

SECURING AMERICA

Solving Our Oil Dependence Through Innovation

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ABOUT NRDC

NRDC (Natural Resources Defense Council) is a national, nonprofit organization of scientists, lawyers, and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles, and San Francisco. For more information, visit www.nrdc.org.

ABOUT IAGS

The Institute for the Analysis of Global Security is a nonprofit public educational organization focusing on energy security. IAGS seeks to promote public awareness to the strong impact energy dependency has on our economy and security and to the myriad of technological and policy solutions that could help us move into an era of energy independence, and increase peace, prosperity, and stability in the world. Visit us on the World Wide Web at www.iags.org.

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EXECUTIVE SUMMARY

Oil dependence has become the Achilles heel of America’s economy—and national security. America consumes more than 20 million barrels of oil every day, oil that powers cars, trucks, factories, and homes. Yet we have less than 3 percent of all known oil reserves and import almost 60 percent of our oil, making us dangerously dependent on a single, precarious energy source to keep our economy moving. Defense and foreign policy experts increasingly point to our oil addiction as an “incipient national security emergency” given the alarming trends in our petroleum demand, the lack of reliable alternatives to Middle East oil, and the vulnerable nature of the oil supply chain.¹ The costs and risks of America’s oil dependence will increase as the global oil market tightens and geopolitical tensions threaten to disrupt supply.

Responding to this threat, the Institute for the Analysis of Global Security (IAGS) and the Natural Resources Defense Council (NRDC) forged a new alliance to advocate for a different, safer path for America. To make us more secure and to stimulate a stronger, energy-efficient economy, we should reduce our dependence on oil and invest in domestic industries that address this vulnerability. A strong national commitment to oil savings would put American manufacturers to work building the most energy-efficient cars in the world and American farms to work growing crops for new fuels. The path to energy efficiency reflects shared priorities of independence, good jobs, freedom from terrorism, and a healthy environment. We recommend the following national commitment, which can be achieved through policy measures such as those detailed in this paper:

Congress should establish a minimum national commitment to save 2.5 million barrels of oil per day by 2015 and 10 million barrels per day by 2025.

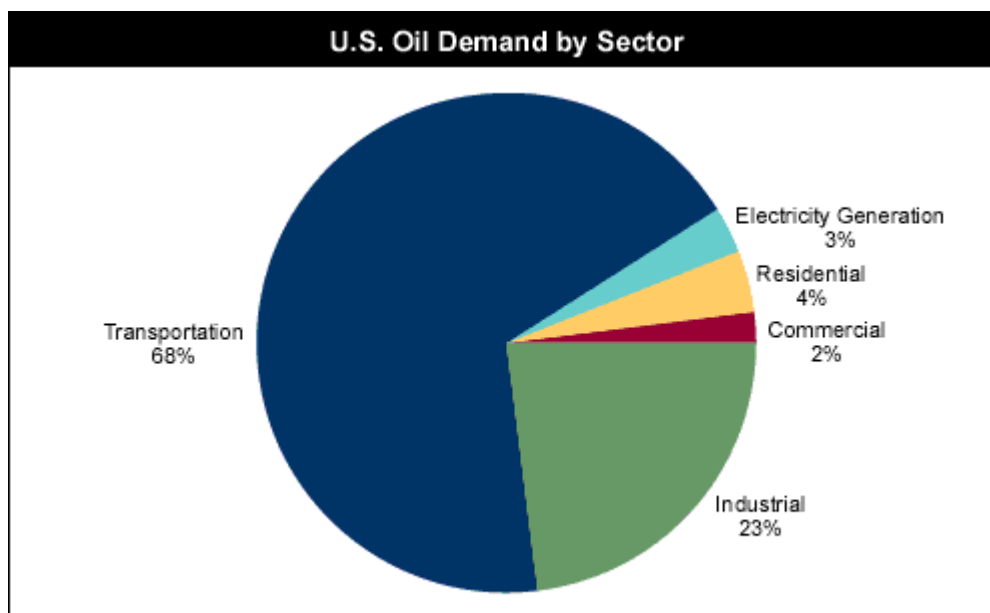
Using available technology, we could save an average of 3.2 million barrels per day within 10 years (see *Technologically Achievable Oil Savings*). Oil savings measures should be implemented across the transportation, industrial, and residential sectors. In the transportation sector, policy measures should raise the fuel efficiency of new vehicles through tax credits for retooling auto factories and consumer purchases, and by raising standards. Motor vehicle policies should facilitate the use of fuel-efficient replacement tires and motor oil, and efficiency improvements in heavy-duty trucks. Oil saving measures such as upgrading air traffic management systems and promoting residential energy savings in homes heated by oil will also contribute to a national savings goal, as will encouraging the growth of the biofuels industry. Through efficiency gains and fuel alternatives, U.S. oil consumption could be reduced almost 40 percent by 2025.

Technologically Achievable Oil Savings (million barrels per day)		
Oil Savings Measures	2015	2025
Raise fuel efficiency in new passenger vehicles through tax credits and standards	1.6	4.9
Accelerate oil savings in motor vehicles through		
fuel efficient replacement tires and motor oil	0.5	0.6
efficiency improvements in heavy-duty trucks	0.5	1.1
Accelerate oil savings in industrial, aviation, and residential sectors	0.3	0.7
Encourage growth of biofuels industry through demonstration and standards	0.3	3.9
Total Oil Saved	3.2	11.2

See Appendix for complete analyses.

AMERICA'S OIL DEPENDENCY UNDERCUTS OUR ECONOMIC STRENGTH

America's economic engine runs on oil. Oil fuels cars, trucks, factories, and homes. (see *U.S. Oil Demand by Sector*). This is especially true for the transportation sector that takes us to and from our jobs and homes; and moves goods between factories, farms, and consumers. Transportation, which forms the backbone of our economy, is also responsible for two-thirds of total U.S. oil demand. Passenger cars and light trucks alone account for nearly half of total U.S. oil consumption and consumption by the transportation sector is predicted to account for 80 percent of the surge in total U.S. petroleum demand during the next 20 years.



Source: Annual Energy Outlook 2003, Energy Information Administration, Department of Energy

The cost of our oil consumption is high. Although gasoline prices hover around just \$2 dollars a gallon, the real price of oil is much higher if we consider the additional expenses associated with the military costs of protecting oil transportation infrastructure, the environmental costs to our wilderness and public health, and the economic risks inextricably linked to dependence on oil. High oil prices are passed on to consumers not only through higher prices at the pump, but also through more expensive goods and services, a weaker job market, and lower stock prices.² In a new global market, where demand is outpacing supply and spare production capacity is dwindling, at least in the short term, the United States should expect oil prices of \$40 per barrel or more.³

In 2004 alone, Americans spent roughly \$270 billion to feed our oil appetite and oil imports accounted for roughly one-quarter of the trade deficit.^{4,5} This deficit increased by 24 percent last year, which some analysts predict will upset stocks and increase interest rates.⁶ The total economic penalty of our oil

dependence, including loss of jobs, output, and tax revenue is estimated to be \$297 to \$305 billion annually.⁷ During the next 25 years, the United States will likely also have to shoulder a substantial portion of the \$3 trillion in global investment necessary to finance additional oil production capacity.⁸

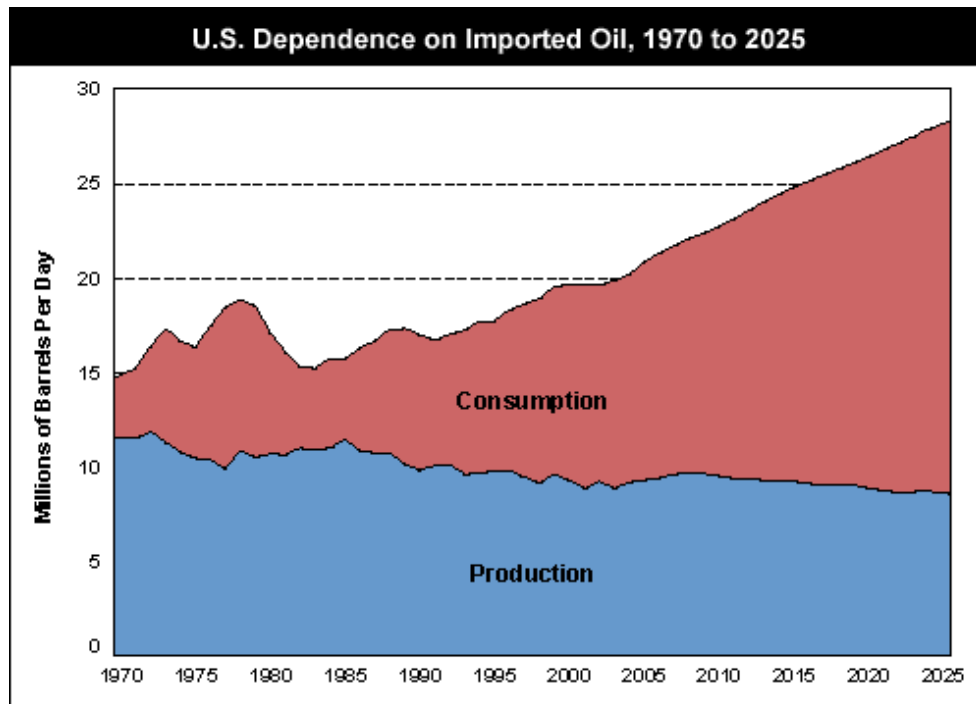
In addition to sustained high prices, a tight marketplace makes for a greater probability of price spikes in response to fears of supply disruptions because of terrorism or other causes. Oil price spikes, according to economist Philip Verleger, have cumulatively sapped 15 percent of our economy's growth resulting in \$1.2 trillion in direct losses.⁹ While some have argued that our economy is less effected by oil shocks than it was 30 years ago due to lower petroleum intensity—the amount of oil used per unit of GDP—America's economy is still highly vulnerable because of our high levels of imports, the global nature of the oil markets, and interdependence of today's worldwide economies.¹⁰

AMERICA’S OIL DEPENDENCY THREATENS OUR NATIONAL SECURITY

Defense and foreign policy experts increasingly point to America’s oil addiction as an “incipient national security emergency.”¹¹ Factors contributing to this security crisis include an alarming increase in global oil demand, America’s heavy reliance on oil imports from the Middle East, the lack of reliable import alternatives, and an oil transport infrastructure vulnerable to supply disruptions.

American and global demand for oil rising faster than supply.

America’s oil consumption continues to grow at breakneck speed. According to the Energy Information Administration’s (EIA) 2004 Energy Outlook, the United States is projected to consume 40 percent more oil in 2025 than we do today, or 28.3 million barrels of oil per day.¹² Production capacity in the United States would only supply 30 percent of this total demand (see *U.S. Dependence on Imported Oil*).



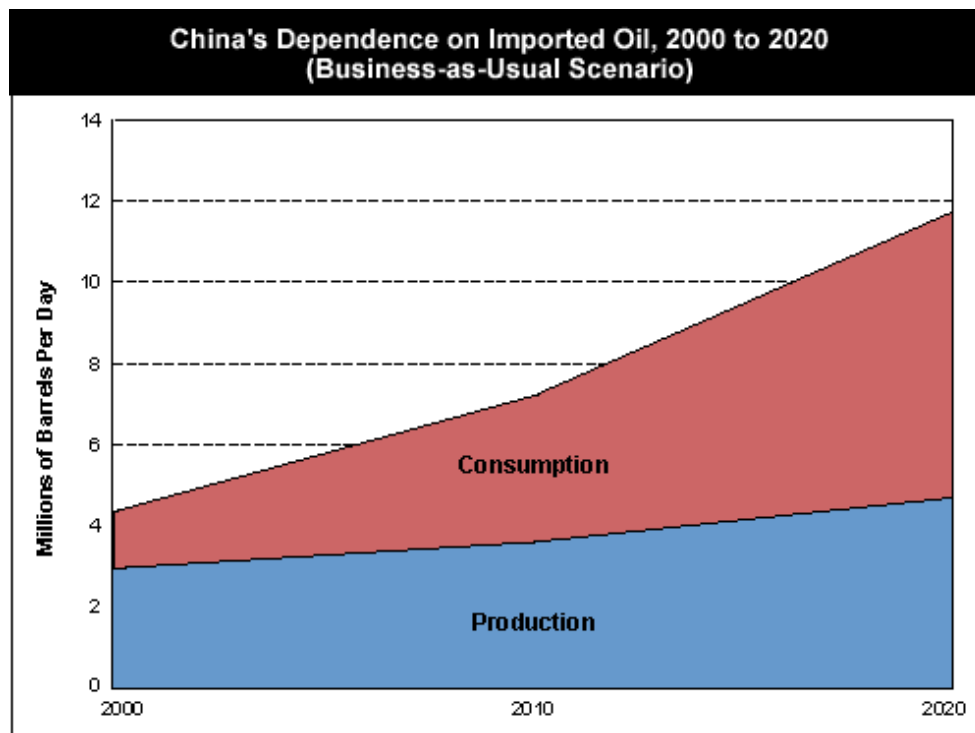
Source: Energy Information Administration, *Annual Energy Outlook 2004*

Some argue that America should open its wild lands for oil exploration and drilling to reduce U.S. dependence on imported oil. But this is a shortsighted, wasteful approach to relieving our oil dependency. Although drilling advocates claim there is potentially 16 billion barrels of technically recoverable oil in the Arctic National Wildlife Refuge, this figure is for oil recovered regardless of extraction costs. When considering the price of oil on which current production decisions are being made, about \$30 per barrel, the

actual amount of oil that is economically extractable is about 5.9 billion barrels.¹³ Moreover, it would take 10 years for any oil from the Arctic Refuge to reach the market. Even during the predicted production peak in 2027, the coastal plain would produce less than 3 percent of America’s daily oil demand.

