DANGEROUS ADDICTION

Ending America's Oil Dependence

Principal Authors
David Doniger, NRDC
David Friedman, UCS
Roland Hwang, NRDC
Daniel Lashof, NRDC
Jason Mark, UCS

NRDC
The Earth's Best Defense

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

January 2002

DANGEROUS ADDICTION

Ending America's Oil Dependence

January 2002

ACKNOWLEDGMENTS

The Natural Resources Defense Council would like to acknowledge the support of the Avocet Charitable Lead Unitrust, The Beatrice R. and Joseph A. Coleman Foundation, Lewis Anthony Dexter Trust, The Energy Foundation, The Charles Evans Hughes Memorial Foundation, Inc., The John D. and Catherine T. MacArthur Foundation, the LuEsther T. Mertz Charitable Trust, the Public Welfare Foundation, the Turner Foundation, Inc., as well as our 500,000 members. The Union of Concerned Scientists would like to acknowledge the support of The Energy Foundation, the W. Alton Jones Foundation, Inc., The J.M. Kaplan Fund, the Steven and Michele Kirsch Foundation, the Oak Foundation, Pew Charitable Trusts, the V. Kann Rasmussen Foundation, the Turner Foundation, Inc., and the Wallace Global Fund.

ABOUT NRDC

The Natural Resources Defense Council is a national nonprofit environmental organization with more than 500,000 members. Since 1970, our lawyers, scientists, and other environmental specialists have been working to protect the world's natural resources and improve the quality of the human environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, and San Francisco. Visit NRDC online at www.nrdc.org.

ABOUT UCS

The Union of Concerned Scientists is a nonprofit partnership of scientists and citizens combining rigorous scientific analysis, innovative policy development, and effective citizen advocacy to achieve practical environmental solutions. UCS is online at www.ucsusa.org.

PRODUCTION

Electronic Assembly
Deborah Faulkner

Cover Design
Jenkins & Page

NRDC Reports Manager
Emily Cousins

NRDC Communications Director
Alan Metrick

NRDC President
John Adams

NRDC Executive Director
Frances Beinecke

TABLE OF CONTENTS

DANGEROUS ADDICTION

Ending America's Oil Dependence

January 2002

EXECUTIVE SUMMARY

America's oil dependence endangers our national security. America consumes a quarter of the world's total oil production, but has just 3 percent of its known reserves. We import more than half of our oil from some of the most unstable regions of the world. At the root of our heavy reliance on oil imports is the inefficiency of our cars, sport utility vehicles (SUVs), and other passenger vehicles.

This report presents practical solutions we can adopt now, using American technology and know-how, to cut the oil needed to power America's cars and light trucks. We can cut that oil demand in half by 2020–and provide American consumers with the best and safest driving choices in the world–by building better vehicles and making better fuels. We can have better, cleaner transportation for less money while strengthening our safety, security, and freedom.

FIXING A DANGEROUS ADDICTION

The events of September 11 highlight the danger in continuing to turn a blind eye to our oil dependence. While oil prices are down for the moment, the instability of the Middle East makes for a situation that could change at any moment. New suppliers like Russia and the Caspian region are hardly more stable.

Sixty-five percent of the world's known reserves lie beneath the Persian Gulf states. That stark fact makes a supply-side strategy based on domestic drilling alone into a recipe for continued dependence on these unstable regions. Drilling in the Arctic National Wildlife Refuge would increase world reserves by less than one-third of one percent. To be sure, we can increase production from existing oil fields. But no matter how much we try to drill for new oil at home, Persian Gulf producers will gain more and more of the American oil market–and limit our ability to conduct foreign policy in the best interests of the American people.

Our oil dependence threatens our environmental security as well. Smog and other toxic air pollutants, constant pressure to drill in pristine wilderness, and growing emissions of the heat-trapping global warming pollutant, carbon dioxide (CO_2), all are effects tied directly to the amount of oil we burn.

The best way to turn that around is to reduce our reliance on imported oil by building better cars and making better fuels. The fastest, cheapest, most secure solution is a comprehensive energy security strategy combining near-term fuel-economy improvements in our cars and trucks with longer-term initiatives to develop the fuels of the future.

