of regulations designed to shift the market. President Bush and others are promoting ethanol as the substitute of choice.[23] Over the past several decades, ethanol has received a subsidy of 51 cents per gallon and yet it still represents a very small segment of the transportation fuel market. If larger subsidies are needed for it to displace gasoline, their cost will be borne by the economy one way or another.

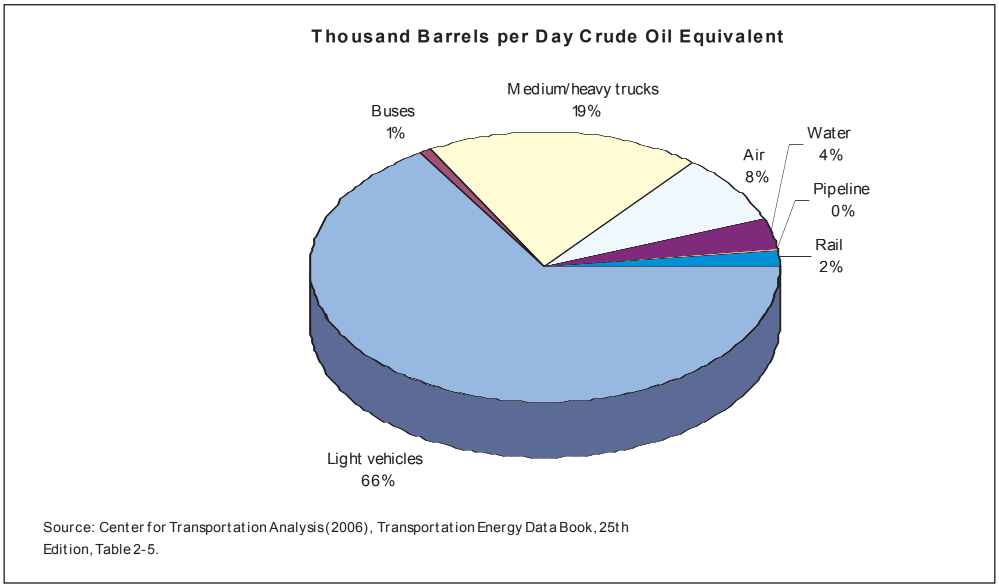
Others recommend imposing new fuel economy standards. Consumer demand for automobiles is highly linked to gasoline prices. If the price of gasoline remains high, consumer preferences will shift away from larger, heavier vehicles toward those with higher fuel economies without the need for government intervention.

The larger and more important question is whether it is even possible to reduce the dependence of the U.S. transportation system on petroleum in the foreseeable future. This section examines the structure of the transportation sector and projected trends, identifies the sources of fuel for that sector, and considers alternatives to that fuel supply.

Structure of the U.S. Transportation System

By virtue of the sheer physical size of the United States, the U.S. transportation system exceeds that of virtually every other nation. Figure 7 shows energy consumption in 2003 for a variety of transportation modes in the U.S. Light vehicles, which are cars, motorcycles, and light trucks, represent two-thirds of the total, and all vehicles utilizing the ground transportation system are 85 percent of the total consumption.

Figure 7 – Share of Transportation Energy Consumed, 2003



The ground transportation system totals just shy of four million miles.[24] A growing population will lead to an increase in miles traveled each year as new drivers enter the system. Also causing a growth in miles traveled is the continued strong economic growth projected for the U.S. According to EIA, a growing economy requires the movement of goods, which will lead to increases in commercial truck and other traffic as well.[25]

Figure 8 – Trends in Motor Vehicle Miles Traveled

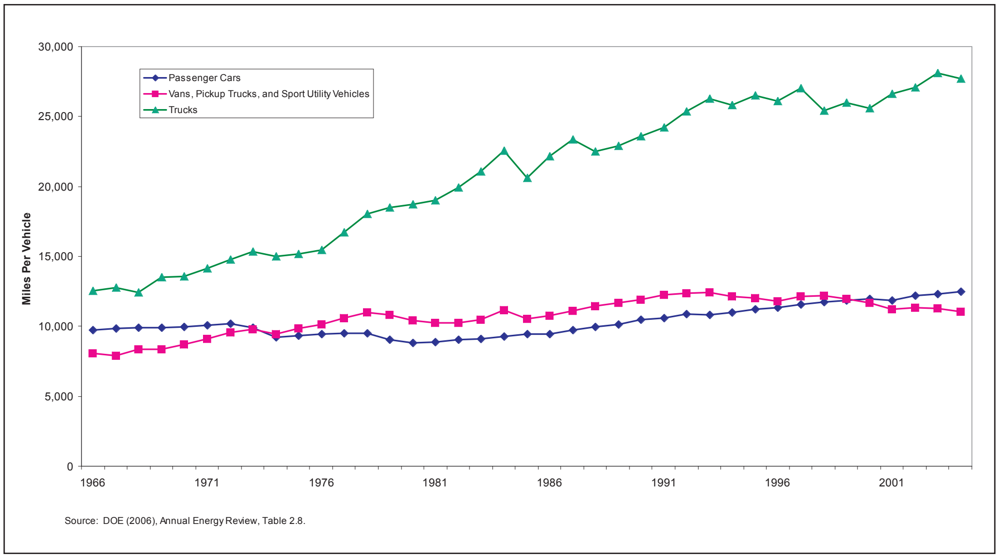


Figure 9 – Trends in Fuel Consumption by Vehicle Type

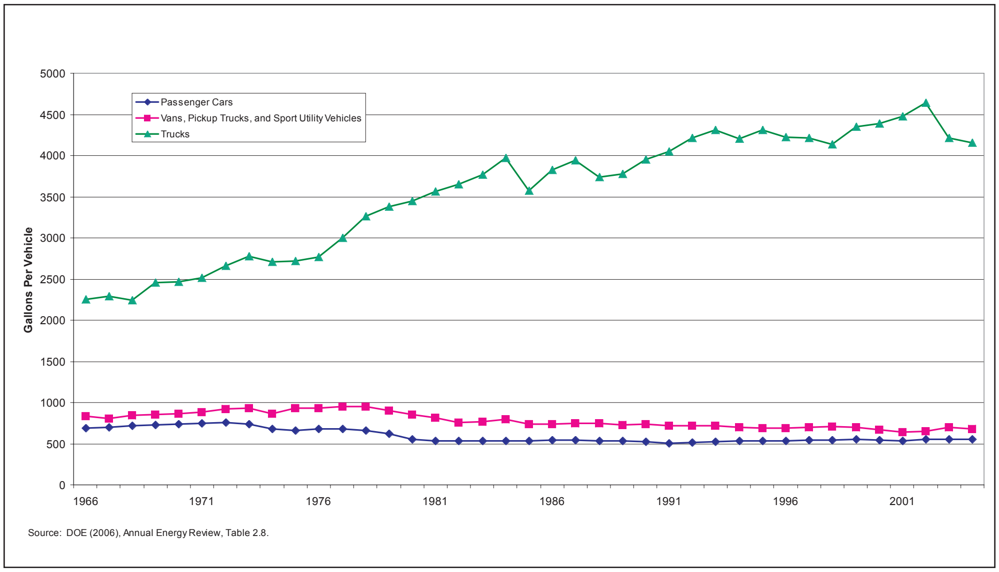
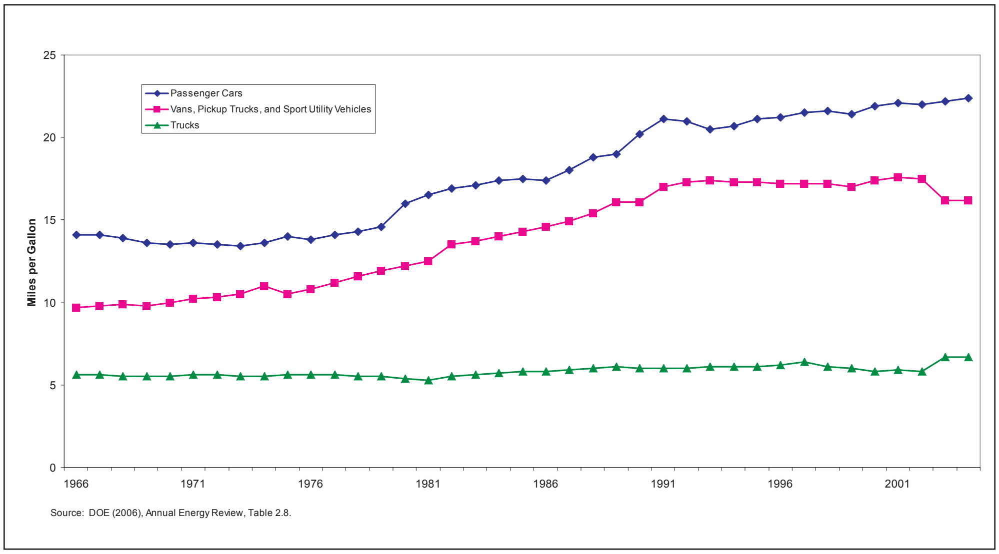