The world now consumes oil faster than it can discover new oil reserves. In fact, the world uses about 12 billion more barrels per year than it finds.¹⁴ OPEC is quickly exhausting excess production capacity, allowing for little relief of demand. And Saudi Arabia’s efforts to cushion the market have largely failed as global capacity utilization remains at 99 percent in 2005.¹⁵ Demand for oil in industrialized and industrializing nations is growing steeply, making the global oil market increasingly competitive. To meet projected world demand of nearly 121 million barrels a day in 2025, global oil output would have to expand by an astonishing 44 million barrels per day or 57 percent between 2002 and 2025.¹⁶ As supply tightens, U.S. demand will continue to drive up the cost of oil in the global market.

One country’s oil demand in particular is growing at an alarming pace: China. Although per capita petroleum consumption in China is just 6 percent of U.S. consumption, rapid industrialization and a growing consumer culture mean China’s demand for oil is projected to grow rapidly (see *China’s Dependence on Imported Oil*). Although China became a net oil importer just 10 years ago, it now imports half of its daily oil demand and in the first half of 2004 its growth accounted for roughly one-third of the increase in global oil consumption.¹⁷



Source: Development Research Center, The State Council, *China's National Energy Strategy and Policy 2000-2020*, November 2003

To supply its growing demand, China has begun scouring the globe (most notably in Canada, Venezuela, Russia, Africa, Kazakhstan, Saudi Arabia, and Iran) for oil supplies. It is moving quickly to

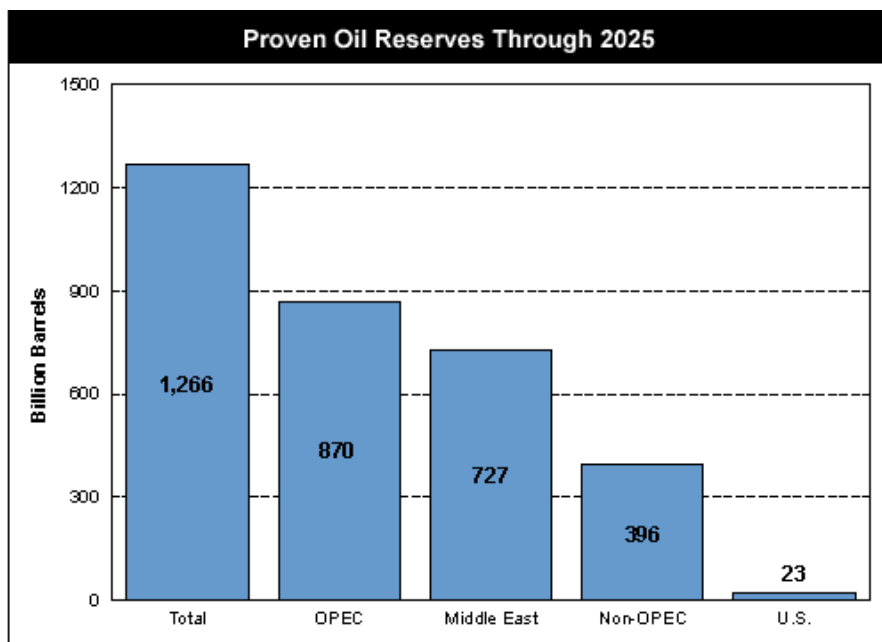
secure exclusive access to future supplies by financing strategically located pipelines, expanding its oil companies, and contracting with the key oil-producing regions around the globe.^{18, 19} More recently, Venezuela elected to limit U.S. production investments in favor of China.²⁰ Increasingly, China and the United States are in direct competition to secure control of the dwindling supply of untapped reserves. However, even China recognizes that increased fuel efficiency is a necessary part of any future energy policy and, in 2004, took an important step towards reducing demand by setting vehicle fuel economy standards more stringent than those in the United States.²¹

Another sign of an increasingly competitive global oil market is the proposed creation of an “Organization for Oil Importing Countries” between China, India, Japan, and South Korea, which would negotiate as a block for adequate supply and low prices for Asian countries.²² In short, intensifying competition for a limited supply of oil will boost prices and increase the potential for conflict between nations addicted to this limited resource.

America is increasingly dependent on oil from the Middle East.

The third millennium marked the first time the United States imported more than half of its oil supply. If this continues, the United States will find itself importing nearly three-quarters of its oil in just 20 years. The Middle Eastern OPEC states already supply the United States with 2.5 million barrels per day—25 percent of all daily imports. So where will America’s oil come from in the future?

Two-thirds of the world’s proven oil reserves are located in Middle Eastern countries, including Saudi Arabia, Iran, Iraq, the United Arab Emirates, Kuwait, and Libya (see *Proven Oil Reserves Through 2025*).



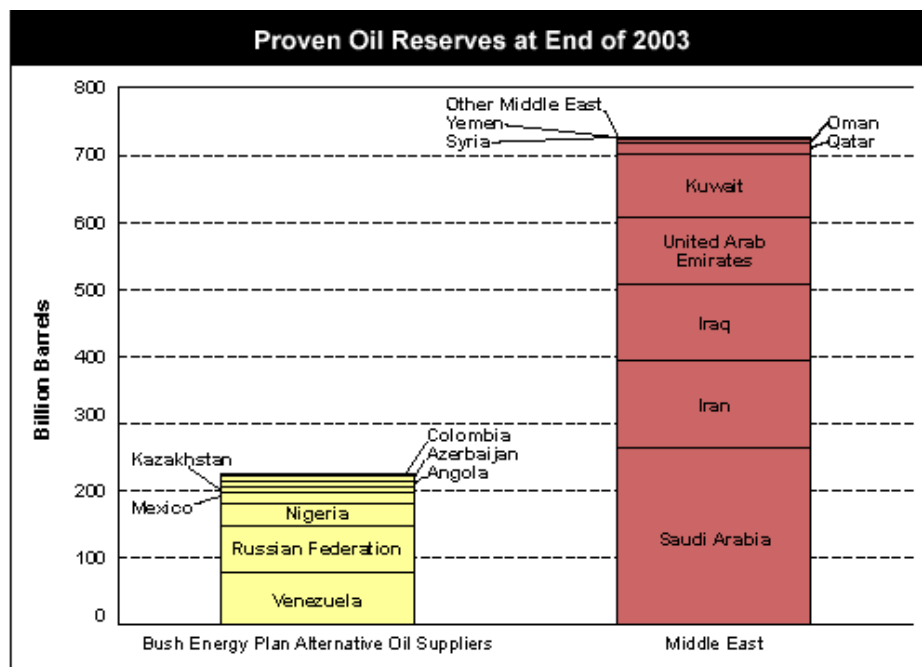
Source: Energy Information Administration, *Annual Energy Outlook 2004*

Alarming, the Department of Energy predicts that oil imports from the Persian Gulf to North America will double from 2001 to 2025.²³ And the International Energy Agency predicts that the global market share of production in OPEC countries, particularly in the Middle East, will soar from 37 percent in 2002 to 53 percent in 2030—slightly above its 1973 historical peak.²⁴

Alternatives to Middle East oil are limited and potentially unstable.

Looking beyond the Middle East to meet U.S. oil demand offers little comfort. In May 2001, the Bush administration released its National Energy Policy. In it, the administration proposed avoiding Middle East oil dependence by targeting alternative oil-supplying nations for government investment and closer alliances, including Angola, Azerbaijan, Colombia, Kazakhstan, Mexico, Nigeria, Russia, and Venezuela.

Unfortunately, increasing imports from states outside the Middle East is a risky, short-term solution at best. The total projected reserves of these alternative oil suppliers are 198 billion barrels—70 percent lower than reserves in the Middle East. More importantly, the average reserve to production ratio of these alternative oil suppliers is just 18 years. In comparison, the Middle East has almost 100 years of proven reserves at current production levels. By depleting reserves outside the Middle East, we are creating a more severe dependence on imports from the Middle East in the future. As a former Energy Secretary put it recently, “We should not deceive ourselves, as long as we are dependent on oil to the degree that we are, that there is a substitute for the Middle East [as a source for oil]...Over time, non-OPEC oil will be depleted and we will become more dependent on oil from the Middle East.”²⁵ Additionally, all of the nations on the administration’s list face significant political and social instability and remain porous to global terrorism, making it difficult to attract the foreign investments necessary to finance future production.²⁶



Source: British Petroleum, *Statistical Review of World Energy 2004*
<http://www.bp.com/genericarticle.do?categoryId=111&contentId=2004175>

Oil transport infrastructure is a target for those who wish America harm.

Thousands of miles of pipelines and hundreds of facilities operate like a global circulatory system to move the world's oil supply. But the system is vulnerable. According to the Institute for the Analysis of Global Security (IAGS), this supply system has multiple chokepoints critical to free-flowing oil commerce. Sixty percent of the world's oil is transported by sea via 3500 tankers annually. Every day 26 million barrels of oil flow through two chokepoints, the Straits of Hormuz in the Persian Gulf and the Straits of Malacca in Asia.²⁷ In the next decades, we can expect oil transportation through these channels to more than double, increasing the vulnerability of the system as well as the security costs to oil-dependent nations.²⁸

America's enemies know the oil is the Achilles heel of the developed world and that the oil transportation system is vulnerable. After a suicide boat attack on the French tanker *Limburg* in October 2002, al-Qaeda issued a statement saying that "by hitting the oil tanker in Yemen the Mujahadeen hit the secret line—the provision line—and the feeding to the artery of the life of the Crusader nation."²⁹ As IAGS and others have documented, jihadists are intent on targeting oil.³⁰ A recent IAGS brief quoted a jihad web site that urges "brothers in the battlefields to direct some of their great efforts towards the oil wells and pipeline."³¹

Since the middle of 2003, more than 200 attacks were carried out against oil pipelines, installations, and personnel in Iraq.³² Thousands more miles of pipelines traversing sparsely inhabited areas of the Middle East are vulnerable to attack.³³ A few targeted strikes against oil facilities in Saudi Arabia, which holds one-quarter of the world's oil reserves and essentially all spare capacity, could take several million barrels of Saudi oil off the global market every day for months and send oil prices soaring to more than \$100 per barrel.³⁴

Estimates suggest that during peacetime the United States spends an additional \$20 to \$40 billion per year in military costs to secure access to foreign oil supplies. This means that prior to the current military operations in the Middle East, the American taxpayer was already paying at least an additional \$4 to \$5 above market price per barrel of oil.³⁵ Domestic pipelines such as the 880-mile Trans-Alaska Pipeline System (TAPS) are also difficult to defend. Experts have said that TAPS is "largely accessible to attackers, but often irreparable in winter. If key pumping stations or facilities at either end were disabled, at least the above-ground half of 9 million barrels of hot oil could congeal in one winter week into the world's biggest ChapStick@..."³⁶

Oil demand may be fueling terrorism.

Many oil-producing countries suffer from corruption and poor governance. Transparency International noted in its Global Corruption report that, "corruption, sustained by skewed standards of living and a lack of transparent governance across the Middle East and North Africa, is a major hindrance to the region's economic development."³⁷ From Yemen, with a per capita income of around US\$300 a year, to the United Arab Emirates (UAE), with a per capita income of around US\$18,000, all countries are confronted by nepotism, favoritism, and profiteering." The problem extends to oil producers outside the region as well.