A COMPREHENSIVE STRATEGY FOR COST-EFFECTIVE SAVINGS

This report offers a five-step solution to make better vehicles and better fuels that reduce our oil dependence with no reduction in safety, performance, or choice. Together, these measures could cut passenger vehicle oil use by nearly a quarter by 2012, by half in 2020, and by three-quarters over the next three decades, compared with business-as-usual projections. That translates into big savings at the gas pump: a person buying a 40 mpg car in 2012 would save a net of $2,200 over the life of the vehicle. Total consumer savings from these policies would equal nearly $13 billion per year in 2012, and almost $30 billion by 2020.

Our action plan to curb oil dependence includes:

- Improving the fuel economy of new vehicles powered by gasoline-engine technology. Congress should ramp up standards for the combined fleet of cars and light trucks in regular steps to 40 mpg by 2012 and 55 mpg in 2020.
- Mass-producing gasoline-electric hybrid vehicles, which get double the mileage of today's cars. Toyota and Honda already have hybrids on the road, and more are coming. Lawmakers should provide consumer tax credits to support the transition to new technology.
- Significantly expanding the use of renewable, non-petroleum fuels, such as ethanol made from crop wastes, by steadily increasing requirements for "renewable content" in gasoline.
- Putting hydrogen-powered fuel-cell vehicles onto the road using incentives and requirements to ramp up production to 100,000 vehicles by 2010 and 2.5 million by 2020. These vehicles will use one-third the energy of today's cars (none of it from oil) and produce near-zero harmful emissions.
- Encouraging "smart growth" instead of suburban sprawl, to increase our transportation choices and make communities more livable with less driving.

The first step alone–raising fuel economy standards–would save nearly 4 billion barrels of oil over the next dozen years. By 2012, we could save nearly 2 million barrels *every day*–a savings of 18 percent below business-as-usual projections. That is slightly more oil than we imported from Saudi Arabia last year, and three times our imports from Iraq. By 2020, savings would grow to nearly 5 million barrels per day, almost twice as much as total current imports from the Persian Gulf.

Unlike the Freedom Car fuel-cell research exercise recently announced by the U.S. Department of Energy, this report offers a real plan for putting better cars and better fuels on the road before it's too late. Our plan calls for introducing vastly more efficient conventional and hybrid technologies that will significantly reduce oil demand during this decade, and putting real fuel-cell vehicles on the road within this decade.

These measures would cut heat-trapping CO_2 and other global warming emissions by more than 400 million metric tons in 2012, and by almost a billion metric tons in 2020. By 2020 we could avoid 240,000 tons of cancer-causing pollution and more than 500,000 tons worth of smog-forming emissions each year.

THE HIGH COST OF OIL IMPORTS

American drivers used more than 120 billion gallons of gasoline in 2000, costing $186 billion. If fuel economy does not improve, passenger-vehicle fuel use will increase more than 50 percent by 2020, to almost 190 billion gallons per year. Without serious action, the share of that oil that is imported will grow from one-half to nearly two-thirds.

The United States spent $106 billion–about $380 per person–importing crude oil and petroleum products in 2000. By 2020, oil-import spending is expected to hit $160 billion, according to the U.S. Department of Energy, an increase of more than 50 percent.

This results in a huge transfer of wealth to oil exporting nations. Over the past 30 years, U.S. consumers have transferred more than a *trillion* dollars to oil producing countries. And each of the three major oil price spikes of the last 30 years was followed by a recession in the United States.

THE ENVIRONMENTAL PRICE TAG

The environmental consequences of our oil demand are well known: cars and passenger trucks are the second largest U.S. source of carbon dioxide pollution–emitting 1.3 billion metric tons of heat-trapping gases in 2000. Emissions of smog- and cancer-causing air pollutants are also a major problem, especially in urban areas.

Our oil addiction also creates constant pressure to drill unspoiled wilderness areas like the Arctic National Wildlife Refuge, Utah's Redrock canyon country, and lands in the vicinity of Yellowstone National Park. Most federal lands with potential oil resources are already available to oil exploration and development; in fact, federal lands account for 29 percent of U.S. crude oil production. Meanwhile oil spills pose a constant threat to the land, water, wildlife, and coastal livelihoods. Almost 1.5 million gallons of oil were spilled into U.S. waters in 2000.