Figure 10 – Trends in Fuel Efficiency by Vehicle Type

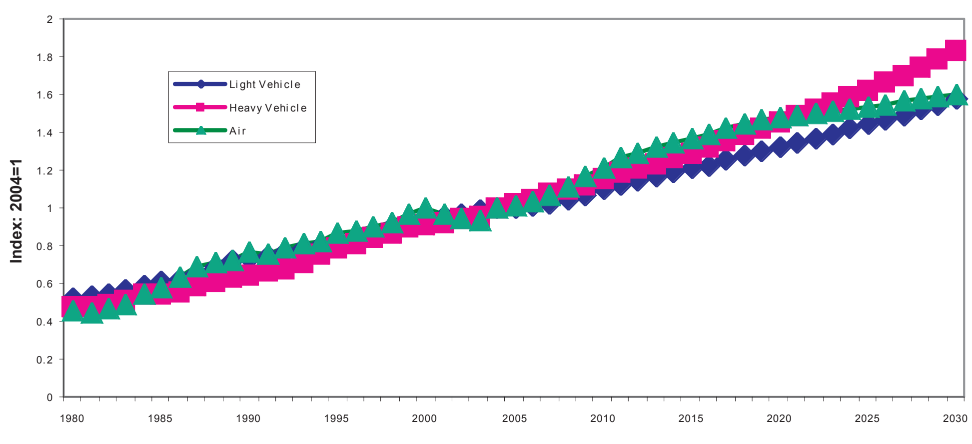


Figures 8, 9, and 10 provide an overview of the ground transportation system. Miles traveled per vehicle and fuel consumption for passenger cars and the category including the much maligned SUV remarkably show flat trends in terms of miles traveled and fuel consumption per vehicle. Figure 10 shows fairly consistent improvement in the fuel economy of both categories. Heavy truck traffic had substantial growth in miles traveled and fuel consumption per vehicle, but not a noticeable improvement in fuel economy, over the four decades surveyed.

Coloring this, of course, are growth in the absolute numbers of vehicles in each class and how that has changed relative to each other. The Center for Transportation Analysis reports that there were 87 million light trucks, including SUVs and vans, registered in 2003, which consumed 56.3 billion gallons of fuel.[26] Cars totaled 135.6 million registrations and consumed 74.5 billion gallons of fuel, also in 2003.[27]

The U.S. Energy Information Administration projects consistent growth in vehicle and aircraft transportation in its projections to 2030.[28] The EIA's projections for the period 2004-2030, shown in Figure 11, all have average annual growth rates below the period of actual observation, 1980-2004.[29] The continuation of higher fuel prices, combined with structural factors unique to each transportation mode, are the justification for the assumption. Even with these assumptions, the demand for transportation is projected to grow unabated throughout the period.[30] Absent dramatic intervention to shift the fuel source for ground transportation, the projected demand for petroleum will grow in a commensurate fashion.

Figure 11 – Transportation Travel Demand, 1980-2030



Source: DOE (2005), Annual Energy Outlook 2005, Figure 50.

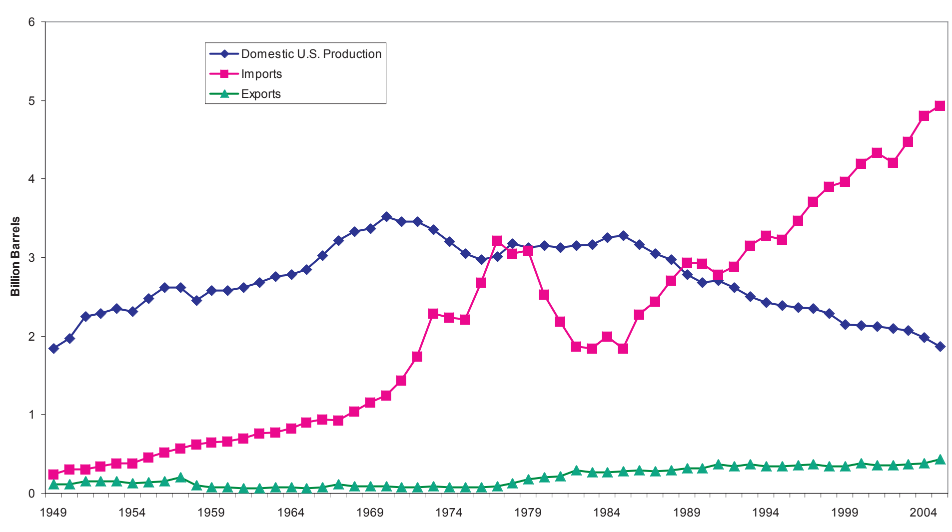
Petroleum Production and Sources of Supply

Much is made of the growth in U.S. oil import dependency. U.S. imports of petroleum have increased markedly in the past 30 years and have shown remarkable growth in the last 20 years (see Figure 12). At the same time, U.S. domestic production has declined precipitously since peaking in 1970.

A corollary concern of the petroleum independence movement is the claim that oil supplies have "peaked" and the world will see declining supplies in the years to come. Proved reserves in the United States have declined, and concerns about peaking may be reinforced by the declining production numbers shown in Figure 12. According to the Energy Information Administration, U.S. proved reserves are 21.3 billion barrels in 2004, which is down from levels observed in the 1960s.[31] The U.S. is the world's most mature oil production region and what is true for it is not true on a global basis. The amount of domestic reserves also can change for the positive. The discovery of a "vast oil pool" in the Gulf of Mexico in September 2006, which is said to have the potential to boost U.S. reserves by more than 50 percent, is an example.[32] The Gulf find is prompting more private efforts into deep water exploration.[33] Should the U.S. government decide to open parts of Alaska for drilling and exploration, the reserve number could change as well. Finally, these reserve projections do not include unconventional reserves which have significant potential to expand domestic supplies. Still, the rest of the world reveals a much different picture for several decades to come.