Nigeria, for example, has received over \$300 billion in oil revenue over the past 25 years, yet most Nigerians live on less than \$1 per day. The bipartisan National Commission on Terrorist Attacks upon the United States (9/11 Commission) found that poor economic conditions provide a context ripe for terrorist recruitment.³⁸

There is ample evidence that economic conditions are not the only element of a terrorist friendly climate in the Middle East. Prodigious oil supply can undermine democracy as well. Oil riches in the developing world have been linked to centralization of state power, difficulties in developing free societies, and the funding of incitement and terrorist networks.³⁹ The situation has complicated U.S.-Saudi relations so much so that the commission included a specific recommendation in its report aimed at healing the relations: “The problems in the U.S.-Saudi relationship must be confronted, openly. The United States and Saudi Arabia must determine if they can build a relationship that political leaders on both sides are prepared to publicly defend – a relationship about more than oil...”⁴⁰

As summarized in a *Foreign Affairs* article, “It is...increasingly clear that the riches from oil trickle down to those who would do harm to America and its friends. If this situation remains unchanged, the United States will find itself sending soldiers into battle again and again, adding the lives of American men and women in uniform to the already high cost of oil...”⁴¹ Therefore, reducing U.S. oil dependence could indirectly support the development of democracy, or as one columnist wrote: “Shrink the oil revenue and [Middle Eastern countries] will have to open up their economies and their schools and liberate their women so that their people can compete. It is that simple.”⁴²

It is becoming clear that U.S. policy must rise to the challenge posed by such regimes. As President Bush summarized at a recent press conference in Europe, “The policy in the past used to be, let's just accept tyranny, for the sake of - well, you know, cheap oil, or whatever it may be, and just hope everything would be okay... Well, that changed on September the 11th for our nation. Everything wasn't okay. Beneath what appeared to be a placid surface lurked an ideology based upon hatred.”

ACHIEVING NATIONAL OIL SAVINGS OF 2.5 MILLION BARRELS PER DAY BY 2015

Saving oil is a matter of national commitment. Technologies exist today that can reduce wasteful use of oil in vehicles, industry, aviation, and buildings, delivering savings of at least 3.2 million barrels per day by 2015—more oil than we currently import from the Middle East each day. And by 2025, the United States could save at least 11.2 million barrels of oil per day (mbd), cutting our demand in half. We can reach these goals while enhancing competitiveness of U.S. automakers and farmers by combining new efficiency standards with tax incentives to give new life to our factories and farms. Smart energy policies can reduce America's dependence on oil, stimulate our domestic economy, and help keep our nation safe.

We recommend the following actions:

Establish a minimal national commitment to save 2.5 million barrels per day by 2015 and 10 million barrels per day by 2025.

Saving oil requires mobilizing American ingenuity, factories, and farms around a clear goal. The first, most critical, step is for Congress to establish a national commitment to cut oil expenses and reinvest the resources—otherwise sent to oil producing countries—in American factories and farms. If the past is an indicator of success for such a commitment, this savings goal is achievable. During World War II, American factories converted in just months from building cars to building tankers and bombers that became the arsenal of democracy. And after the first oil crisis in the early 1970s, America cut its oil demand to keep our economy strong. Although some may doubt the ability to turn this ship around, history shows us that American efficiency and ingenuity can meet the challenge. Saving 2.5 mbd by 2015 and 10 mbd by 2025 is well within our technical potential.

We recommend the following policy measures to achieve the oil savings:

Accelerate oil savings in passenger vehicles by:

- **establishing tax credits for manufacturers to retool existing factories so they can build fuel-efficient vehicles and engineer advanced technologies, and for consumers to purchase the next generation of fuel-efficient vehicles; and**
- **raising federal fuel economy standards for cars and light trucks in regular steps.**

As oil prices have risen, so has the demand for fuel-efficient cars and trucks, especially hybrids. Unfortunately, the “Big 3” automakers, General Motors, Ford Motor Company, and DaimlerChrysler, have been slow to get into the hybrid market. As a result, they are losing the race for clean and efficient vehicles, putting thousands of U.S. jobs at risk. A recent study by the University of Michigan found that unless U.S.

automakers move faster to build hybrids, thousands of jobs could be lost.⁴³ And with business as usual, the Big 3 will face a significant competitive disadvantage in the global auto market over the next few decades.⁴⁴ Putting American innovation to work can reverse this course, saving jobs while saving oil.

Tax credits for factories, consumers. Producing fuel-efficient, advanced technology vehicles will require automakers and their suppliers to retool their factories. Hybrid vehicles rely on advanced equipment such as battery packs, electric motors and generators, and electronic power controllers. Advanced diesel drivetrains require sophisticated fuel injection systems, turbochargers and advanced pollution control devices (to meet emission standards). Factories in Japan and Europe currently supply these components to the United States. Tax credits help expand market demand for these vehicles, aid manufacturers in making capital investments necessary to retool their factories, make advanced technologies more cost-effective, and stimulate job growth in the production of cleaner, more efficient vehicles.

We endorse the proposals offered by a bipartisan group, the National Commission on Energy Policy (NCEP), which recommended a total of \$3 billion over the next five to ten years in consumer and manufacturer tax credits.⁴⁵ These tax credits will not only help reduce oil dependence but also will pay for themselves through increased tax revenue from new economic activity, including new jobs in the production of high-efficiency vehicles.

Fuel economy standards. The NCEP also recommended that to ensure public benefits from these tax credits, federal fuel economy standards should be raised to ensure that the increased production of the most fuel-efficient vehicles translates into national oil savings. Fuel economy standards were highly effective in cutting oil use in the late 1970s and the 1980s. According to a 2002 report from the National Academy of Sciences, Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards, the CAFE standards enacted in 1975 were a key factor in the dramatic rise of car and light-truck fuel economy between 1975 and 1988.⁴⁶ Fuel economy for new passenger cars nearly doubled, rising from 15.8 mpg in 1975 to a peak of 28.6 in 1988.⁴⁷ Fuel economy for new light trucks increased 50 percent, rising from 13.7 mpg in 1975 to 21.6 mpg in 1987.⁴⁸

Although total fuel use by passenger vehicles has risen by 30 percent since the federal fuel economy standards were enacted, the majority of this increase took place after the fuel economy standards leveled in the mid- and late 1980s. Adding to the growth in fuel use was the rise in sales of light trucks (such as SUVs, minivans, and pickups) for general passenger use. The increase in fuel consumption would have been even greater if fuel economy standards had not been in place.⁴⁹

Accelerate oil savings in motor vehicles through the following:

- **requiring replacement tires and motor oil to be at least as fuel efficient as original equipment tires and motor oil;**
- **requiring efficiency improvements in heavy-duty trucks; and**
- **supporting smart growth and better transportation choices.**

Replacement tires and motor oil. We should adopt a program that ensures replacement tires are as fuel-efficient as original equipment tires. The program should follow the approach already being implemented in California, by developing tire efficiency and labeling standards (based on rolling resistance) that will enable consumers to purchase the most efficient models. This measure would achieve an overall decrease in gasoline consumption by all U.S. vehicles of approximately 3 percent.

Automakers already equip new cars with low rolling resistance, fuel-efficient tires in order to comply with federal fuel-economy standards. Rolling resistance is the measure of the amount of energy needed to move a tire, so the higher the rolling resistance, the more gas the car consumes. There are no efficiency standards or efficiency labels for replacement tires, so most consumers unknowingly buy high rolling resistance tires to replace originals. A set of four low rolling resistance tires would cost consumers just \$5 to \$12 more than conventional replacement tires, but the average driver would recoup the additional expense of tires in fuel savings in less than one year.⁵⁰ The efficient tires would save the typical driver \$50 to \$150 over the 50,000-mile life of the tires.⁵¹

A program similar to the tire replacement program should be implemented to encourage the use of fuel-efficient motor oils. Like replacement tires, more efficient motor oil can provide fuel savings from on road passenger cars and light trucks. According to the U.S. Department of Energy, the use of specifically formulated low-friction motor oil can increase a vehicle's fuel economy by 1 to 2 percent.⁵² A producer of synthetic motor oil has projected that fuel economy benefits could be as much as 5 percent.⁵³

Heavy-duty trucks. We should establish standards for the smallest and largest heavy trucks. The smallest of the heavy trucks, those from 8,500 to 10,000 pounds can be improved with the same technology systems applied to other light-duty trucks. Improvements could be achieved by expanding the upper weight limit of the light-duty fuel economy standard from 8,500 to 10,000 pounds, which would bring the smallest heavy trucks into federal fuel economy program.

Improving the fuel economy of heavy-duty trucks offers a major opportunity for oil savings. Today, vehicles ranging from 8,500 pounds to more than 33,000 pounds consume the equivalent of more than 2.8 million barrels of oil each day.⁵⁴ More than two-thirds of this energy is consumed by the heaviest trucks, such as tractor-trailers weighing more than 33,000 pounds. Lighter, shorter range trucks use the remaining third of trucking fuel energy. All truck classes can benefit from fuel-efficiency gains from current and emerging technology. Technology assessments by the American Council for an Energy-Efficient Economy

(ACEEE) found that truck fuel-efficiency advances up to 70 percent are cost-effective. The heaviest long-range trucks can increase fuel economy through conventional technology improvements, including enhancements to aerodynamics, reduction of rolling resistance using tires, improved engine fuel injection and thermal management, and reductions in vehicle weight.

Although medium, short-haul trucks can also benefit from conventional technology improvements, large fuel economy advances can best be achieved through hybrid gasoline-electric or diesel-electric drivetrains. Approximately 47 percent of the mileage covered by medium trucks is in urban stop-and-go traffic where hybrid designs offer significant fuel savings by shutting down combustion engines and driving short distances on electric motors.⁵⁵

A wide range of technologies also exists to reduce the tremendous amount of fuel used during idling. Long-haul truckers travel the highways for days. During their rest stops, drivers commonly idle their diesel engines to warm or air condition their sleeping cab, to run electrical appliances and to keep their truck's engine block warm during cold weather. Large diesel engines are designed to move heavy loads, not run auxiliary systems. More efficient technologies are available to perform the needed idling functions. Auxiliary power units sip diesel fuel compared with engine idling and, in many cases, the idling services can be performed by electrical hookups and other non-petroleum-fueled systems.

Smart growth and better transportation choices. Saving oil is one more reason to pursue smart-growth as an alternative to suburban sprawl and to expand Americans' transportation options. Federal strategies to support smart growth and better transportation choices save oil by reducing the total amount we are required to drive when we commute or run errands. The potential for smart growth oil savings is immense. If all new construction were built in a similar fashion to existing smart growth developments, the nation would save over half a million barrels of oil per day after 10 years of construction.

Congress can overcome barriers to smart growth in several ways. First, it should direct federal agencies to revise their planning models so that they account for smart growth. Currently, when new highway projects or new transit projects are evaluated economically, they rely on models that all but ignore the influence of smart growth development. Upgraded models will save money in directing investment toward more cost-effective transit and highway projects and away from ones that do not justify their cost. Enhanced models can also be used in clean air planning and in the evaluation of transit service levels.

One barrier to smart growth is that many homes located in efficient neighborhoods cost more, and the lending system treats such additional costs as barriers to affordability. The Location Efficient Mortgage® solves these problems by allowing potential borrowers with low transportation costs to apply the savings to qualification for a mortgage. Congress could require agencies like Freddie Mac and Fannie Mae to offer Location Efficient Mortgages® throughout the country in a way that allows dollar-for-dollar tradeoffs between lower transportation costs and higher housing costs.

We should promote commuter choice with a tax-free benefit for employees who car-pool, use transit, bike to work, or telecommute (currently limited to \$100 per month) equal to that provided in the form of free parking (which is at about \$200 and is pegged to inflation). This can have a big effect: One recent study in Minneapolis-St. Paul found that more than one in 10 employees shifted from driving to some other way of commuting when offered tax-free commuter benefits equal to those provided in the form of free parking.⁵⁶

We should also support cutting the red tape and streamlining financing for public transportation projects that significantly increase mobility of public-transportation-dependent populations and promote economic development in urban “transit-oriented development zones.” Projects to evaluate road user charges, which would make the portion that a driver pays for highway maintenance costs depend on how much a person uses the roads, are also worthy of support. This system of recovering costs, currently being researched by several experts, would ensure continued revenue to the highway trust fund.⁵⁷

Accelerate oil savings in industrial, aviation, and residential building sectors through the following:

- **expanding industrial efficiency programs to focus on oil use reduction and adopting standards for petroleum heating;**
- **replacing chemical feedstocks with bioproducts through research and development and government procurement of bioproducts;**
- **upgrading air traffic management systems so aircraft follow the most-efficient routes; and**
- **promoting residential energy savings with a focus on oil-heat.**

Approximately one-third of U.S. oil demand is consumed in industrial manufacturing plants, airplanes, and residential homes. Efficiency gains in these sectors can save America more than 300,000 barrels per day in 2015 or 12 percent of the 2.5 millions barrels per day national target.

Industrial process heating efficiency. The industrial sector includes manufacturers of diverse products including steel, cement, food, plastics, glass, paper, and chemicals. Heating fuel oil, diesel fuel, and liquefied petroleum gas are used by manufacturing companies for firing boilers and heating and reheating materials during the manufacturing process. Improving the efficiency of boilers and process heating can reduce oil consumption by 15 percent by 2020. We should expand industrial efficiency programs to focus on oil use reduction and adopt standards for petroleum heating efficiency and incentives to accelerate old, inefficient equipment.