WE CAN DO IT

A safer, more secure energy future is well within the reach of America's industrial prowess. Studies by the National Academy of Sciences, the Union of Concerned Scientists, and other independent analysts have all demonstrated that a 40-mpg fleet average is achievable within a decade or so, using technology that is available today.

America has already proven that such strides are possible. Fuel economy for new passenger cars nearly doubled between 1975–when standards were first adopted–and their peak in 1988. Fuel economy for new light trucks increased by 50 percent. But the rules haven't changed since 1985. Average mileage of our new cars and trucks today is at its lowest level in 20 years.

And today we have the know-how to turn crop wastes into fuel, replace the internal combustion engine with emission-free fuel cells, and practice smart-growth development that increases our transportation choices.

Together these proposals are the best way to curb our reliance on Middle East oil. We can regain control over our future by providing American consumers with the safest and best performing passengers vehicles in the world. *This* is the road to increase our national security, strengthen our economy, and protect our environment.

CHAPTER 1

WHY AMERICA NEEDS AN OIL SECURITY PLAN

Since the terrorist attacks of September 11, Americans are focusing once again on our nation's oil security, and especially our dangerous dependence on Middle East oil. Even with oil prices down for the moment, Americans are justifiably worried about our vulnerability to future disruptions in oil supplies or surges in world oil prices. As our elected leaders debate the first major energy bill in a decade, it is critical to understand what makes us so vulnerable, what responses would really increase our oil security, and what proposals offer only false promises.

Americans are also concerned about oil's impact on our environment. Global warming, caused by the heat-trapping carbon dioxide (CO_2) pollution from burning oil and other fossil fuels, is itself a threat to global security. Oil dependence also means oil spills in the oceans, smog over our cities, and constant pressure to drill in our few remaining wilderness areas. The right kind of energy legislation can reduce oil's burden on the environment even as it enhances our national security. The wrong kind can leave us worse off on both counts.

There is a path that leads to both oil security and environmental security. We can use American technology and know-how to produce better vehicles and fuels that will dramatically reduce oil use by passenger vehicles–by more than 20 percent in the next 10 years, nearly 50 percent by 2020, and 75 percent over the next 30 years–reducing both our dependence on oil and our contribution to global warming.

THE *OIL SECURITY* ROADMAP: FIVE STEPS TO CUT AMERICA'S OIL DEPENDENCE

The United States is not locked into ever-greater oil dependence. We can kick our oil addiction by following a five-step program to reach energy security:

- Improve the fuel economy of new vehicles powered by conventional gasoline-engine technology
- Mass-produce gasoline-electric hybrid vehicles, which get double the mileage of today's cars
- Use more "renewable" fuels, such as ethanol produced from crop wastes with new, efficient technology
- Bring hydrogen-fuel-cell vehicles and clean sources of hydrogen to full-scale production

- Encourage smart growth instead of suburban sprawl to increase our transportation choices and make communities more livable with less driving

These goals are all within reach, but they will not happen by themselves. To achieve these results, we need a package of strong federal policies in the following five areas.

Raise Fuel Economy Standards Congress should boost fuel economy standards for the combined new car and light-truck fleet to 40 miles per gallon (mpg) by 2012 and 55 mpg by 2020. Automakers can reach 40 mpg with improvements in conventional gasoline technology, and they can reach 55 mpg with expanded production of gasoline-electric hybrids.

This is the most important step we can take to cut our oil dependence and increase our oil security. These fuel economy standards would save nearly 4 billion barrels of oil over the next dozen years. They would save nearly 2 million barrels of oil every day in 2012–more than one-quarter of the oil we now use every day to fuel our cars and light trucks. Oil savings would just keep growing and growing as fuel economy standards continue to rise and as new vehicles replace old ones. By 2020 oil savings would reach 4.8 million barrels per day–more oil than we now import from the Persian Gulf.

These fuel economy standards would also bring huge reductions in global warming pollution. Emissions of CO_2 and other global warming pollutants would be cut by more than 320 million metric tons (CO_2-equivalent) by 2012, compared with business-as-usual projections for that year.[1] By 2020 the reduction from business-as-usual emissions would be over 800 million metric tons, reducing passenger vehicles' global warming emissions in that year by 40 percent.