Proven reserve projections released in 2006 for the world's two largest energy companies show that overall the amount of crude oil in proven reserves has increased over the past 20 years. British Petroleum (BP) estimates that world proven reserves have increased from 770 billion barrels in 1985 to 1.2 trillion barrels today, even though the U.S. alone has consumed approximately 140 billion barrels over the same period.[34] Similarly, ExxonMobil's outlook on energy concludes that the world has more than two trillion barrels of conventional oil resources remaining.[35]

Figure 12 – Sources of Petroleum Consumed in the United States



Source: DOE (2006), Annual Energy Review, Table 5.1.

While the two estimates disagree on the overall size of the remaining reserves, they are in agreement about where the reserves are located. The Middle East remains the main source of supply, holding nearly 62 percent of the world's proved reserves, according to BP.[36] Africa's potential is noteworthy. Its share of proved reserves increases two percentage points in the 20-year period examined in the BP report. Europe's share drops from 13 percent in 1985 to just 5 percent in 2005 while Central and South America increase slightly from 8.2 percent to 8.6 percent.

In summary, the best evidence indicates that oil reserves are adequate for decades to come, and that improved technology will increase our ability to recover oil from known resources.[37] The Department of Energy, for example, recently announced that new carbon dioxide enhanced oil recovery technology could increase U.S. recoverable oil resources by 89-430 billion barrels.[38]

Conventional oil is only one of the fossil fuel resources that can be used to supply transportation fuels. The petroleum industry is already using heavy oil from Venezuela and oil sands from Canada to supplement conventional oil resources. Canadian oil sands reserves are estimated at 178 billion barrels, second only to Saudi Arabia's oil reserves.[39] Others put the Canadian tar sand reserves much higher, up to 2.5 trillion barrels.[40] The global base for oil shale is "huge," with the EIA estimating a minimum global base of 2.9 trillion barrels of recoverable oil, including 750 billion barrels in the U.S.[41] Reserves of these unconventional oil resources are also available in other countries, ensuring many more years of oil supply.[42]

Given the expected continued primacy of the Middle East as the source of most of the world's oil, concerns about that are understandable, but in examining the import

Table 1 – U.S. Imports of Petroleum by Country

U.S. Imports of Petroleum by Country, 2000-2005
(Thousand Barrels)

	2000	2001	2002	2003	2004	2005
All Countries	3,319,816	3,404,894	3,336,175	3,527,696	3,692,063	3,695,971
Non OPEC	1,656,653	1,635,274	1,845,991	1,856,866	1,846,659	1,938,257
OPEC	1,663,163	1,769,620	1,490,184	1,670,830	1,845,404	1,757,714
Persian Gulf	881,741	972,479	807,640	884,998	878,510	805,653
Canada	493,256	494,796	527,304	565,533	591,489	596,183
Mexico	480,469	508,715	547,443	572,572	585,023	567,955
Saudi Arabia	557,569	588,075	554,500	629,820	547,125	527,287
Venezuela	447,736	471,243	438,270	431,704	474,531	452,914
Nigeria	320,137	307,173	215,122	303,617	394,560	393,038
Iraq	226,804	289,998	167,638	175,663	239,758	192,524
Angola	107,820	117,254	117,058	132,349	112,018	166,404
Ecuador	45,685	41,403	36,491	50,726	84,937	100,730
Algeria	211	3,966	10,906	40,992	78,719	83,359
Kuwait	96,367	86,535	78,803	75,870	88,359	82,730
United Kingdom	106,332	89,142	147,935	130,938	87,193	81,621
Russia	2,547	0	31,047	54,938	58,010	72,638
Colombia	116,311	94,844	85,783	60,491	52,049	57,002
Gabon	52,237	51,065	52,208	47,670	52,061	46,515
Norway	110,653	102,724	127,136	65,935	52,365	43,454

Source: Energy Information Administration,
http://www.eia.doe.gov/oil_gas/petroleum/info_glance/petroleum.html

portfolio of the United States, the limits of the Middle Eastern oil dependency argument become apparent. Table 1 provides the list of the top-15 countries that supply the U.S. with petroleum. Of the 15 countries listed, three are from the Middle East. In total, Persian Gulf countries account for 21 percent of total U.S. imports in 2005, a figure which has declined since 2000.

Projected Use of Petroleum

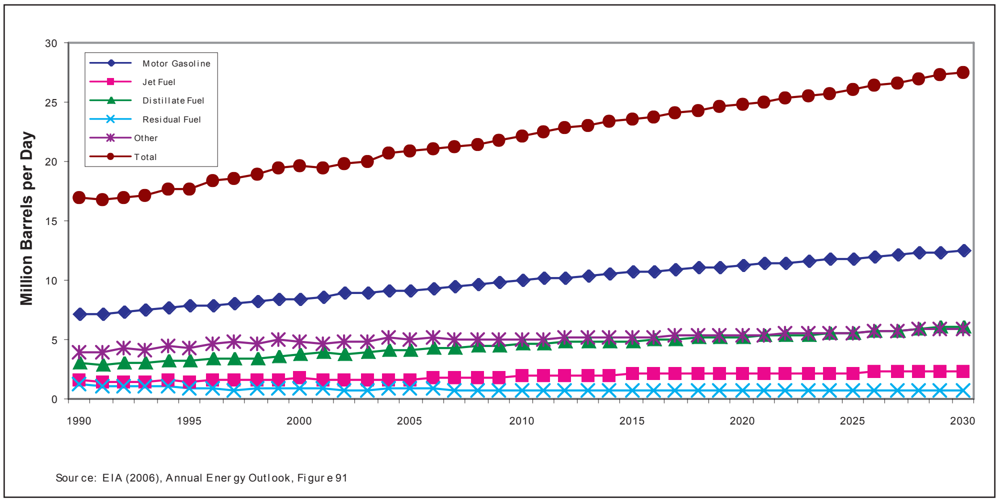
The EIA projects U.S. consumption of petroleum to increase by more than 30 percent by 2030.[43] Gasoline posts the largest increase over the projected period, driven by increased demand and economic expansion. The EIA believes that demand will outstrip gains in efficiency and changes in consumer preferences about vehicle type. That assumption is not necessarily shared by other projections of vehicle fuel use; for instance, in ExxonMobil's projections of vehicle fuel use for North America to 2030, they expect "significant improvement in the basic efficiency of new cars, as well as growth in the numbers of hybrids and diesel vehicles" which reduces the impact of a greater number of vehicles on the road.[44]

The EIA numbers offer a respectable and conservative basis for projecting future trends. A 43 percent increase in total energy consumption for transportation by 2030 is projected by EIA,[45] with the most rapid increases coming from demand for freight movement (61 percent) and air travel (47 percent), followed by light duty vehicles (42 percent). Diesel fuel consumption is expected to grow from 1.6 percent of total light-duty vehicle fuel consumption in 2004 to 5.2 percent in 2030, and demand for alternative fuels (mostly ethanol) will increase from currently 1.9 percent to 5.9 percent in 2030.