Bioproducts. Also in the industrial sector, using petroleum as a feedstock for chemicals and manufactured materials consumes four times the amount of oil used for heating. Oil savings can be achieved by substituting petroleum-based feedstocks with materials derived from crops, or biomass. Today,

biomass is used in the production of solvents, pharmaceuticals, adhesives, resins, detergents, inks, paints, lubricants and plastics. According the U.S. Department of Energy (DOE), bio-feedstocks could displace 13 percent of petroleum-based feedstocks by 2020.⁵⁸ Continued funding of biomass research and development efforts and on-going requirements for government procurement of environmentally sustainable bioproducts will spur the production of substitutes to petrochemical feedstocks. In 2015, oil saving in the production of industrial chemicals could add up to 120,000 barrels per day.

Air traffic management. Airlines use less jet fuel when they use the most direct traffic patterns and minimize idling time before and after landing. Advanced air traffic management technologies available today for aviation communications, navigation, and surveillance (CNS) systems improve airline fuel efficiency by enabling planes to take more direct routes (such as more great circle routes) between destinations, use more airspace at currently prohibited lower elevations, and minimize time waiting for landing and take-off strips. Improvements to CNS systems allow aviation control to migrate from ground-based, limited-range systems to less-constrained satellite-based systems.

According to the U.S. DOE, CNS improvements can reduce commercial jet fuel consumption by 5 percent by 2020.⁵⁹ CNS upgrades minimize aircraft rerouting (when conditions unexpectedly change in the air or at airports), control take-off and landing spacing and enable after-flight aircraft and routing performance analysis. We should fund advancements to the air traffic management system that increase routing efficiency and therefore reduce per-passenger fuel consumption.

Oil-heated homes. Petroleum products remain an important source of heating energy in homes. According to the EIA, approximately 8 million residences continue to burn fuel oil, liquefied petroleum gases (LPG), propane, and kerosene for space and water heating.⁶⁰ Cost-effective home improvements to space and water heating systems such as insulating walls, ceilings and pipes, sealing drafts and especially sealing ducts, installing new windows, upgrading thermostats; updating furnaces; replacing old clothes washers and dishwashers with new efficient models; and replacing water heaters can reduce heating oil use by 30 percent or more.

We should promote residential energy savings with a focus on oil heat to help reduce the nation's oil dependence by adopting stringent efficiency standards for house and apartment building boilers and furnaces; by adopting performance-based tax incentives for home retrofits and for efficient water heaters; and by updating codes for new buildings. Together these measures can save 100,000 barrel of oil per day in 2015. We should promote residential weatherization and other energy saving programs to help achieve the national oil savings commitment.

Encourage growth of the biofuels industry through the following:

- **requiring all new cars and trucks to be capable of operating on biofuels or other non-petroleum fuels by 2015;**
- **converting the federal oxygenate requirement, which is not necessary to meet clean air goals, to a renewable fuel standard; and**
- **allocating \$2 billion in federal funding over the next 10 years to help the cellulosic biofuels industry expand production capacity to 1 billion gallons per year and become self-sufficient by 2015.**

Although fuel efficiency is critical to immediately reducing our oil dependence, we must also develop alternative, non-petroleum fuels that can be grown by American farmers. The biofuel feedstock with the potential to displace the largest amount of oil is cellulosic biomass, which includes agricultural residue (the leaves, stems, and stalks of plants), dedicated energy crops, and the biomass portion of the municipal waste stream. Ethanol and methanol, both alcohol fuels, can be made from cellulosic biomass.

A market for biofuels already exists. In 2004, the United States produced more than 3.4 billion gallons of ethanol, almost all from corn, for use as an additive to gasoline.⁶¹ Because the gasoline oxygen additive methyl tertiary butyl ether (MTBE) has been found to contaminate water supplies, the chemical is being replaced by ethanol. Gasoline blended with 10 percent by volume ethanol can be used in unmodified vehicles, but it creates air pollution problems in today's on-road cars. Higher blends of these alcohol fuels, however, can be used only in vehicles specifically designed to burn high-oxygen fuel. So-called flexible-fuel vehicles (FFV) can run on gasoline blended with almost any amount of alcohol fuel. The most common high-blend fuel is 85 percent ethanol, E-85. Because high blend ethanol fuel is typically more expensive than gasoline, less than 1 percent of the FFVs on the road today burn gasoline with high ethanol content such as E-85 high blend ethanol from corn.⁶² Fortunately, ethanol made from other sources, called cellulosic ethanol, promises to substantially reduce this cost.

Biofuels in new cars and trucks. We should require the use of higher-biofuel blends in gasoline. Higher ethanol blends not only displace more oil but also decrease harmful particulate air pollution associated with lower-ethanol blends in gasoline. To accomplish this, we should require all new cars and trucks to be capable of operating on biofuels or other non-petroleum fuels by 2012. To operate on E-85, and other high-ethanol and methanol blends, FFVs require low-cost technology improvements that generally make the FFV only slightly more costly to buy than its conventional, gasoline-only counterpart.

Ethanol made from cellulosic biomass offers numerous advantages, as detailed in a recent report lead by NRDC for the National Centers for Environmental Prediction (NCEP). The technology for converting cellulose to biofuels is expected to be cost-competitive with petroleum-based fuels. Cellulosic biomass crops, such as switchgrass, have the potential to produce more biomass per acre than almost any other crop and as a perennial they require lower inputs of energy, fertilizer, pesticide, and herbicide, and is accompanied by less erosion and improved soil fertility. Cellulosic biomass also contains substantial

amounts of non-fermentable, energy-rich components that can be used to provide energy for the conversion process as well as to produce electricity and other fuels using non-biological conversion processes.⁶³ With the right policies in place, there is tremendous potential for biofuels to displace petroleum in our cars and trucks. By 2050, biofuels could contribute the equivalent of 7.9 million barrels of oil per day, or 53 percent of our current demand.⁶⁴

Federal oxygenate requirement. To facilitate the transition to cellulosic biofuels, the federal oxygenate requirement, which is not necessary to meet clean air goals, should be converted to a renewable fuel standard. Such a system would provide much needed flexibility to areas that are suffering from the nation's worst air quality to blend effective, low cost, cleaner burning gasoline formulations. To encourage cellulosic production, credits for biofuel production should be awarded based on the environmental performance of its lifecycle including its feedstock production, processing, refining and combustion. In addition to displacing oil consumption, the EPA should be required to ensure that biofuels are used in a way that maintains or improves air quality, water quality and water supply. As the capacity for biofuels production with cost-effective and sustainable practice grows, We should increase production targets of the renewable fuels standard only if it can be demonstrated that there will be no increase in air pollution.

Biofuels funding. Two billion dollars in federal funding for biofuels over the next 10 years would spur innovation, development, and demonstration projects aimed at making biofuels cost-effective for consumers. The funding should supply incentives that will stimulate the growth of the cellulosic biofuel industry toward a production target of 1 billion gallons per year and make the industry self-sufficient by 2015. These funds should be used to achieve two major goals:

- Investing in a package of research, development, and demonstration policies that create the innovations and advances needed for a large-scale, competitive biofuels industry; and
- Funding deployment policies that drive the development of the first billion gallons of cellulosic biofuels capacity at a price approaching that of gasoline and diesel.

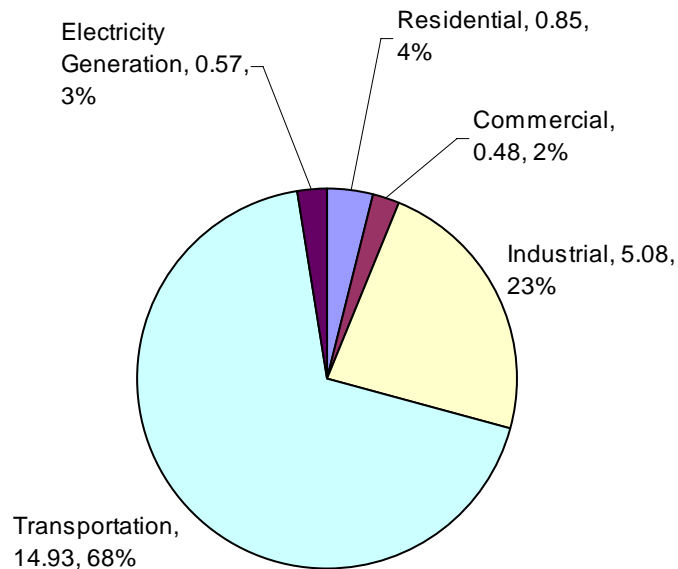
APPENDIX

METHODOLOGY TO ANALYZE OIL SAVINGS POTENTIAL

This report analyzes the potential to save oil through a combination of greater efficiency and switching to domestic, biomass-derived fuels and materials. To evaluate the potential to reduce petroleum consumption, we used stock-turnover models for various sectors. Our baseline scenario for petroleum demand is calibrated against the U.S. Energy Information Administration’s *Annual Energy Outlook 2003* unless otherwise noted.⁶⁵

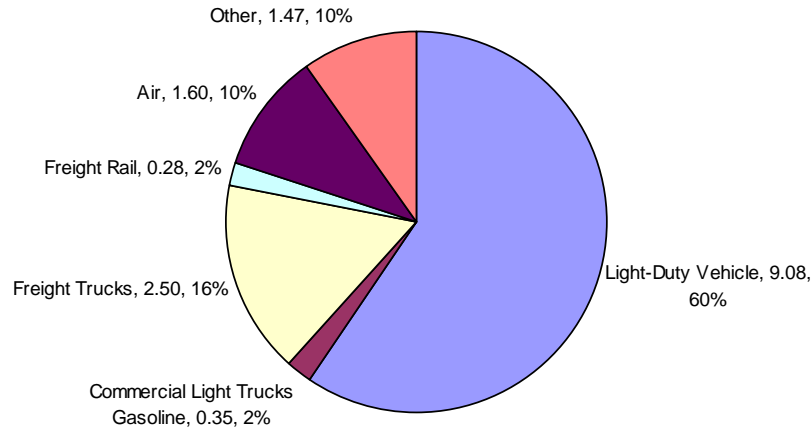
In 2003, the United States consumed nearly 20 million barrels of oil per day (mbd) in the transportation, industrial, and residential sectors. Figures 1 and 2 describe the breakdown of oil consumption across all sectors and within the transportation sector.

Figure 1: Petroleum Consumption by Sector (mbd, % of total), 2003



Source: Energy Information Administration (EIA), *Annual Energy Outlook 2003* (AEO 2003).

Figure 2: Transportation Sector Petroleum Consumption (mbd, % of total), 2003



Source: EIA AEO 2003.

Over the next 20 years, U.S. oil demand from the transportation, industrial and residential sectors is projected to grow by 45 percent to more than 29 mbd (see Table 1).⁶⁶ In 2025, these three sectors will comprise 94 percent of U.S. oil demand.

Table 1: Oil Demand Profile for the Transportation, Industrial, and Residential Sectors

	2003	2015	2025
Demand, mbd	19.46	25.14	29.35
Percent of Total U.S. Demand	89%	92%	94%
Total Growth (from 2005)		24%	45%

We assess oil savings potential across the three key petroleum consuming sectors. The key measures we examine are as follows:

- Transportation sector: we analyze efficiency gains in light-duty passenger vehicles, heavy-duty trucks (over 8,500 pounds gross vehicle weight) and aviation operations. We also consider the use of renewable fuels, primarily ethanol, to displace gasoline and diesel fuel in cars and trucks.
- Industrial sector: we calculate oil savings from boiler and process heating efficiency gains and from the substitution of biomass-derived products for petroleum as the feedstock, or key ingredient, for industrial chemicals and other manufactured materials such as plastics.
- Residential sector: we analyze oil savings from improved home space and water heating through furnace burner upgrades, wall insulation, and other measures.

The oil savings in each sector are technically achievable. We assume cost-effective technologies and practices are implemented over the next two decades starting between 2008 and 2011, depending on the oil

saving measure. We chose aggressive yet attainable technology penetration rates; these rates are driven by federal programs that establish performance requirements coupled, in some cases, with incentives for consumers or producers or both.

Table 2 summarizes, in millions of barrels per day (mbd), the total savings that can be achieved from oil savings measures in the transportation, industrial, and residential sectors. Using existing technologies, the United States could reduce its demand for oil by over 3 mbd by 2015 and more than 11 mbd by 2025. The remainder of this appendix provides greater detail on the source and level of oil savings for each sector.

Table 2: Oil Savings Potential from All Sectors

	2015	2025
Oil Savings Potential (mbd)	3.15	11.17

PASSENGER VEHICLE FUEL EFFICIENCY

To ensure that the increased production of the most fuel-efficient vehicles translates into national oil savings, Congress can raise federal fuel economy standards. New legislation should ramp up the standards for the combined fleet of cars and light trucks in regular steps to as much as 40 miles per gallon (mpg) by 2015 and as much as 55 mpg by 2025.