Raising fuel economy standards is by far the most important *Oil Security* policy to save oil soon. It accounts for 80 percent of the oil savings we can achieve in 2012 and 2020, and is still 70 percent of savings by 2030. So while the other policies we recommend are critical to America's long-term oil security, there is no substitute for better fuel economy in this decade.

Create Tax Incentives for Hybrids and Fuel Cells Hand in hand with better fuel economy standards, Congress should enact tax incentives for car buyers who choose high-mileage, advanced-technology vehicles, including hybrid gasoline-electric and fuel-cell vehicles.

Tax incentives for consumers who buy hybrids will speed up the market penetration of these oil-saving technologies. Two hybrid models are already on the market, and more are coming from both domestic and foreign automakers this year.

Tax incentives for hybrids and fuel cells will also help to meet higher fuel economy standards and boost the introduction of hydrogen-fuel-cell vehicles. We have incorporated the effects of these tax incentives into our assessment of the savings from these other policies.

Boost Renewable Fuels Building on current proposals to replace the problematic gasoline additive MTBE, Congress should mandate steady annual increases in the "renewable content" of gasoline–the percentage of motor fuel that must come from renewable, oil-free sources. Under our *Oil Security* policies, biomass ethanol made from crop wastes by new efficient conversion processes would cut oil consumption in 2020 by almost 400,000 barrels every day–over and above the savings from fuel-economy increases. Biomass ethanol would cut an additional 76 million metric tons of heat-trapping CO_2 pollution in 2020.

Put Fuel Cells and Hydrogen Fuel on the Road Congress should set the goal of converting America's passenger transportation system to fuel-cell vehicles running on hydrogen, the ultimate clean fuel whose only byproduct is water. To protect national security, our economy, and the environment over the long-term, we need to start a program now to get our passenger vehicles completely off of oil.

A real hydrogen-fuel-cells program must be more than another R&D exercise. Unlike the new Freedom Car research program just unveiled by the Department of Energy, it should include a combination of requirements and incentives to move fuel-cell technology out of the laboratory and onto the road. Our *Oil Security* policies would require automakers to scale up production to at least 100,000 hydrogen-fuel-cell vehicles by 2010, to 600,000 by 2015, and to 2.5 million by 2020. Tax incentives for buying hydrogen-fuel-cell vehicles would help consumers and automakers in the early years, when initial production costs would likely be higher.

Simultaneously, the fuel-cell program should require that an adequate supply of hydrogen is cleanly produced and delivered as demand grows. Tax incentives would be available to fuel providers as well.

In 2020, hydrogen-fuel-cell vehicles would cut oil consumption by nearly 225,000 barrels per day over the reductions achieved by fuel efficiency and biomass ethanol. The greatest benefits occur over the long-term. With economies of scale fully achieved by 2030, we forecast hydrogen-fuel-cell vehicle sales rising to 13 million. By then, oil consumption would be cut by nearly 2.5 million barrels per day. Emissions of CO_2 and other heat-trapping gases would be reduced by more than 240 million metric tons in 2030 (CO_2-equivalent) over and above the reductions from increased fuel efficiency and biomass ethanol.

Support Smart Growth and Better Transportation Choices Saving oil is one more reason to pursue smart-growth initiatives 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 drive.