These expected increases in demand for transportation services are a result of population growth and an increasing standard of living. Shifting populations within the United States will contribute to these trends as well. The continuation of the trend of growing suburbs, coupled with people moving from more densely populated Northern cities to more spread out Southern cities, suggests that individuals should expect to be driving as much or more than they do today. The EIA expects that high fuel prices will slow the growth in demand for light-duty vehicle travel until 2008, when fuel prices are expected to stabilize. Predicting price changes is notoriously difficult, but other factors affecting this estimate, such as consumer preferences and vehicle demand trends, provide more well-established information on which to base such projections for future possibilities. In general, rising disposable income is expected to lead to a more rapid increase in travel demand.

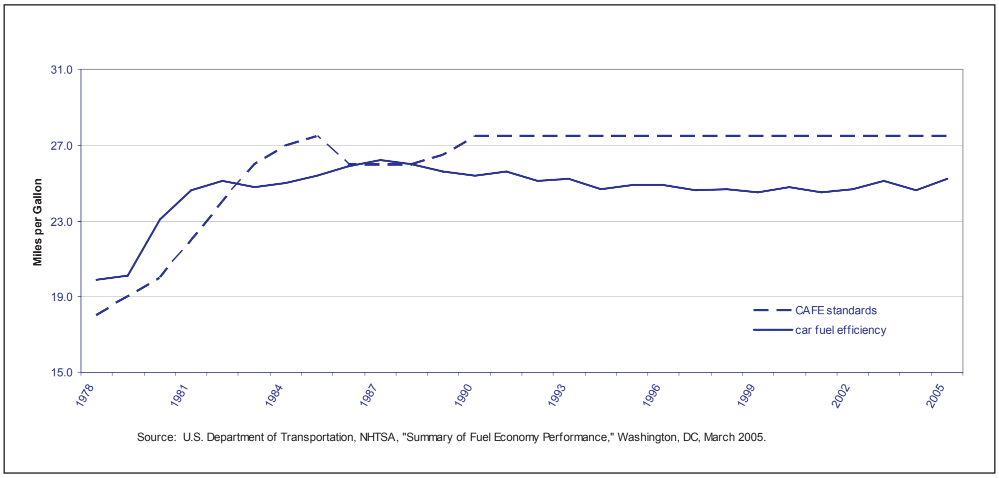
Even if the EIA's projections are off, as they may well be, the magnitude of the increase in petroleum use may be debatable, but the reality of increased petroleum use is not.

Figure 13 – Projected Uses of Petroleum, 1990-2030



Due to increased sales of light trucks (sport utility vehicles, minivans, and pickups), the average fuel economy of new light-duty vehicles, which had peaked in 1987 at 26.2 miles per gallon, declined to 24.9 miles per gallon in 2004. CAFE standards for light trucks had initially been 20.7 miles per gallon compared to 27.5 miles per gallon for cars, but were progressively raised and are expected to reach 22.2 miles per gallon for model year 2007. Beyond 2007, the EIA's forecasts an increase in average fuel economy of new light-duty vehicles to 29.2 miles per gallon by 2030, which will mainly be due to advances in fuel-saving technologies.

Figure 14 – CAFE Standards vs. Actual Fuel Efficiency



Despite these expected advances in vehicle fuel economy, overall consumption of transportation fuels is not projected to decline. For the immediate future, then, there is little disagreement that petroleum demand will increase across all its uses.

Alternatives to Petroleum Use in the Transportation Sector

Over the past two years, political support for shifting from oil-based transportation fuels to ethanol has increased dramatically. Automobile manufacturers are promoting initiatives to produce more flexible fuel vehicles that can run on E-85, a fuel mix containing 85 percent ethanol and 15 percent gasoline. The Big Three automakers are touting their commitments to flexible fuel vehicles with Ford even going so far as to advertise its investments in the supply network. Even President Bush has proposed a policy reducing dependence on Persian Gulf imports by shifting to ethanol. Members of Congress, prodded by agricultural interests, are embracing corn-derived ethanol and other biomass sources as fuels of the future. A congressional initiative gaining support calls for 25 percent of transportation fuels consumed in the U.S. to come from biomass by 2025. Midwestern governors are rushing to put forward their plans to make their states part of the nation's energy "solution." These goals are laudable and the expectations for the future are widely discussed and highlighted. Unfortunately, in the rush to embrace the alternative fuel future, the challenges to achieving this objective are overlooked and the consequences of pursuing this approach are ripe for debate.[46]

The Clean Air Act Amendments of 1990 required that reformulated gasoline, used in about 40 percent of the U.S. market, contain 2 percent oxygen. This action, combined with a tax subsidy for ethanol, created another impetus for ethanol's use — ethanol contains one atom of oxygen per molecule[47]— although the automotive emission reduction requirements of the Clean Air Act could have been achieved without an oxygen mandate.[48] The Energy Policy Act of 2005 repealed the Federal oxygen requirement for reformulated gasoline. Many refiners are expected to continue using ethanol in gasoline because it is a high octane component. In addition, some states mandate the use of oxygen and/or ethanol in gasoline.

Ethanol-gasoline blends are characterized by the percent by volume of ethanol that they contain. Conventional vehicles can use blends containing 15 percent or less ethanol in gasoline without modification. If more than 15 percent ethanol is used, engine modifications are required to compensate for the changes in fuel properties. When these modifications are made, the vehicles are designed to operate on either gasoline or ethanol-gasoline blends. Such vehicles are known as flexible fuel vehicles (FFVs), many thousands of which have been manufactured. The highest concentration of ethanol that can be used in an FFV is 85 percent; 15 percent gasoline is necessary to provide sufficient volatility to start the engine. Specially designed vehicles can use higher concentrations of ethanol.

When corn-based ethanol was first produced for fuel use in the 1980s, almost all studies showed that it required more fossil fuel energy input than the energy contained in the product. Since the mid-1990s, most studies have shown that ethanol produced from corn contains more energy than the fossil fuel used to produce it. A gallon of ethanol contains 76,000 BTU (Low Heating Value, the amount of energy theoretically available for use by an automotive engine). Most recent studies show that ethanol from corn contains about 20,000 more BTUs per gallon than the fossil fuel used in its production. Table 2 provides a breakdown of current energy inputs and outputs for corn-based ethanol production.[49]

Table 2 – Energy Balance for Corn-Based Ethanol

Energy Balance for Corn-Based Ethanol	
	BTU/Gallon
Corn Production and Transportation	21,400
Ethanol Production and Transportation	49,300
Byproduct Energy Credit	-12,900
Net Fossil Energy Inputs	57,800
Energy in Ethanol	76,000
Net Energy Benefit	18,200

EIA documents both current energy use and price, and forecasts future energy demand and price. According to EIA and other sources:

- 2004 domestic production plus net imports of gasoline totaled 140 billion gallons.[50]
- EIA's reference case for the future, which forecasts crude oil price to be \$57/Bbl in 2030 (2004\$), projects U.S. demand for gasoline to grow to 163 billion gallons by 2015 and 191 billion gallons by 2030.[51]
- Ethanol for gasoline production totaled about 3.9 billion gallons in 2005,[52] or about 2 percent of the gasoline pool.
- EIA's reference case projects ethanol production to grow to 10.7 billion gallons in 2030, or 5.6 percent of the gasoline pool.[53]
- EIA's high oil price case for the future, which forecasts crude oil price to be \$96/Bbl in 2030 (2004\$), projects gasoline demand to be only marginally lower, at 188 billion gallons in 2030, and ethanol production to be 13.8 billion gallons, or 7.3 percent of the gasoline pool.[54]

EIA's projections are a reasonable outlook for ethanol. It will play a role as a transportation fuel, but it is far from a panacea. It will not free the U.S. from dependence on fossil fuels, nor will it eliminate U.S. oil imports.