Fuel economy standards were highly effective in cutting oil use in the late 1970s and the 1980s. According to a 2002 report from the National Academy of Sciences, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*, the CAFE standards enacted in 1975 were a key factor in the dramatic rise of car and light-truck fuel economy between 1975 and 1988.⁶⁷ Fuel economy for new passenger cars nearly doubled, rising from 15.8 mpg in 1975 to a peak of 28.6 in 1988.⁶⁸ Fuel economy for new light trucks increased 50 percent, rising from 13.7 mpg in 1975 to 21.6 mpg in 1987.⁶⁹

While total fuel use by passenger vehicles has risen by 30 percent since federal fuel economy standards were enacted, the majority of this increase took place after the fuel economy standards leveled in the mid- and late 1980s. Adding to the growth in fuel use was the rise in sales of light trucks (such as SUVs, minivans, and pickups) for general passenger use. The increase in fuel consumption would have been even greater if fuel economy standards had not been in place.⁷⁰

As shown in Table 3, oil demand from passenger vehicles is projected to become an increasing share of total U.S. demand. This growth can be offset by raising fuel economy standards for passenger vehicles. Today, new passenger cars and trucks achieve a combined fleet fuel economy of 24.4 mpg.⁷¹ Just raising the standard to achieve a fleetwide average for new vehicles as much as 40 mpg by 2015 and as much as 55 mpg by 2025 would reduce oil consumption from passenger vehicles by more than 13 percent in 2015 and more than 34 percent in 2025.

Table 3: Passenger Vehicle Sector Profile

	2003	2015	2025
Demand, mbd	9.08	12.21	14.34
Percent of Total U.S. Demand	41%	45%	46%
Total Growth (from 2005)		28%	51%

Measure 1: Increase Fuel Efficiency of New Passenger Vehicles

The 2002 report by the National Academies of Science (NAS) and independent studies by the Union of Concerned Scientists (UCS), the American Council for an Energy-Efficient Economy (ACEEE), and the Massachusetts Institute of Technology all indicate that cars and light trucks can achieve large additional fuel savings if fuel economy standards are increased.^{72,73,74} In fact, it is clear that automakers have the technology to raise fuel economy standards for new cars and light trucks to 40 mpg by 2015 and 55 mpg by 2025.

Description of Technologies

Cost-effective technologies exist today for near-term and longer-term improvements in vehicle fuel economy. Table 4 provides a short list of conventional technologies that have already been developed by automakers that could significantly increase the fuel economy of today’s cars and light trucks, many of which are already in some cars.

Table 4: Conventional Technology Options for Fuel-Economy Improvement

Vehicle Load Reduction Aerodynamic improvements Rolling resistance improvements Safety-enhancing mass reduction Accessory load reduction
Efficient Engines Variable valve control engines Stoichiometric burn gasoline direct injection engines
Integrated Starter Generators
Improved Transmissions Five- and six-speed automatic transmissions Five-speed motorized gear shift transmissions Optimized shift schedules Continuously variable transmissions

The NAS report, which assumed more constraints on light truck weight reduction, and the USC report suggested that similar fuel economy levels could be achieved within 10 to 15 years. Both the NAS and UCS results agree that a fleet average of close to 35 mpg is technically feasible and cost effective in less than 10 years. In short, even a standard of 55 mpg by 2020 is feasible and cost-effective.

The NAS report indicates that a standard as high as 47 mpg could be achieved with further improvements to conventional gasoline-powered internal combustion vehicles. Further, ACEEE and UCS studies demonstrate that by combining these improvements in conventional vehicle technology with gasoline-electric hybrid drive systems, it is possible to reach a fleet average of 54 to 56 mpg.

Oil Savings Potential

To estimate the oil savings from these scenarios (see Table 5), we used a stock turnover model developed by the Tellus Institute for projecting transportation and other energy demands under different policy and technology scenarios. The stock model, called the Long-range Energy Alternatives Planning System, or LEAP, is calibrated to EIA’s AEO 2003 to establish a baseline of energy consumption to 2025 from the light-duty fleet.

Table 5: Fuel-Efficient Vehicle Savings Potential

	2015	2025
Oil Savings Potential (mbd)	1.65	4.89

Since AEO 2003 was published, the National Highway Traffic Safety Administration (NHTSA) enacted a 1.5 mpg increase in light truck fuel economy standards from 2005 to 2007. To account for these new standards, we modified the baseline in LEAP to include the increase in fuel economy. Oil savings are calculated in LEAP using this new baseline. We assume a 40 mpg fleet wide fuel economy is achieved by 2015, and then linearly ramps up to achieve 55 mpg by 2025. We also assume a mileage ‘rebound’ of 10 percent due to the possibility for increased fuel economy to induce slightly more driving.

Our projections of oil savings are conservative because they are relative to an AEO 2003 baseline that assumes long-term increases in fleet fuel economy. Based on trends for the last 15 years of decreasing fleetwide fuel economy, we find it difficult to believe the EIA’s forecast that fleet fuel economy will increase without increases in federal fuel economy standards. According to EPA analysis, fleet fuel economy reached its peak value in 1987-1988 and then declined into the late 1990s. Since then it has remained relatively constant.⁷⁵ AEO 2003 projects greater fleetwide fuel economy gains in years following 2015 than would be achieved by simply adding the 2005-2007 light truck CAFE standard increases.

A baseline that considers a constant fleetwide fuel economy after the light-truck CAFE increases could be used as an alternative baseline for oil demand. NRDC analyzed the oil savings scenarios in comparison to the ‘flat-efficiency’ baseline and found greater oil savings. For example, in a scenario where fuel economy standards require new vehicles to meet 40 mpg by 2015 and 55 mpg by 2025, oil savings in 2025 were an additional 250,000 barrels of oil per day. This is a 5 percent increase in savings as compared to the AEO 2003 baseline, which includes the 1.5 mpg light truck standard increase.

Measure 2: Adopt Fuel-Efficient Replacement Tires

Automakers equip new cars with tires that are more fuel efficient than those sold as replacement tires. Automakers do this in order to help these cars meet federal fuel-economy standards. Rolling resistance is the measure of the amount of energy needed to move a tire. Requiring replacement tires to be as fuel-efficient as the original equipment tires would improve a vehicle’s fuel economy by up to 6 percent.⁷⁶

California has just begun a program whose goal is to ensure that replacement tires, on average, are as fuel efficient as original equipment tires. This program (AB844, Nation 2003) is modeled after the highly successful home appliance energy efficiency program. The program, known as the Replacement Tire Efficiency Program, requires the California Energy Commission to test and rate passenger vehicle replacement times. By 2008, replacement tires sold in California must meet minimum fuel efficiency standards, and dealers must prominently display fuel efficiency ratings for all tires they sell.

Description of Technologies

The technology to make replacement tires is literally “off-the-shelf” since it is being used by virtually all manufacturers of original equipment tires. A common strategy for producing low rolling resistance tires is to use rubber compounds infused with silica. The silica replaces traditional carbon black materials and can be added to the tire manufacturing process at little additional cost.

Furthermore, this technology does not involve compromising any traction or tread life. Low rolling resistance tires can have excellent grip, handling, and tread wear characteristics. This is demonstrated by the organization Green Seal in a report that rates a variety of tire brands and models for rolling resistance, traction, tread wear and consumer satisfaction.⁷⁷

Low rolling resistance tires are highly cost-effective. Consultants to the California Energy Commission (CEC) estimated the cost for a set of four low rolling resistance tires to be just \$5 to \$12 more than conventional replacement tires.⁷⁸ The average driver would recoup the additional expense of tires in fuel savings in less than one year. The efficient tires would save the typical driver \$50 to \$150 over the 50,000-mile life of the tires.⁷⁹

Oil Savings Potential

To analyze the oil savings potential, we developed our own spreadsheet model that uses the AEO 2003 passenger vehicle fuel consumption as our baseline (see Table 6). From the baseline, we subtract the fuel used by on-road cars and light trucks riding on replacement tires (approximately 75 percent of the on-road fleet). We assume that low rolling resistance replacement tires are made to be as fuel efficient as original equipment tires and provide a 4 percent reduction in fuel consumption. This is a conservative estimate of the CEC consultant report which noted potential savings of up to 6 percent.

Table 6: Fuel-Efficient Replacement Tire Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.36	0.42

Since proven fuel-efficient tire technology already exists it can penetrate the replacement tire market rapidly. We assume that by 2014, the technology penetrates the entire market and is in use by passenger vehicles.

Measure 3: Adopt Fuel-Efficient Motor Oil

Advances in light-duty vehicle motor oil can save oil through two methods: (1) increase the fuel economy of vehicles using the advanced oil and (2) reduce the frequency of oil changes. In this analysis, we only look at the first method.

Description of Technology

Motor oils are formulated to minimize friction losses in the engine across a broad range of temperatures. Low viscosity, or thin, oils with 0W or 5W ratings are often used because they reduce engine load and save fuel. Advancements in oil technology have enabled the low viscosity oils required in low temperatures to also stand up to the stress of high temperature engine operation.

Low viscosity oils are produced from petroleum (mineral bases) and from man-made compounds (synthetics). Producers of synthetic oils claim superior engine protection performance and fuel economy but these oils are more expensive to produce. Research by the Society of Automotive Engineers demonstrates that the fuel efficiency of mineral oils can be improved so that they qualify as ultra-low viscosity oils, which have been demonstrated to reduce fuel consumption by 3 percent compared to a vehicle using a 5W-rated oil.⁸⁰

The U.S. Department of Energy (DOE) suggests using engine oil grades recommended by the vehicle manufacturer and using oils specially formulated to achieve larger reductions in engine friction. According to the DOE, the use of fuel efficient motor oil can increase a vehicle's fuel economy by 1 to 2 percent.⁸¹ Synthetic engine oil producer, AMSOIL, notes that fuel economy benefits could be as much as 5 percent.⁸²

Synthetics offer benefits other than greater energy efficiency. Oils made from synthetics last longer than mineral oils. While automobile manufacturers recommend changing oil every 3000 miles, some synthetic oils are said to protect and lubricate engines for 35,000 miles or 1 year.⁸³ While drivers typically change their oil two to four times per year, switching to synthetic oil could reduce changes to one per year and lead to a large reduction in motor oil consumption.

Oil Savings Potential

To analyze the oil savings potential, we only account for oil saved from increased engine efficiency; we chose to not include the oil savings potential from longer lasting oil because current vehicle warranties require more frequent oil changes and because synthetic oils are more expensive (see Table 7).

Table 7: Fuel-Efficient Motor oil Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.12	0.14

We conservatively assume that fuel-efficient motor oil reduces fuel consumption in passenger vehicles by 1 percent. A national fuel-efficient motor oil program could set efficiency and labeling standards for motor oil so that energy-saving motor oil is widely available by 2011. Since drivers typically change their oil multiple times each year, we assume that all passenger vehicles use the advanced motor oil by the end of 2012. To prevent double-counting oil savings from different technologies applied to the same vehicle, we calculate the motor oil savings from an oil consumption baseline that has already had the savings from fuel-efficient replacement tires removed.

HEAVY-DUTY TRUCK EFFICIENCY

Heavy-duty trucks includes all trucks of gross vehicle weight of 8,500 pounds to over 33,000 pounds. Heavy trucks are the second largest consumer of oil in the transportation sector and third largest among all sectors. Within trucking, efficiency gains are made from improved fuel economy when running and from the reduction of fuel consumption during idling (see Table 8).

Table 8: Heavy-Duty Truck Sector Profile

	2003	2015	2025
Demand, mbd	2.84	3.97	4.74
Percent of Total U.S. Demand	13%	15%	15%
Total Growth (from 2005)		32%	57%

Measure 4: Raise Fuel Economy of New Heavy-Duty Trucks

Improving the fuel economy of heavy-duty trucks offers a major opportunity for oil savings. Today, the equivalent of over 2.8 million barrels of oil are consumed each day to power trucks ranging from 8,500 pounds to more than 33,000 pounds.⁸⁴ More than two-thirds of this energy is consumed by the heaviest trucks, such as tractor-trailers weighing more than 33,000 pounds. Lighter, shorter range trucks use the other one-third of trucking fuel energy. All truck classes can benefit from fuel-efficiency gains from current and emerging technology. Technology assessments by ACEEE find that truck fuel-efficiency advances of up to 70 percent are cost-effective.

Description of Technologies

Fuel-saving technology advances fall into two categories: conventional and hybrid drivetrain. Tractor-trailers and long-haul straight trucks are good candidates for conventional technology improvements including enhancements to aerodynamics, reduction of rolling resistance using tires, improved engine fuel injection and thermal management and reductions in vehicle weight.