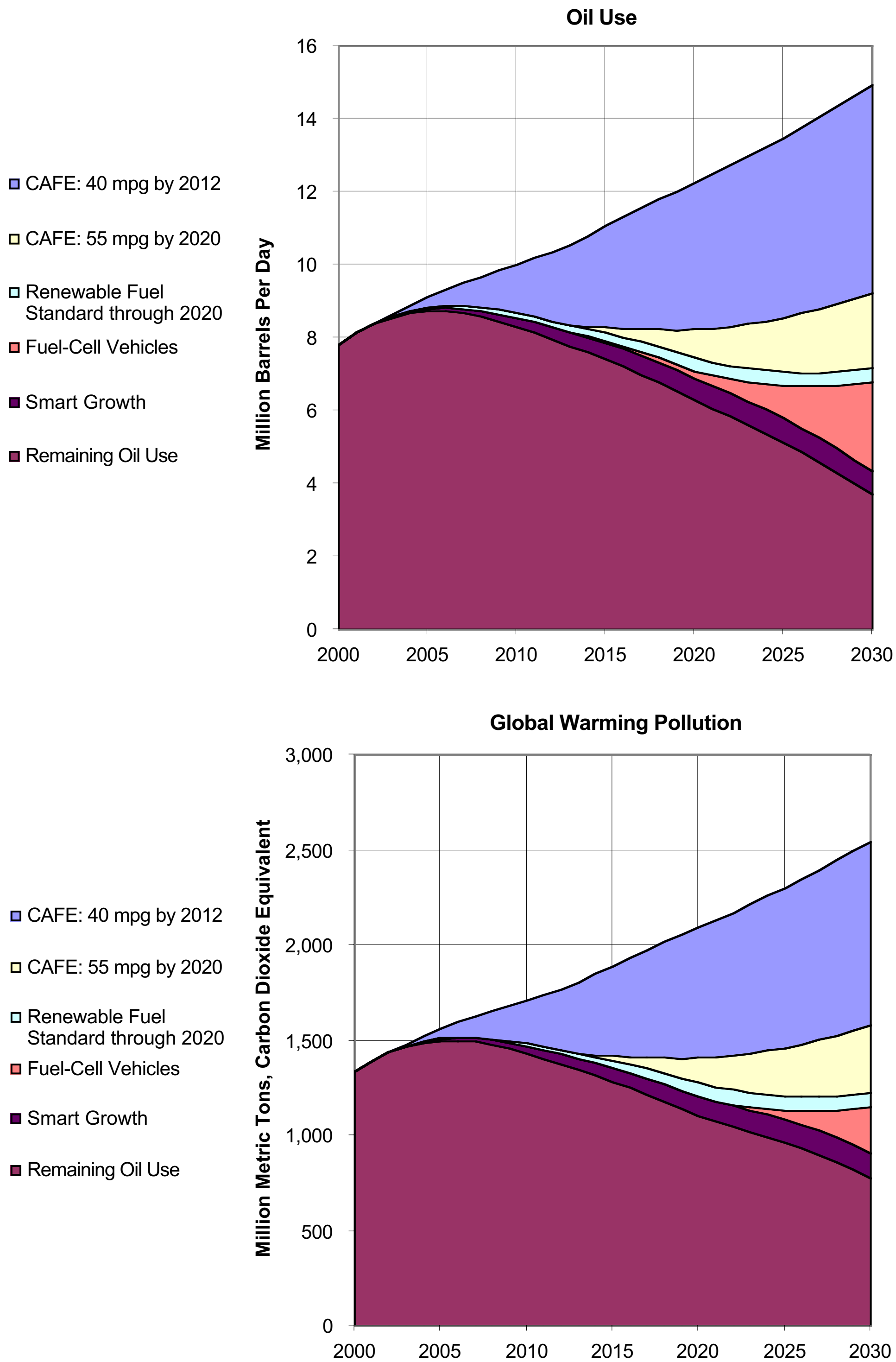
Congress could achieve greater oil savings by giving public-transit commuters tax benefits equivalent to workplace-parking space subsidies that drivers now enjoy. Congress should adopt "pay-as-you-drive insurance" legislation to make a portion of automobile insurance costs depend on how much you drive. Fannie Mae should aggressively promote a new "location efficient mortgage" lending policy that rewards building and buying homes located near public transit. Most important, Congress should increase support for smart-growth strategies and public-transit investments in the next round of transportation legislation.

In 2012, we estimate that smart-growth and transportation-choice policies could cut oil consumption by an additional 320,000 barrels per day. These savings would rise in 2020 to nearly 590,000 barrels per day, while cutting CO_2 pollution by 100 million metric tons.

Total Oil Savings from the *Oil Security* Policies The five elements of the *Oil Security* plan work together by addressing vehicles, fuels, and travel with a combination of research, incentives, and performance standards. All together, they would dramatically reduce America's oil dependence:

- Overall, compared to projected business-as-usual levels, passenger-vehicle oil use would be reduced by 23 percent in 2012, by 49 percent in 2020, and by 75 percent in 2030 (see Figure 1).