Corn-based ethanol is unlikely to become cost competitive with gasoline anytime soon. As indicated above in the discussion of energy balance, there has been considerable improvement over the last 20 years in the efficiency of producing ethanol. With any process, continued efficiency gains are governed by the law of diminishing returns. The easy and most dramatic improvements are achieved early, while later improvements are smaller and more difficult to implement.

The actual price to the consumer is not the only cost of ethanol to consider. At current production rates, the $0.51/gallon subsidy for ethanol costs U.S. taxpayers nearly $2 billion/year. If ethanol production increases as projected by EIA, this cost will grow to more than $5 billion/year by 2015. Whether this is a cost effective way of increasing U.S. energy supply is a subject for debate.

Sugarcane yields more sugar, and therefore more ethanol, per acre than corn. In addition, the combustion of sugarcane waste, known as bagasse, for energy in sugarcane processing is well established. As a result, the energy balance for ethanol from sugarcane is far more attractive than the energy balance for ethanol from corn.

Currently, ethanol is not produced from sugarcane in the U.S., but the Energy Policy Act of 2005 included $36 million funding for sugar-to-ethanol demonstration grants, and $50 million funding for loan guarantees for sugarcane and sucrose-to-ethanol facilities. It is unlikely that production of ethanol from domestic sugarcane could make a significant impact on U.S. energy supply. The U.S. has a large sugar industry, currently fifth in the world, but still does not grow enough sugar to meet its own needs.[55] A variety of discussions are underway about expanding U.S. sugar production to produce ethanol, but many of these actually focus on using both the sugar itself and the cellulose in bagasse as feedstocks. Production of ethanol from cellulose is currently uneconomic. Imports from Brazil and other sugar producing countries could significantly increase U.S. supplies of ethanol, but would do nothing to increase U.S. energy independence. Also, imported ethanol is subject to a $0.54/gallon tariff, which eliminates any economic benefit for its use.

Because of the limitations of corn-based ethanol and the political obstacles to sugarcane ethanol, the Bush Administration and others are promoting R&D and technology to produce ethanol from the cellulose in biomass (forest and agricultural by-products and wastes). The roadmap of scientific challenges released by the Department of Energy implies that it could take decades of research and development to overcome the barriers to widespread use.[56]

Ethanol produced from biomass is less energy intensive than corn-based ethanol, so costs should be lower. The challenges for achieving greater ethanol use to offset gasoline consumption are not insignificant or inexpensive. The technology for large scale conversion of biomass into ethanol is not commercially viable and when it will become so is unknown.

Even under the optimistic assumptions of the EIA's high technology case, biomass ethanol production reached just three billion gallons by 2020 or roughly 2 percent of current gasoline consumption. The IEA projects that biomass fuels' share of global road transportation will grow from currently 0.6 percent to 1.4 percent by 2030. Even in the International Energy Agency's alternative scenario, which assumes that countries will implement policies favoring the increased use of renewables, biofuels are only expected to account for 3.6 percent of global road transportation.[57] Biodiesel's potential is so small that EIA did not consider the impact of its use in its 2006 *Annual Energy Outlook*.

The Department of Agriculture has examined the land availability issues involved in increased biomass ethanol production and concluded that forest and crop land resources have the potential for enough biomass to produce about one-third of today's fuel demand by mid-century.[58] It also concluded that achieving this potential would require concerted R&D to "develop technologies to overcome a host of technical, market and cost barriers."[59]

There are currently over 230 million vehicles operating in the United States. Annual sales are on the order of 17 million with about 700,000 being ethanol capable. If that number increased by 100,000 annually, which would probably be a significant increase, the total number of ethanol vehicles sold in a decade would still only represent 10 percent of current vehicles sales and the total on the road would be about 5 percent of the current vehicle fleet. This is not an argument against an increasing role for ethanol as a transportation fuel. It is an argument for being realistic in expectations and for understanding the magnitude of the challenge and long lead times involved in reducing gasoline use.

While it is clear that biomass-derived fuels have a role to play in the transportation sector, that role currently is limited by technological maturity, cost, and supply. Studies at both the U.S. and global levels indicate that the technical potential for sustainably grown biomass is insufficient to provide the energy required by the current transportation system, let alone the significant increase in transportation energy demand projected for the future.

Methanol is often discussed as a potential contributor to energy independence because it is a liquid fuel that relatively easily can be manufactured from any source of carbon: fossil fuels, biomass, or waste. By tapping its vast coal reserves to produce methanol, advocates claim the United States could significantly shift its dependence on imported petroleum for transportation fuel. Use of methanol as a motor fuel requires dedicated vehicles and a dedicated distribution system, and raises a new and potentially difficult to address set of health and safety issues. While advocates of U.S. energy independence promote methanol, California, which was the site of most of the experimental and demonstration work on methanol-fuelled vehicles, dropped this effort and moved on to other alternatives. There is no evidence of new programs to develop methanol-fuelled vehicles.

Vehicles powered by hydrogen have potential for future use, but it may be decades before the technologies are mature enough for market introduction and then decades more before the vehicles successfully penetrate the market sufficiently to make a difference. Estimates from MIT's Laboratory for Energy and the Environment conclude that it will be 15 years before a hydrogen fuel cell vehicle is market competitive, 20 years before they would account for more than one-third of the mileage driven, and 25 years before they would account for one-third of new vehicle production.[60] Research programs, like the Administration's Hydrogen Fuel Initiative, will attempt to shorten these timescales, but the technical obstacles and cost competitiveness concerns will take time to overcome.

Achieving the promise of alternative fuels is not inevitable and will not be without cost and dislocation. Limits on supply, technical barriers, and cost differences all suggest that gasoline derived from petroleum will remain the predominant transportation fuel for the foreseeable future.

Electric Power Generation

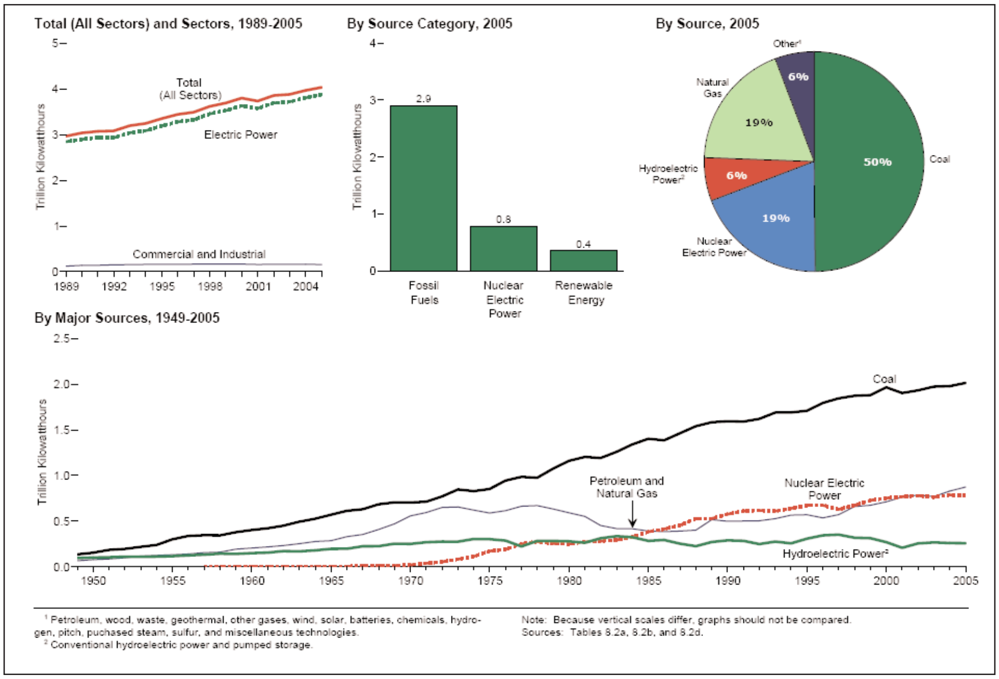
As Figure 1 showed, the energy budget of the U.S. involves considerably more than petroleum used in transportation. Considering the future of the U.S. economy requires analysis and understanding of how electricity is supplied. This section examines the structure of the fuel system supplying America's electricity consumption.