Table 9 outlines the different cost-effective technologies and their contribution to fuel efficiency as evaluated by ACEEE. Unless otherwise noted, all technologies are available for introduction into the market by 2008. Aerodynamic improvements minimize the resistance caused by air flowing over the truck cab and trailer. Pneumatic blowing is a technology under development that reduces drag and rolling resistance by blowing streams of air under the truck. Wide-based tires are also designed to have low-rolling resistance. Electrically powered auxiliaries replace equipment that is normally driven by the mechanical power of the engine. For example, pumps, compressors and fans are energized by an electrical starter-generator or a fuel cell (beginning in 2012). Efficiency gains within the engine are achieved through low-friction lubricants, increased cylinder compression ratios, more precise fuel injection and better use of waste heat through mechanisms such as turbocharging. Vehicle mass reduction is achieved through light-weight, high-strength metals or plastics to replace heavier steel components.

Table 9: Conventional Heavy Truck Technologies to Improve Fuel Economy

Technology	% Improvement in Fuel Economy
Aerodynamics	
Cab top deflector	1.5
Cab-trailer gap closing	2.5
Trailer edge curvature	1.3
Pneumatic blowing	6.0 beginning in 2012
Rolling Resistance	
Low-rolling resistance, wide-based tires	3.0
Electrical auxiliary power	
Starter-generator	1.5
Fuel cells	6.0 beginning in 2012
Engine	
Friction reduction	2.0
Increased peak cylinder pressure	4.0
Improved fuel injection	6.0
Turbocharging and other thermal management	5.0; Additional 5.0 beginning in 2012
Vehicle mass reduction	7.5 beginning in 2012

While medium trucks can also benefit from conventional technology improvements, large fuel economy advances can best be achieved through hybrid gasoline-electric or diesel-electric drivetrains. Approximately 47 percent of the mileage covered by medium trucks is in urban stop-and-go traffic where hybrid designs offer significant fuel savings by shutting down combustion engines and driving short distances on electric motors.⁸⁵

Oil Savings Potential

Oil savings estimates are based on fuel-efficiency gains for each truck type as new technologies are introduced into the heavy-duty fleet (see Table 10). Stock turnover models for each truck class from the EIA’s National Energy Modeling System (NEMS) are used to calculate annual oil savings.⁸⁶

Table 10: Fuel-Efficient Heavy-Duty Truck Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.38	1.00

Table 11 summarizes the assumptions used in the model and the resulting oil savings for 2015 and 2025. The fuel-efficiency increases for each truck type are based on technical assessments by ACEEE for a report to the National Commission on Energy Policy.⁸⁷ Advances in fuel economy before 2008 are assumed to be zero although existing technologies are gradually being integrated into the truck fleet. From 2008 and beyond, technology penetrates new trucks rapidly to achieve the fuel efficiency gains shown in the table. For trucks more than 10,000 pounds we assume that fuel efficiency gains are achieved in 10 years, and for the smallest trucks (8,500 to 10,000 pounds) we assume that gains are reached by 2015. The small truck trajectory is consistent with the rate assumed in light-duty trucks since the technology and primary manufacturers are the same.

Table 11: Heavy-Duty Truck Efficiency Gains and Oil Savings

Truck Type	Fuel Efficiency Gain	Oil Savings (mbd)	
		2015	2025
Long-haul tractor-trailers (Class 8, 33,000 lbs and up)	61%	0.25	0.71

Conventional technology			
Long-haul straight trucks (Class 7&8, 26,000 lbs and up) Conventional technology	55%	0.01	0.04
Local trucks (Class 3-8, 10,000 lbs and up) Hybrid drivetrain technology	70%	0.03	0.07
Small commercial trucks and large SUVs, vans and pickups (Class 2b: 8,500 – 10,000 lbs) Conventional technology	66%	0.09	0.18

Fuel efficiency gains in tractor trailers deliver the bulk of oil savings from heavy-duty trucks. New fuel efficiency standards for heavy trucks over 26,000 pounds encourage technologies to be implemented into the new truck stock over ten years resulting in fuel economy gains of 61 percent in long-haul tractor trailers and 55 percent in long-haul straight trucks. Total long haul oil savings reach 260,000 barrels in 2015 and 750,000 barrels in 2025.

The introduction of hybrid technology into locally-driven trucks can raise fuel economy by 70 percent or more. Hybrid drive trains are already being designed for some delivery trucks, and with expanded research and development funding these drivetrains can be quickly expanded to other local truck platforms. Tax incentives can also lower the risk to manufacturers of producing trucks with more expensive hybrid technology. The potential oil savings from using hybrid drivetrains in trucks more than 10,000 pounds is 30,000 barrels per day in 2015 and 70,000 in 2025.

The lightest of the heavy-duty trucks, class 2b trucks ranging from 8,500 to 10,000 pounds, use more than 350,000 barrels of gasoline per day. The introduction of fuel-saving technologies similar to those available to light-duty vehicles can reduce oil usage by more than 90,000 barrels per day by 2015, a reduction of 18 percent from projected oil use in this class. Currently, class 2b trucks are not regulated under the CAFE system for light-duty passenger vehicles, but over half of the trucks in this class are used as personal vehicles.⁸⁸ Analysis by ACEEE found no significant technical barriers to expanding CAFE to include trucks up to 10,000 pounds.⁸⁹ Class 2b trucks can benefit from much of the same fuel-saving technology designed for lighter trucks and can fit into the existing fuel economy and emissions testing programs.

Measure 5: Reduce Heavy Duty Truck Idling

Currently, approximately 2.8 million heavy trucks travel U.S. highways to deliver their freight. The heaviest trucks, those with a gross weight of more than 26,000 pounds, are often traveling long distances that require the drivers to rest. During their rest stops, drivers commonly idle their diesel engines to warm or air condition their sleeping cab, to run electrical appliances, and to keep their truck’s engine block warm during cold weather. In many cases, however, the functions performed by engine idling can be replaced by other technologies that do not run on petroleum fuel. Therefore, introducing these technologies can reduce the diesel fuel consumption by heavy trucks and provide significant oil savings.

Description of Technologies

Technologies to displace diesel engine idling and provide truck heating and cooling include (1) direct-fired heaters (heating only), (2) thermal storage systems, (3) auxiliary power units (APU), and (4) truck stop electrification. Both the direct-fired heaters and APUs burn petroleum, but they operate much more efficiently than the diesel engine for supplying services to the engine and cab (the direct-fired heater is approximately 80 percent efficient for heat delivery compared to only 11-15 percent for truck idling).⁹⁰ Thermal storage systems provide only cab heating and cooling services by storing heat energy in a phase-changing material when the engine is operating. Truck stop electrification allows the truck to be plugged into the local electrical grid to receive energy services. It requires special configurations in the truck and development of the truck stop infrastructure. Some companies have already begun providing this service for truckers. For example, IdleAire Technologies Corporation has installed systems in 10 states, providing heat and television and Internet connections for drivers.⁹¹

Oil Savings Potential

Only those heavy trucks (over 26,000 pounds) that travel over 500 miles per day, or 18 percent of on-road heavy trucks, are considered eligible for the technology (see Table 12). We assume that diesel-powered APUs with an efficiency of 82 percent (as compared to truck engine idling) penetrate the market over a four year period reaching 100 percent of eligible truck stock by 2012.

Table 12: Heavy-Duty Idling Reduction Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.07	0.08

Efficiency standards for idling equipment along with purchase incentives to drive market demand can ensure rapid reductions in diesel fuel use when heavy trucks are off the road.

INDUSTRY

Measure 6: Improve Industrial Efficiency

The industrial sector includes manufacturers of diverse products including steel, cement, food, plastics, glass, paper and chemicals (see Table 13). Heating fuel oil, diesel fuel, and liquefied petroleum gas are used by manufacturing companies for firing boilers and heating and reheating materials during the manufacturing process. Improving the efficiency of boilers and process heating provides modest but significant reductions in U.S. oil consumption.

Table 13: Industrial Sector Profile

	2003	2015	2025
Demand, mbd	5.08	5.83	6.55
Percent of Total U.S. Demand	23%	21%	21%
Total Growth (from 2005)		11%	25%

Description of Technologies

Better practices and new technologies can significantly raise boiler and furnace fuel efficiency and reduce material heating and reheating requirements. According to the DOE many existing boiler and heating systems exhaust as much or more heat energy than goes into heating the manufactured materials.⁹² To reduce waste heat losses, the DOE recommends that industries (1) ensure that boilers and heating enclosures are properly insulated to minimize wall losses and air infiltration, (2) properly tune burners to optimize the fuel-air ratio, (3) carefully schedule material loading rates and amounts to operate heating systems at designed capacity, and (4) closely align materials entering the heating process with those that are exiting the system so that waste heat can be used to preheat the incoming materials.

Additional equipment can also improve process heating efficiency. Direct heat exchangers capture waste heat from boiler stacks and preheat materials before they enter the boiler. Gas-to-gas heat exchangers, called recuperators, reduce fuel usage by preheating incoming combustion air with heat from stack gases. Regenerators also capture waste heat; however, they store the thermal energy in metal or ceramic blocks and discharge it to materials during process heating. Upgrading boilers and furnaces with advanced burners and combustion controls also improves fuel efficiency.

Oil Savings Potential

The oil savings potential of the industrial sector is based on ACEEE's analysis of EIA's 1998 Manufacturing Energy Consumption Survey (MECS) and the EIA 2004 *Annual Energy Outlook*. The MECS quantifies the breakdown of petroleum use among boiler and furnace fuel, process fuel and other non-process use, such as on-site transportation (see Table 14). It is assumed that the end-use breakdown

from the MECS remains constant through 2025. The growth in petroleum demand is determined from the *Annual Energy Outlook*.

Table 14: Industrial Process Efficiency Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.04	0.09

Oil savings estimates are developed for boiler fuel and process heating. ACEEE estimates that oil consumption reductions in boilers of 19 percent by 2020 are technically achievable. Reductions of total process petroleum use are estimated at 15 percent by 2020. Assuming that no savings are achievable in non-process industrial oil use, the weighted average of savings from industrial efficiency gains (across boiler, process and non-process uses) is 14.6 percent in 2020. Year-by-year reductions are calculated by assuming linear ramp up in savings from 2009 to the 2020 value and then continuing improvements at the same rate to 2025.

Efficiency standards for boilers, furnaces and other heating processes, programs to institute industrial heating best practices and incentives to retire old, inefficient equipment are instrumental in driving improved industrial efficiency.

Measure 7: Substitute Bio-Feedstocks for Petrochemical Feedstocks

In the industrial sector, four times more oil is used as the feedstock for chemicals and manufactured materials than for heating. Oil savings would result from substituting petroleum-based feedstocks with materials derived from crops, or biomass. Today, biomass replaces petroleum feedstocks in solvents, pharmaceuticals, adhesives, resins, detergents, inks, paints, lubricants and plastics.

Description of Technologies

Two principle conversion technologies, biochemical and thermochemical, are used to convert biomass into industrial chemicals and bio-based products. Biochemical technologies use enzymes or microorganisms to ferment the starch and sugars in grains such as corn. Thermochemical technologies use an acid or metal or combined catalyst in high temperature and pressure processes to convert biomass. Table 15 lists the technologies used for each category of biomass and the resulting products from biomass conversion.

Table 15: Current Industrial Bioproduct Production from Domestic Biomass

Category	Principal Technologies	Feedstock	Chemical	General Product	Annual Biobased Production (M lb)
Starch and Sugars*	Biochemical	Biomass sugars derived from corn and sorghum	Lactic acid, citric acid, ethanol, starch, sorbitol, levulinic acid, itaconic acid	Polymers, solvents, cleaners, coatings, inks, detergents, pharmaceuticals, adhesives, paints, composites, laminates, toiletries, cosmetics	5,413
Oil/Lipids	Thermochemical	Oils/lipids derived from soybean, rapeseed	Glycerol/glycerine, alkyd resins, high erucic acid rapeseed, polyurethane, epoxidized soybean oil, factice, sulfurized fatty oils, fatty acids, cyclopentadienized oils, lecithin, maleinized oils	Pharmaceuticals, personal care, urethanes, alkyd resins, plasticizers, lubricants, paints, resins, printing inks, industrial and textile finishes, semi-rigid foam, thermoplastic elastomers, cosmetics, coatings, surfactants, sealants, caulks, pesticides	1,589
Specialty Crops	Thermochemical	Spearmint, peppermint, sweet almond	Spearmint oil, peppermint oil, sweet almond oil	Personal care, pharmaceuticals, epoxy and alkyd resins, paints, cosmetics, and toiletries	9
Forest Derivatives	Thermochemical	Pine, black liquor, soft wood	Turpentine oil, rosin, tall oil, and cellulose derivatives (esters, acetates, etc.)	Solvents, soaps, detergents, toiletries, perfumes, rubber, adhesives, coatings, printing inks, phenolic resins, plastics, textiles	5,326
Total					12,337

*The ethanol and citric acid included here are for industrial use only (e.g., solvent, cleaning reagent).