Figure 1. Oil Security Scenario



- By 2012 these savings would almost equal our current imports from the Persian Gulf, increasing to more than four times current Persian Gulf imports by 2030.

All of these steps need to be initiated now, even though some–such as fuel cells–will pay off only down the road. Improving the fuel efficiency of conventional vehicles and hybrids paves the way for the other elements of the *Oil Security* path by reducing total energy requirements. Increased use of biomass ethanol can be easily accommodated at existing fuel pumps, mostly by blending up to 10 percent ethanol with gasoline. The infrastructure investments needed to supply hydrogen are significant, but modest in comparison to the value of fuels and vehicles. With adequate planning and policy support, fueling infrastructure will not be an obstacle to the *Oil Security* path.

The specific policies we describe extend through 2020, but they will have long-lasting effects. For example, once we mass-produce fuel-cell vehicles and put a hydrogen fueling infrastructure in place, we expect market momentum to carry fuel cells forward to dominate the 2030 vehicle market. Nonetheless, there will be an ongoing need for federal transportation policies to address oil security and environmental goals throughout the period. Rather than attempt to describe today the policies that will be needed in 2030, it should be recognized that we will have to update and revise these policies at regular intervals in light of experience.

To be sure, oil is also used in freight trucks, airplanes, factories, and sometimes for home heating. Large opportunities to save oil and cut pollution also exist in each of these areas. The *Oil Security* policies recommended in this report focus on passenger vehicles, because they are the largest single user of oil in the U.S. economy and the driving force behind our dependence on oil from the Middle East. A complete oil security policy should also include measures to save oil and other energy resources in these remaining sectors, and a comprehensive energy policy should address the full range of energy uses and resources. The opportunities for Congress to promote energy efficiency, renewable energy, and environmentally sound use of other energy resources have been addressed in other reports by NRDC *(A Responsible Energy Policy for the 21st Century)* and UCS *(Clean Energy Blueprint)*.[2]

Detours and False Hopes

Only a path that reduces both our oil dependence and the threat of global warming will give us lasting security. Some argue for more domestic drilling, even in the pristine Arctic National Wildlife Refuge and our few other remaining wilderness areas. This is a path for destroying America's natural legacy. Surely, some small part of our landscape should simply be off limits to industrial activities.

More than that, it is the path that will utterly fail to ensure our oil security or national security. The Arctic Refuge and other natural reserves simply do not contain enough oil to reduce our vulnerability to price spikes and disruption of imported oil supplies. America consumes 25 percent of the world's oil production, even though we have only 4 percent of the world's population and less than 3 percent of its proven oil reserves. The amount of economically recoverable oil in the Arctic Refuge, according to U.S.

Geological Survey estimates, would increase world reserves by only 0.3 percent–not nearly enough to make a significant dent in our imports and too little to influence world oil prices. [3]

The Arctic Refuge would likely produce less oil over its 50-year estimated life than our country now consumes in six months–less than 1 percent of the oil we are projected to consume over those 50 years.[4] Raising fuel economy standards to 40 mpg would save more oil in the next dozen years than the Arctic Refuge would produce over 50 years.[5] And by 2020 the *Oil Security* fuel-economy increases would reduce CO_2 emissions by over 800 million metric tons, compared to a business-as-usual, drill-and-burn strategy.

To be sure, we can do more to enhance oil production from existing domestic oilfields. Indeed, ingenious new technologies offer the promise of using CO_2 captured from other energy production facilities–CO_2 that ordinarily would pollute the atmosphere–to pump more oil out of oilfields. The CO_2 used for this purpose could then be safely stored underground.

We can also do more with Alaska's plentiful supply of natural gas by building a gas pipeline to the lower 48 states–with appropriate environmental safeguards–along the route of the existing trans-Alaska oil pipeline. Natural gas is the cleanest fossil fuel, with the lowest CO_2 emissions. It can be used to generate electricity. It can be converted to hydrogen for fuel cells.

But we cannot drill our way to oil security. No matter how much new oil drilling we do in the United States, we cannot change one fundamental fact: 65 percent of the world's oil reserves lie under the countries of the Persian Gulf, compared to less than one-third of 1 percent in the Arctic National Wildlife Refuge.