Structure of the U.S. Electricity System

Figure 15, which presents data on net electricity generation in the U.S. drawn from the EIA's *Annual Energy Review*, clearly shows the pivotal role fossil fuels play in meeting the electricity needs of U.S. citizens. Fossil fuels accounted for 70 percent of the fuel used to meet U.S. electricity needs in 2005, a share which has not changed appreciably for many years. Nuclear power provides about 20 percent of the nation's electricity needs, with hydroelectric power and other forms of renewable energy filling the remaining 10 percent.

Coal is the largest fuel source used for electricity generating, providing 50 percent in 2005. Coal's contribution has increased steadily over time as the bottom graphic in Figure 15 makes clear. Natural gas met 19 percent of the electricity generation needs in 2005. Combined with the minimal amount of petroleum, natural gas surpassed nuclear power in 2004-2005 to become the second largest source of net electricity generation.

Figure 15 – Electricity Generation in the U.S., 2005



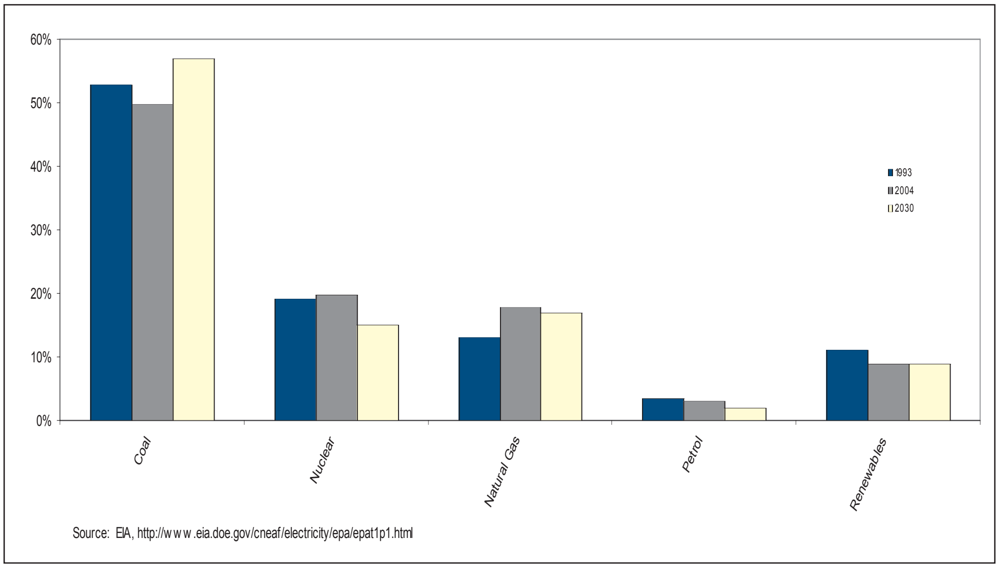
Projected Changes in Electricity Demand

The EIA predicts an increase in total electricity demand of about 50 percent, from 3,567 billion kilowatt-hours in 2004 to 5,341 billion kilowatt-hours, in 2030. The increase in energy demand is largely driven by the commercial sector and the service industry in particular. Efficiency gains in both the commercial and the residential sectors are offset by increased consumption due to more intensive use of electrical equipment and increases in demand for houses with more floor space.

To be able to meet demand, 347 gigawatts of new capacity are needed by 2030. The EIA projects that due to their cost advantages and higher operating efficiency, coal-fired power plants will continue to supply most of the nation's electricity through 2030.[61] More than 50 percent of the additions to generating capacity from 2004 until 2030 expected by EIA are coal-fired plants (see Figure 16). Coal-fired plants currently account for approximately 50 percent of all electricity generation and their share is projected to increase to 57 percent by 2030. As a result, the EIA projects strong growth in coal production through 2030.[62] The available supplies appear capable of meeting this strong expected demand. Recoverable reserves in the United States in 2005 were 18.9 million short tons, with 81 percent of the coal remaining to be recovered from coal reserves at U.S. mines.[63]

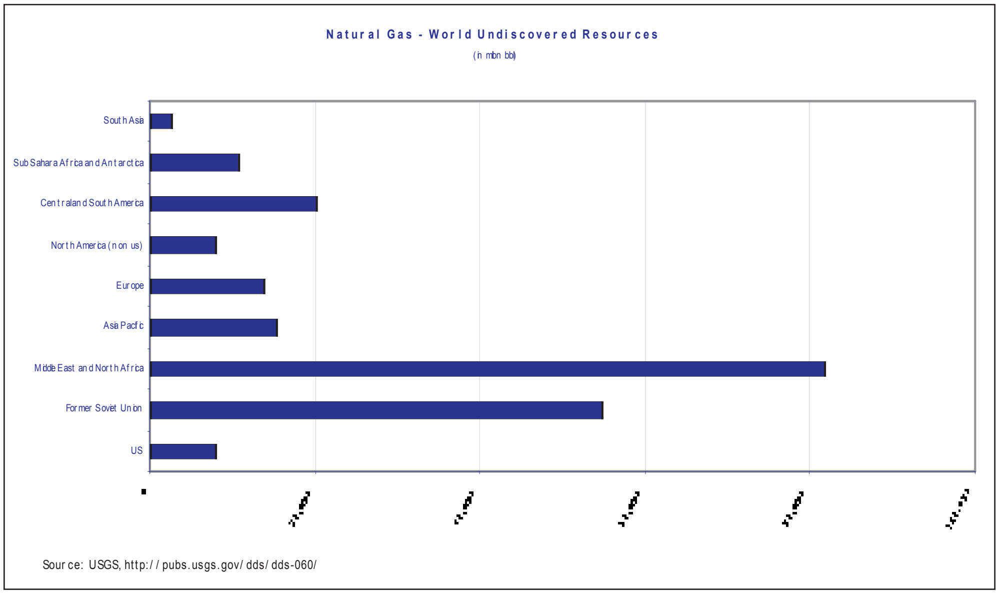
Because of comparatively higher fuel prices, natural gas-fired plants are not now being used as intensively as coal-fired plants. Natural-gas fired plants currently provide about 18 percent of total supply. Forty percent of early additions to capacity generation will, according to the EIA's projections, be natural-gas-fired plants, but their share of total generating capacity is projected to decline slightly to 17 percent in 2030.