Source: Paster, Mark, Joan L. Pellegrino, and Tracy M. Carole, *Industrial Bioproducts: Today and Tomorrow*, Prepared by Energetics, Incorporated for the U.S Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of the Biomass Program, Washington, DC, July 2003, p. 37.

The growth of bioproducts is dependent on advancements in several technology areas. Cellulase enzymes are being developed to more cost effectively break down cellulosic biomass. Unlike petroleum feedstocks, the availability of biomass feedstocks is dependent on weather, water, soil and pest conditions. Sustainable agricultural advancements such as conservation tillage, integrated pest management and sophisticated irrigation techniques are important to the economics of bioproducts and provide opportunities to expand industrial use of biomass.

Oil Savings Potential

According to the DOE, petro-chemical feedstocks reductions of 13 percent by 2020 are technically achievable.⁹³ Assuming the DOE estimate, we developed year-by-year reductions using a linear ramp up in savings from 2009 to the 2020 value and then continuing improvements at the same rate to 2025 (see Table 16).

Table 16: Oil Savings from Industrial Bio-feedstock Substitution

	2015	2025
Oil Savings Potential (mbd)	0.11	0.26

Renewable content standards and labeling enable consumers to differentiate products made from biomass. Requirements on government agencies to purchase chemicals and materials with significant biomass content will drive technically achievable reductions in oil use.

AVIATION

Table 17: Aviation Sector Profile

	2003	2015	2025
Demand, mbd	1.60	2.24	2.86
Percent of Total U.S. Demand	7%	8%	9%
Total Growth (from 2005)		37%	75%

Measure 8: Improve Air Traffic Management

When airplanes fly the most direct routes and spend less time idling before takeoff and after landing, less jet fuel is used. Improved aviation fuel efficiency can result in petroleum savings of over 140,000 million barrels per day in 2025. In 1998, the Federal Aviation Administration (FAA) began its Free Flight Program (<http://ffp1.faa.gov/>) to implement technologies that streamline flight planning and ground logistics.

Description of Technologies

Air traffic management (ATM) technology advances cut across aviation communications, navigation and surveillance (CNS) systems. So-called CNS/ATM programs enable planes to take more direct routes (such as more great circle routes) between destinations, use more airspace at currently prohibited lower elevations, and minimize time waiting for landing and take-off strips. CNS/ATM improvements establish a network of ground- and satellite-based systems to more precisely track airplane locations and movement and allow for more efficient routing and rerouting (when conditions unexpectedly change in the air or at airports), take-off and landing spacing and after-flight performance analysis.⁹⁴

Oil Savings Potential

According to the U.S. Department of Energy, CNS/ATM efforts can deliver 5 percent reductions in fuel use by 2020.⁹⁵ With new CNS/ATM technology introductions, the FAA has set an even more ambitious goal of “improving aviation fuel efficiency per revenue plane-mile by 1 percent per year through 2009, as measured by a three-year moving average, from the three-year average for calendar year 2000-2002.”⁹⁶

For our oil savings potential analysis (see Table 18), we assume the DOE estimate of 5 percent reduction in jet fuel usage by 2020. Efficiency savings ramp up from zero to 5 percent from 2008 to 2020 and then remain constant at 5 percent through 2025.

Table 18: Air Traffic Management Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.07	0.14

RESIDENTIAL

Measure 9: Improve Efficiency of Oil-Heated Homes

Petroleum products remain an important source of heating energy in homes. According to the EIA, approximately 8 million residences continue to burn fuel oil, liquefied petroleum gases (LPG) such as propane and kerosene for space and water heating.⁹⁷ Petroleum residential heating products are expected to grow slightly over the next decade but become a smaller share of total U.S. oil consumption as oil use in other sectors experiences higher growth rates (see Table 19). Efficiency gains in residential oil use can counter any growth and lead to overall decreases in annual oil consumption from the sector.

Table 19: Residential Sector Profile

	2003	2015	2025
Demand, mbd	0.85	0.90	0.86
Percent of Total U.S. Demand	4%	3%	3%
Total Growth (from 2005)		0%	-4%

Description of Technologies

ACEEE analyzed cost-effective efficiency improvements to homes that will save fuel energy for space heating and water heating. Home improvements such as insulating walls and ceilings, sealing spaces where air can infiltrate from the outside, installing new windows, sealing heating ductwork, and upgrading thermostats to better control heaters all contribute to improved efficiency. Heater and furnace efficiency can be improved through burner replacement or a heating system upgrade. Water heating efficiency is improved with pipe insulation, low-flow faucets and shower heads, and low-water use clothes washers.

Potential Oil Savings

The potential oil savings are determined by multiplying the percentage gain in efficiency from the measures above to a baseline of residential petroleum use from the EIA's 2001 Residential Energy Consumption Survey (see Table 20).⁹⁸ The reduction in fuel use from each efficiency measure is determined from existing home energy efficiency studies.⁹⁹ We recognize that homeowners may choose to implement only a subset of the efficiency measures based on the condition of their home, so the savings from each measure are multiplied by an estimate of the number of eligible homes and a percentage of participation by homeowners.

Table 20: Residential Efficiency Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.09	0.23

The final savings numbers are considered the oil savings achieved in 2020. We assume that oil savings linearly ramp up from 2009 through 2025; this was calculated by a simple extrapolation of the 2020 savings. As noted above, the savings are developed from a 2001 baseline. Since residential heating oil use projected by AEO 2003 is expected to grow very slowly and then flatten out, using the 2001 baseline creates a conservative savings estimate.

The oil savings are categorized by policy mechanisms to encourage the efficiency improvements. These categories include (a) efficiency standards for oil and LPG boilers and furnaces, (b) building codes for new homes built after 2009, and (c) home retrofit programs for single-family and multi-family dwellings. The savings from the implementation of efficiency standards for new boilers and furnaces ranges from 5 to 11 percent. Updated building codes for new homes deliver savings of 15 to 30 percent. Home retrofit programs are intended for homes built before 2001; their participation rate and savings potential are a function of how much the program is expanded.

We assume that increased efficiency standards and new home building codes are set at the Energy Star level, representing a 30 percent savings from current building codes; apartment and home retrofit programs are maximized through low-cost or zero-interest loans and technical assistance; and savings of 30 percent are realized for the 90 percent of eligible homes that participate in the program.

RENEWABLE FUELS

Measure 10: Increase the Use of Renewable Fuels

While raising vehicle fuel economy will make the largest contribution to reducing U.S. oil consumption over the next two decades, it is also essential to begin moving beyond oil as the primary energy source for our vehicles. The biofuel that has the potential to reduce the largest amount of oil is ethanol derived from cellulosic materials, rather than today's dominant source in the United States: corn.

There is a market for ethanol already. In 2004, the U.S. produced over 3.4 billion gallons of ethanol almost all from corn and used as an additive to gasoline.¹⁰⁰ Since the gasoline oxygen additive MTBE has been found to contaminate water supplies, the chemical is being replaced by ethanol. Gasoline blended with 10 percent by volume ethanol can be used in unmodified vehicles, but it creates air pollution problems in today's on-road cars. Higher blends of ethanol can be used only in vehicles specifically designed to burn the high-oxygen fuel. So-called flexible-fuel vehicles (FFV) can run on gasoline with no ethanol or fuels with nearly 100 percent ethanol by volume. The most common high-blend fuel is 85 percent ethanol, known as E-85. However, because high blend ethanol fuel is typically more expensive than gasoline, less than 1 percent of the FFVs on the road today burn gasoline with high ethanol content like E-85 in high blend ethanol from corn.¹⁰¹

Description of Technologies

Today, almost all ethanol produced in the United States is made from corn grown specifically for making the fuel. Ethanol is produced by fermenting the sugars in the corn. Ethanol derived from cellulosic biomass has the potential to make biofuels a cost-effective petroleum replacement within a decade. The feedstock for cellulosic ethanol is the woody biomass from crops that has little food value. Cellulosic ethanol is produced from existing agricultural waste (such as corn stover and rice straw) and municipal waste (such as yard waste and food scraps) and from fast-growing energy crops (such as switchgrass, poplars and willows). Using waste products and energy crops as feedstock can drastically lower the production costs of the fuel.

Cellulosic ethanol also has environmental benefits. The net energy content (energy input during ethanol production subtracted from ethanol fuel energy) of cellulosic ethanol is approximately three times that of corn ethanol.¹⁰² Greenhouse gas emissions are also minimized when using cellulosic feedstocks. According to a study by Argonne National Laboratory, on a per vehicle mile basis greenhouse gas emissions are reduced 1-2 percent when using corn-based ethanol in E10 and 24-26 percent in E85. Cellulosic ethanol achieves reductions of 8-10 percent in E-10 and 68-91 percent in E-85.¹⁰³

However, the production of cellulosic ethanol is more complicated and expensive than fermenting the sugars in corn. The cellulose has to be first broken down into fermentable sugars, and the methods of

cellulose decomposition are currently not economic on a commercial scale. A recent study lead by NRDC for the National Commission on Energy Policy (NCEP) describes a program for bringing cellulosic biofuels to the market. We use the recommendations of the NCEP project in our estimates of petroleum substitution by biomass ethanol.

Oil Savings Potential

Oil savings over the next two decades come from both the growing of the corn-based ethanol supply and the development and growth of cellulosic ethanol supplies (see Table 21). We assume that corn-based ethanol production reaches a five billion gallon per year capacity by 2007 and then remains constant. Cellulosic ethanol reaches 1 billion gallon annual capacity by 2015 through aggressive research, development, and deployment policies.

Table 21: Renewable Fuels Savings Potential

	2015	2025
Oil Savings Potential (mbd)	0.28	3.92

A spreadsheet model is used to calculate the oil savings from the combined contributions of corn and cellulosic ethanol through 2025. Cellulosic ethanol production capacity reaches 1 billion gallons in 2015 and then grows at an annual rate of 60 percent with a maximum added capacity of 10.8 billion gallons from one year to the next. The growth rate is consistent with maximum growth rate seen in the corn ethanol industry. The additional capacity cap is based on the highest capacity addition made by the refining industry weighted by GDP.

The long-term goal of biofuel use is to entirely displace gasoline and diesel use in vehicles and other motor equipment. As biofuel supplies expand beyond their current levels, their use should be focused on high-blend applications. This is especially important with ethanol. Widespread use of low blends of ethanol (with 10 percent or less ethanol in gasoline) has been shown to harm air quality in metropolitan areas already struggling to meet federal standards for pollutants such as oxides of nitrogen and ozone. High blend applications (such as E-85 in FFVs) avoid these air quality challenges and promote the infrastructure needed to support greater biofuel distribution.

ENDNOTES

- 1 Chung, Joanna, Laitner, Sarah, and Denning, Liam, "Transatlantic alliance to secure fuel supplies," *Financial Times*, January 27, 2005.
- 2 Stone, Amey, "\$50 Oil: A Spreading Slick of Pain," *Business Week*, September 29, 2004.
- 3 Energy Information Administration, Short Term Energy Outlook, January 2005. EIA projects 2005-06 crude oil prices of \$42 to \$43 per barrel.
- 4 Estimates based on 2004 petroleum supply and price data provided by Energy Information Administration, January 2005 Short Term Energy Outlook, www.eia.doe.gov/emeu/steo/pub/steo.html.
- 5 Odessey, Bruce. "U.S. Trade Deficit Surges as Exports Fall, Oil Imports Rise", January 12, 2005. US Consulate trade statistics, www.hongkong.usconsulate.gov/usinfo/statis/ft/2004/11.htm.
- 6 "Trade: Deficit Soared in 2004," *The Week*, February 25, 2005.
- 7 National Defense Council Foundation, "The Hidden Cost of Imported Oil," September 2003, as cited by the Institute for the Analysis of Global Security, *Energy Security Bi-Weekly*, October 30, 2003.
- 8 International Energy Agency, *World Energy Outlook 2004*, (119-121). Organization for Economic Cooperation and Development, 2004.
- 9 As quoted in Roberts, Paul, *The End of Oil: On the Edge of a Perilous New World*, Houghton Mifflin, New York, NY, 2004.
- 10 "The Costs of US Oil Dependence" by Parry, Ian W.H. and Joel Darmstadter. Resources for the Future, November 17, 2004 (Technical appendix to National Commission on Energy Policy Report).
- 11 Chung, Joanna, Laitner, Sarah, and Denning, Liam, "Transatlantic alliance to secure fuel supplies," *Financial Times*, January 27, 2005.
- 12 Energy Information Administration, *Annual Energy Outlook 2004: With Projections to 2025*, DOE/EIA-0383(2004), Table 21, January 2004.
- 13 Arctic National Wildlife Refuge production analysis conducted by Richard A. Fineberg, Fineberg Research, January 2005.
- 14 PFC Energy. *Global Crude Oil and Natural Gas Liquids Supply Forecast*, September 2004.
- 15 Stone, Amey, "\$50 Oil: A Spreading Slick of Pain," *Business Week*, September 29, 2004.
- 16 Ibid.
- 17 Bremmer, Ian. "Are the U.S. and China on a Collision Course?" *Fortune Magazine*, January 12, 2005.
- 18 Luft, Gal, "In Search of Crude: China Goes to the Americas," Institute for the Analysis of Global Security, www.iags.org/n0118041.htm.
- 19 Romero, Simon, "China Emerging as U.S. Rival for Canada's Oil," *New York Times*, December 21, 2004.
- 20 "Venezuela and China Sign Oil Agreements," Associated Press, January 29, 2005.
- 21 Bradsher, Keith, "China Sets its First Fuel Economy Rules," *New York Times*, September 23, 2004.
- 22 Kripalani, Manjeet, Dexter Roberts and Jason Bush, "India and China: Oil-Patch Partners?" *Business Week*, February 7, 2005.
- 23 *International Energy Outlook 2004*, Energy Information Administration, Department of Energy.
- 24 *World Energy Outlook*, International Energy Agency, 2004.
- 25 Former Secretary of Energy James Schlesinger, "The Oil Embargo 30 Years Later: Are We Prepared?" Heritage Foundation panel, October 14, 2003.