Figure 16 – Electricity Generation by Source



Even if the price of natural gas dropped to levels of a few years ago, increased reliance on natural gas for power generation would raise new concerns about energy independence. Proven reserves of natural gas reveal a distribution pattern that ought to raise the same concerns as those raised about oil imports. Natural gas has been a regional fuel but increasingly will become a global one as increases in demand are met by increased production and transportation of liquefied natural gas (LNG). Figure 17 details projections for probable sources of natural gas. The preponderance of known reserves being found in the Middle East ought to incite concerns similar to those of imported petroleum, here and abroad.

Figure 17 – Natural Gas Reserves



Only about 8 percent of the expected capacity expansion is predicted to consist of renewable generating units. The share of power generation from renewables will rise close to 10 percent of total power generation by 2030. Nearly 50 percent of the additions in renewable capacity are projected to come from state programs and more than 93 percent of that capacity is projected to come from wind plants. The potential contribution of wind power has been the subject of debate and will not be soon resolved. The important point is not whether we have more or less wind power or more electric power from alternatives, it is that alternatives are not projected to make a significant contribution over the next few decades.

Renewables are expected to become more competitive over time, but average levelized cost for solar thermal and biomass technologies is still significantly higher than its avoided cost through 2030.[64] Dispatchable geothermal and biomass resources compete directly with new coal and nuclear plants. At some point, new geothermal or biomass plants may be competitive with new coal-fired plants, but their development is limited by the availability of geothermal resources or the factors affecting the competitiveness of biomass fuels described above. Although conventional hydropower remains the largest source of renewable generation through 2030, a lack of untapped large-scale sites, coupled with environmental concerns, limits its growth, and its share of total generation falls from 6.8 percent in 2004 to 5.1 percent in 2030, under the EIA's projections. Nevertheless, electricity generation from nonhydroelectric alternative fuels is expected to increase, bolstered by technology advances and state and Federal supports.

The remaining 2 percent of additions to total generating capacity will be new nuclear capacity. Nuclear power is expected to account for only about 15 percent of total U.S. generation in 2030 (currently 20 percent) as total generation grows at a faster rate than nuclear generation. Under the EIA's projections, no new nuclear capacity is expected to be added after 2020.

Reducing losses associated with the transmission of electricity would also contribute significantly to efficiency improvements in the electric utility sector. The EIA's *Annual Energy Review 2005* estimates that transmission and distribution losses, which are electricity losses that occur between the point of generation and delivery to the consumer, are estimated at 9 percent of gross generation. Technological enhancements and improved management offer potential approaches for reducing these losses.

Table 3 places these generation options in a comparative cost context to further underscore the points about competitiveness. EIA's cost projections suggest that coal will remain the low-cost electricity generation option for the near-term, followed closely by geothermal, natural gas, and wind.

Table 3 — National Average Levelized Generation Costs for New Plants in 2010

Technology	Levelized Costs (2003 cents per kilowatthour)
Pulverized Coal	4.3
Geothermal	4.4
Natural Gas Combined-Cycle	4.7
Wind	4.8
Open-Loop Biomass	5.1
Nuclear*	6.0
Solar Thermal	12.6
Photovoltaic	21.0

*The time required to license, permit, and construct a new nuclear plant makes it impossible to bring one on line by 2010. The costs shown are for a plant beginning operation in 2013.

Excludes transmission costs and impact of PTC.

Source: National Energy Modeling System run, aeo2005.d102004a; Statement of Howard Gruenspecht, Deputy Administrator, Energy Information Administration, U.S. Department of Energy, Testimony Before the Subcommittee on Select Revenue Measures of the House Committee on Ways and Means on May 24, 2005

What Could Technology Achieve?

The IEA recently published a report titled *Energy Technology Perspectives 2006: Scenarios and Strategies to 2050*, in which they examined seven scenarios for future energy technology:

- a baseline scenario, which envisioned a normal rate of technological progress;
- five Accelerated Technology (ACT) scenarios, which assumed that technological progress occurred at the fastest reasonable rate — one of these scenarios, called Map, was optimistic about all technologies (energy efficiency, carbon capture and storage, nuclear, renewables), the other four were pessimistic about one of the technologies; and
- a TECH Plus scenario, which assumed that technological progress was even faster than in the ACT scenarios.

IEA did not provide an explanation of the assumptions embedded in the TECH Plus scenario. We assume they represent the expert judgment of the IEA authors.

While the ACT and TECH Plus scenarios envision a dramatic reduction in global fossil fuel use in 2050, compared to the baseline, they still show a significant increase in demand for oil, compared with current demand.

Primary Energy Supply in IEA Scenarios

	Demand, Mtoe*			
	2003	2050		
		Baseline	Map	TECH Plus
Coal	2,584	7,532	2,912	2,654
Oil**	3,643	6,011	5,818	4,862
Gas	2,244	5,349	3,747	3,698
Nuclear	226	267	852	1,531
Hydro	227	380	421	431
Biomass***	1,142	~500	~620	~1,000
Other Renewables***	53	~2,000	~2,400	~3,400
Total	10,579	22,112	16,762	17,566

* Mtoe = Million metric tonnes oil equivalent, i.e. the energy content of 1 million metric tonnes of crude oil

** Includes conventional and unconventional oil, but not liquid fuels derived from coal or biomass. These are accounted for under coal and biomass.

*** Biomass includes the use of firewood and other traditional fuels, which is expected to decline in the future. Values for biomass and other renewables for 2050 are approximate, having been read from graphs. IEA provides total energy use for all scenarios.

The IEA report does not include a discussion of energy demand in the U.S., but analysis of the global information is sufficient to draw some conclusions about the U.S. outlook.

continued on next page

Our focus in this report is on the potential to replace oil in the transport sector. Three possibilities exist: use of biomass fuels, use of hydrogen in fuel cells vehicles, and use of synfuels from coal or gas. IEA examines all three. In 2050:

1. biomass supplies ~3 percent of the world's transportation energy in the base case, 13 percent of the world's transportation energy in the Map Scenario, and 25 percent in the TECH Plus Scenario;

2. hydrogen fuel cell vehicles play negligible roles in the base case and Map scenarios, but supply 9 percent of transport energy demand in the TECH Plus scenario; and

3. synfuels contribute about a quarter of transportation energy needs in the base case, but decline to about 9 percent in both the Map and TECH Plus scenarios, because reduced fossil fuel use in other sectors reduces oil price and the incentive to produce synfuels.

Taking all three alternatives into account, non-oil sources supply about 28 percent of global transportation energy in the base case, 22 percent in the Map scenario, and 43 percent in the TECH Plus scenario. Globally, oil will remain the dominant fuel for transportation, and there is no reason to believe that the U.S. will depart significantly from the global pattern.

It should be emphasized that the TECH Plus scenario is highly speculative, and would require technological breakthroughs in both hydrogen use and biofuels production, The IEA believes that a carbon price of \$25/t CO_2, about \$1/gallon gasoline, would be sufficient to drive implementation of the Map scenario, but this, too, is highly speculative.

Policy Choices

America has the economic wherewithal to change its energy future by the policy choices it makes. As a nation, we can pour significantly more resources into increasing energy efficiency and changing the mix of fuels that we consume. But, four fundamental realities underlie the choices:

- The American economy relies overwhelmingly on fossil fuel energy. Coal, oil and natural gas make up 85 percent of today's energy usage, and it will take many years to significantly change that mix.
- These fuels are dominant for good reason; they are the most economical, and it is to the country's advantage to obtain its energy as inexpensively as possible. The less we spend to obtain the energy we need, the more we can devote to the many other things we want.
- Future economic growth will require yet more energy than is utilized today, and the more cheaply we can obtain the additional energy, the better off we will be.
- Policy choices are not free. The more resources we devote to policies aimed at significantly changing our energy mix, the fewer are available for other priorities.

Viewed in this way, the policy challenge is not just to find new sources of energy or mechanisms to utilize it more efficiently, but rather to develop and deploy such sources and mechanisms as economically as possible. Further, we should evaluate policy alternatives not only by whether they can provide increased energy security, but also by how cost effectively they will do so.

What policy choices do we have? For one thing, we can encourage the development of more of the fuels that we already use. America has a large fossil fuel resource base that includes hundreds of years of coal deposits and very substantial offshore and onshore oil and gas resources. Much of this can be developed relatively inexpensively, providing low cost means to fuel the country's economic growth and substituting for imported energy sources.

Other low cost policies include providing information to energy consumers and support for technology development. EPA's Energy STAR program, for example, identifies and labels products that are highly energy efficient so that consumers can make informed choices. The program covers over 30 classes of products from light bulbs to buildings and has been steadily expanding.

Support for energy technology research and development can be justified because private parties cannot always fully appropriate the results of their efforts. The Federal government is spending several billion dollars annually on such research, with resulting technologies such as improved gas turbines and batteries that have been entering the marketplace, displacing fossil sources or increasing the efficiency with which they are used.

Other policy choices are possible. For example, we can continue to develop wind and solar energy, which are appealing because they are renewable and carbon free. Over time they will add to the country's energy supply, but in many applications they are still quite expensive. Wind energy, for example, requires backup sources of power because it is intermittent, while photovoltaic cells, also requiring backup sources of power, are expensive to produce and convert only a small percentage of their input energy into usable power. Both of these technologies are improving, but they will supply only a small share of the nation's energy for many years to come, and attempts to force their growth through compulsory mechanisms such as renewable portfolio standards are undesirable because they will drive up the costs of energy to consumers.

Another choice lies in the development of biofuels such as ethanol and methanol, which offer substitutes for petroleum-based fuels and can be produced from farm products and from used vegetable oils. Since they come from plant matter, they often are considered renewable fuels. Ethanol and methanol have substantially lower energy content than gasoline or diesel, they require energy in the growing and production processes, neither can be shipped by existing pipeline, and historically they are more expensive to produce and distribute than gasoline. Other biofuels may prove superior, and it should be left to the marketplace to sort them out. Congress nevertheless has mandated the use of 7.5 billion gallons of ethanol by 2012, a policy that appears aimed as much at providing income to farmers and processors as it is at developing new energy alternatives. Unfortunately, the policy will add to the nation's overall cost of fuel until such time as ethanol becomes cost competitive.

Mandates also can be used to compel energy efficiency. The DOE has imposed mandatory efficiency standards for various home appliances, and the Department of Transportation has mandated mile per gallon requirements for the American light vehicle fleet. These mandates have led to various inefficiencies, however, including a highly distorted vehicle market. American automakers have been forced to produce and subsidize the purchase of large numbers of smaller cars in order to sell the larger cars that Americans have wanted. This has put them into direct competition with Japanese and Korean automakers, which have large small-car home markets as their base. Mandates almost always cause costly market distortions which are largely hidden from view but which impose significant burdens on both producers and consumers. They are not an economically efficient way to obtain energy security.

Broad policy choices such as taxes on fuels or on carbon also are possible. Such taxes would raise the costs of energy in America, leading to substitution of other resources to economize energy use or to produce low carbon fuels. The result would be more energy efficiency and a lower carbon mix of fuels. If imposed rapidly such taxes would render a portion of America's capital stock obsolete, decreasing national wealth. In addition, the substitution of other resources for energy would lower national output, reducing the amount Americans would have to spend on defense, counterterrorism, health, housing, foodstuffs, aid to other countries, and other desirable things.

Or, we might re-evaluate nuclear power. Over the next 20 years, the U.S. will require 400,000 megawatts of new electricity generating capacity — that's about 400 power plants, fossil fuel or nuclear — to meet new electricity demand. Based on past policy and investment policies, electricity generators will be hard pressed to keep pace with this increasing demand. The utilities industry has incentives to increase operating efficiencies for existing fossil fuel and nuclear power plants. And they can be expected to build new based load electrical plants using incentives in the Energy Policy Act of 2005.

The Energy Policy Act of 2005 promotes nuclear energy support to the transportation sector through support for the Next Generation Nuclear Plant (NGNP). The NGNP is intended to produce the high-temperature heat required to produce hydrogen. If hydrogen can be made available in practical quantities, the transportation side of the energy picture could be improved by making hydrogen powered vehicles feasible, if fuel cell costs decline and infrastructure challenges are solved. This impact (energy input) in the near term will be negligible because the demonstration NGNP is not planned for deployment until 2021. Even then, this hydrogen-producing demonstration model would be a very small energy source compared to a standard oil well.

The Global Nuclear Energy Partnership (GNEP) is moving to make bold, short-term policy changes which will have long-term energy generation possibilities. The goals of GNEP are to produce lots of electricity while almost eliminating the long-term "waste" problem in a proliferation resistant manner. The underlying principle of GNEP is that spent nuclear fuel (nuclear waste) is an energy asset. In fact, the amount of energy still contained in the "waste" is over 90 percent of what was generated. That means we are currently extracting only about 3 percent of the available energy from nuclear fuel rods, and expecting to then bury the rest in the Yucca Mountain repository. The GNEP's advanced burner reactor (ABR) is the tool that will extract that energy from the old spent nuclear fuel, a truly indigenous source of energy.

The situation then is this: The country has the wherewithal and skills to change the mix of energy sources it consumes and to use energy more efficiently. It has done so in the past and will continue to do so in future. But it can do so wisely or poorly. The rational approach is to develop the least costly options available to us that will advance our energy security. These should include energy efficiency as well as energy production technologies and we should be willing to provide encouragement through support for research, development, and deployment. If instead we are lured into mandating or heavily subsidizing the use of politically popular but costly technologies, we will not much advance the country's energy security, but we will surely decrease its wealth.

Endnotes

1. Primary consumption includes coal, natural gas, petroleum, nuclear electric power, conventional hydroelectric power, wood, waste, alcohol fuels, geothermal, solar, wind, and net imports of coal, coke and electricity. Total consumption includes primary consumption, electricity retail sales, and electrical system energy losses.
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21. EIA (2006b): 65.
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24. Federal Highway Administration. (2006). Highway Statistics. (Washington, DC: Annual issues), table HM-20.
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27. Center for Transportation Analysis (2006): Table 4-1.
28. Additional data on aircraft and other modes of transportation is available in: Center for Transportation Analysis. (2006). Transportation Energy Data Book, 25th Edition. (Oak Ridge, TN: Oak Ridge National Laboratory).
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30. Even in the high price case examined by EIA, demand for travel increases noticeably in the 2004-2030 period. See EIA (2006b), http://www.eia.doe.gov/oiaf/aeo/excel/aeohptab_7.xls.
31. Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/hist/rcrr01nus_1a.htm. According to EIA, "Proved reserves of crude oil are the estimated quantities which geological and engineering data demonstrate with reasonable certainty can be recovered in future years from known reservoirs, assuming existing economic and operating conditions."
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