- 26 Klare, Michael T., *Blood and Oil : The Dangers and Consequences of America's Growing Dependence on Imported Petroleum*, Metropolitan Books, New York, New York, 2004.
- 27 Luft, Gal and Anne Korin, *The Journal of International Security Affairs*, December 2003.
- 28 National Defense Council Foundation, "The Hidden Cost of Imported Oil," September 2003, as cited by the Institute for the Analysis of Global Security, *Energy Security Bi-Weekly*, October 30, 2003.
- 29 "Chilly response to U.S. plan to deploy forces in the Strait of Malacca," *Energy Security*, May 2004.
- 30 Schuster, H. and N. Robertson, "Attack adds to oil security focus: Supply disruption could send price soaring," CNN.com, December 7, 2004; Blum, J., "Terrorist Have Oil Industry in Cross Hairs," *Washington Post*, September 27, 2004; Luft, G, "Terror's Big Prize," *The New York Sun*, April 30, 2004.
- 31 "Al Qaeda's economic war against the United States," Institute for the Analysis of Global Security (IAGS) *Energy Security newsletter*, January 24, 2005.
- 32 "Iraq Pipeline Watch," IAGS, www.iags.org/iraqpipelinewatch.htm.
- 33 *The World Factbook*, Central Intelligence Agency, January 1, 2004.
- 34 Baer, Robert 2003. *Sleeping with the Devil: How Washington Sold Our Soul for Saudi Crude*. New York: Crown.
- 35 Jaffe, Amy Myers. *United States and the Middle East: Policies and Dilemmas*. Analysis commissioned by the National Commission on Energy Policy, www.energycommission.org.
- 36 Woolsey, R. James, Amory B. Lovins, and L. Hunter Lovins, "Energy security: It takes more than drilling," *Christian Science Monitor*, March 29, 2002.
- 37 Transparency International, *Global Corruption Report*, October 15, 2001
- 38 In fact, one of the recommendations that the Commission made is to create a "comprehensive U.S. strategy" for terrorism reduction that includes "economic policies that encourage development of more open societies, and opportunities for people to improve the lives of their families and to enhance prospects for their children's future." *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States*, p. 379.
- 39 *The Paradox of Plenty: Oil Booms and Petro-States, Studies in International Political Economy*, No. 26, University of California, 1997; Zakaria, Fareed, *The Future of Freedom: Illiberal Democracy at Home and Abroad*, Norton, 2004.
- 40 *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States*, p. 374.
- 41 Wirth, Timothy E., C. Boyden Gray, John Podesta, "The Future of Energy Policy," *Foreign Affairs*, July/August 2003.
- 42 Friedman, Thomas, "The Geo-Green Alternative," *New York Times*, January 30, 2005.
- 43 Hammet, Patrick, Michael Flynn, Maitreya Kathleen Sims and Daniel Luria, "Fuel-Saving Technologies and Facility Conversion: Costs, Benefits, and Incentives," A report to the National Commission on Energy Policy and the Michigan Environmental Council, University of Michigan Transportation Research Institute, November 2004.
- 44 Duncan Austin, Niki Rosinski, Amanda Sauer, Colin Le Duc. *Changing Drivers*. World Resources Institute, Sustainable Asset Management (SAM), 2003.
- 45 National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges*, December 2004.
- 46 NRC, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*, National Academy of Sciences, Washington, DC: National Academy Press, 2002, pp. 2-3.
- 47 Hellman, Karl H. and Robert M. Heavenrich. *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, EPA420-R-04-001, Advanced Technology Division, Office of Transportation and Air Quality, EPA, April 2004, p. 4.
- 48 Ibid. p. 7.
- 49 NRC, pp. 2-3.

- 50 Consultant report to the California Energy Commission, "California State Fuel-Efficient Tire Report: Volume II," Consultant Report 600-03-001CR Vol. II, January 2003.
- 51 Ibid.
- 52 U.S. Department of Energy, "Gas Mileage Tips: Keeping Your Car In Shape," Fuel Economy website, www.fueleconomy.gov/feg/maintain.shtml, Viewed August 23, 2004.
- 53 AMSOIL INC, "The Right Environmental Choice" product brochure for 100% synthetic oil, Superior, WI, 2003.
- 54 Calculation based on projections in EIA's Annual Energy Outlook 2003 for energy consumption by commercial light, medium and heavy trucks.
- 55 Langer, Therese, Report to the National Commission on Energy Policy "Energy Savings Through Increased Fuel Economy for Heavy-Duty Trucks," 2004.
- 56 Van Hattum, David et al, "Implementation and Analysis of Cashing-out Employer Paid Parking by Employers in the Minneapolis-St. Paul Metropolitan Area," June 30, 2000, p. 2 (table).
- 57 Forkenbrock, David J. and Jon G. Kuhl, *A New Approach to Assessing Road User Charges*, University of Iowa, 2002.
- 58 U.S. Department of Energy, Roadmap for Biomass Technologies in the United States, December 2002.
- 59 U.S. Department of Energy Interlaboratory Working Group, Scenarios for a Clean Energy Future. Oak Ridge, TN: Oak Ridge National Laboratory; Berkeley, CA: Lawrence Berkeley National Laboratory; and Golden, CO: National Renewable Energy Laboratory, ORNL/CON-476, LBNL-44029, and NREL/TP-620-29379, November 2000.
- 60 Energy Information Administration, Residential Home Energy Use and Cost: Residential Energy Consumption Survey, 2001 data. www.eia.doe.gov/emeu/recs/.
- 61 Renewable Fuels Association. "Homegrown for the Homeland: Ethanol Industry Outlook 2005," February 2005.
- 62 Energy Information Administration, "Alternatives to Traditional Transportation Fuels," September 2002. www.eia.doe.gov/cneaf/alternate/page/datatables/atf1-13_00.html.
- 63 Greene, Nathanael, et al., Growing Energy: How Biofuels Can Help End America's Oil Dependence, NRDC, December 2004.
- 64 Ibid.
- 65 Energy Information Agency, Annual Energy Outlook 2003: With Projections to 2025, DOE/EIA-0383(2003), January 2003.
- 66 Oil demand values in the Appendix are based on calculations from the Energy Information Agency's Annual Energy Outlook 2003. These oil demand values may differ slightly from other values in the report that are provided in AEO 2004.
- 67 NRC, Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards, National Academy of Sciences, Washington, DC: National Academy Press, 2002, pp. 2-3.
- 68 Hellman, Karl H. and Robert M. Heavenrich, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2004, EPA420-R-04-001, Advanced Technology Division, Office of Transportation and Air Quality, EPA, April 2004, p. 4.
- 69 Ibid. p. 7.
- 70 NRC, pp. 2-3.
- 71 Hellman and Heavenrich, p. 6.
- 72 Friedman, David, Jason Mark, Patricia Monahan, Carl Nash and Clarence Ditlow, *Drilling in Detroit: Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles*, Cambridge, MA: Union of Concerned Scientists, June 2001.
- 73 DeCicco, John, Feng An and Mark Ross, Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010-2015, Washington, DC: American Council for an Energy-Efficient Economy, 2001.

- 74 Weiss, Malcolm A., John B. Heywood, Elisabeth M. Drake, Andreas Shafer, and Felix F. AuYeung, "On the Road in 2020: A Life-Cycle Analysis of New Automobile Technologies," Energy Laboratory Report # MIT EL 00-03, Cambridge, MA: Massachusetts Institute of Technology (MIT), October 2000.
- 75 Hellman and Heavenrich, p 2.
- 76 Consultant report to the California Energy Commission, California State Fuel-Efficient Tire Report: Volume II, Consultant Report 600-03-001CR Vol. II, January 2003.
- 77 Green Seal, Inc., Choose Green Report: Low Rolling Resistance Tires, March 2003.
- 78 Consultant report to the California Energy Commission.
- 79 Ibid.
- 80 Tamoto, Yoshitaka, Masahiko Kido and Hideyuki Murata, Possibilities of Ultra Low Viscosity Fuel Saving Gasoline Engine Oil, SAE Technical Paper Series 2004-01-1936, Warrendale, PA: SAE International, 2004.
- 81 U.S. Department of Energy, "Gas Mileage Tips: Keeping Your Car In Shape." Fuel Economy website, www.fueleconomy.gov/feg/maintain.shtml, viewed August 23, 2004.
- 82 AMSOIL INC, "The Right Environmental Choice" product brochure for 100 percent synthetic oil, Superior, WI, 2003.
- 83 Ibid.
- 84 Calculation based on projections in EIA's Annual Energy Outlook 2003 for energy consumption by commercial light, medium and heavy trucks.
- 85 Langer, Therese. Report to the National Commission on Energy Policy "Energy Savings Through Increased Fuel Economy for Heavy-Duty Trucks," 2004.
- 86 NCEP NEMS Model (version 060903), a stand-alone version of the EIA NEMS Transportation Model developed by Meszler Engineering Services for the National Commission on Energy Policy, June 2003.
- 87 Initial technology assessments were conducted by ACEEE's Therese Langer for her report to the National Commission on Energy Policy, "Energy Savings Through Increased Fuel Economy for Heavy-Duty Trucks," 2004. NRDC worked with Ms. Langer to refine the analysis to year-to-year technology advances and oil savings.
- 88 Langer, p. 15.
- 89 Ibid.
- 90 Stodolsky, Frank, Linda Gaines, Anant Vyas. Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks. (ANL/ESD-43) Argonne, IL: Argonne National Laboratory. June 2000.
- 91 www.idleaire.com
- 92 Department of Energy, Energy Efficiency and Renewable Energy, Industrial Technologies Program, "Waste Heat Reduction and Recovery for Improving Furnace Efficiency, Productivity and Emissions Performance: A Best Practices Process Heating Technical Brief," DOE/GO-102004-1975, November 2004.
- 93 Biomass Research and Development Technical Advisory Committee for the U.S. Department of Energy and U.S. Department of Agriculture, Roadmap for Biomass Technologies in the United States, December 2002.
- 94 U.S Department of Energy Interlaboratory Working Group, Scenarios for a Clean Energy Future, Oak Ridge, TN: Oak Ridge National Laboratory; Berkeley, CA: Lawrence Berkeley National Laboratory; and Golden, CO: National Renewable Energy Laboratory, ORNL/CON-476, LBNL-44029, and NREL/TP-620-29379, November 2000.
- 94 Federal Aviation Administration. Flight Plan 2005-2009. Washington DC. 2004. www.faa.gov/AboutFAA/FlightPlan2005_2009.cfm.
- 95 U.S. Department of Energy Interlaboratory Working Group.
- 96 Federal Aviation Administration, Flight Plan 2005-2009, Washington DC, 2004. www.faa.gov/AboutFAA/FlightPlan2005_2009.cfm.

97 Energy Administration Administration, Residential Home Energy Use and Cost: Residential Energy Consumption Survey, 2001 data. www.eia.doe.gov/emeu/recs/.

98 Ibid.

99 ACEEE referred to multiple national and state studies to determine a savings potential for each technology used in the home.

100 Renewable Fuels Association. "Homegrown for the Homeland: Ethanol Industry Outlook 2005," February 2005.

101 EIA. "Alternatives to Traditional Transportation Fuels." September 2002. www.eia.doe.gov/cneaf/alternate/page/datatables/atf1-13_00.html.

102 M. Wang, C. Saricks, and D. Santini. Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions, ANL/ESD-38. Argonne, IL: Argonne National Laboratory, Center for Transportation Research, January 1999.

103 Ibid.