Trying to feed current consumption trends by drilling for new domestic oil supplies is inevitably a recipe for remaining dependent on oil imports and leaving decision-makers in the Persian Gulf in charge of the price we pay. The more oil we consume, the more leverage we give them to disrupt our economy and our security.

If we want to control our own destiny, we need to use our edge: our high-tech economy's ability to make smarter vehicles and fuels. A more efficient, less oil-dependent economy will put us back in the driver's seat.

HOW AMERICA'S OIL DEPENDENCE THREATENS OUR NATIONAL SECURITY, OUR ENVIRONMENT, AND OUR ECONOMY

America consumes 25 percent of the world's oil production, even though we have less than 3 percent of proven global oil reserves and only 4 percent of the world's population. America's insatiable and growing oil consumption threatens our national security, our environment, and our economy.

National Insecurity

Dependence on Oil Imports More than 51 percent of the oil we use is imported, putting our national security and economic well-being at the mercy of unstable regimes in the Middle East and other volatile regions.[6] Sixteen percent of our imports come from Saudi

Arabia and 25 percent from all Persian Gulf states.[7] New prospects, such as Russia and the Caspian region, hardly look more secure.

The inefficiency of our cars, SUVs, and other passenger vehicles is present the single largest factor in our disproportionate oil demand and our heavy reliance on oil imported from unstable regions. Forty-two percent of U.S. oil consumption goes to gasoline for these vehicles.[8] U.S. drivers consumed 121 billion gallons of gasoline in 2000, at a total cost of $186 billion.[9] The most effective way to reduce that dependence is to move to better vehicles and fuels by increasing fuel economy standards and by taking the other *Oil Security* measures recommended in this report.

The fuel efficiency of passenger vehicles rose through the mid-1980s under the corporate average fuel economy (CAFE) standards, which were enacted in response to the first oil embargo of the previous decade. But fuel economy standards have not been substantially changed in 15 years. Eroded by sales of SUVs, the combined fuel economy of new cars and light trucks actually fell in 2000 to 24 miles per gallon, a 20-year low.[10]

Greater Dependence Ahead Without a program to produce better vehicles and fuels, our reliance on Middle East oil is likely to rise over the next 20 years. If average vehicle fuel economy remains stagnant, we estimate that passenger-vehicle fuel use will increase by 56 percent by 2020, to 189 billion gallons per year. U.S. dependence on imported oil is expected to grow from 51 percent today to 64 percent by 2020,[11] making us even more susceptible to supply shortages and rapid rises in world oil prices.

The Middle East holds 65 percent of the world's one trillion barrels of proven oil reserves. Worldwide excess oil production capacity is about 5 million barrels per day, about 90 percent of which belongs to members of the Organization of Petroleum Exporting Countries (OPEC). About 40 percent of the world's total excess production capacity lies in Saudi Arabia alone.[12] Middle East OPEC members supply only about 26 percent of world oil now, but unless we alter our demand, the International Energy Agency projects that their share will grow to 41 percent by 2020.[13] Of the nearly 19 million barrels per day increase in world oil demand now forecast between 2010 and 2020, more than 85 percent will come from Middle East OPEC countries.[14]

While increased oil production from other regions, including the North Sea and Alaska's North Slope, drove the Persian Gulf share down over the past 20 years, many non-OPEC oilfields are past their peak-production levels. In recent years, OPEC has regained its ability to substantially influence the price of oil throughout the world. Despite the temporary softening of oil demand due to the current global economic slowdown, OPEC's market power will only grow as its production approaches half of all world oil output in the next two decades.

Some cite our dependence on foreign oil as a reason for drilling in the Arctic National Wildlife Refuge and other ecologically sensitive places. But we cannot significantly reduce our reliance on imported oil with more domestic production. Domestic crude oil production peaked in 1970 at 9.64 million barrels per day, and has since declined by 40 percent.[15] Even opening the Arctic Refuge to drilling and production would yield only 410,000 barrels per day at its peak production (estimated to be 2027), less than 2 percent of projected annual demand for that year.[16] There simply is not enough new oil recoverable from domestic sources at reasonable cost to influence the world price for oil or to substantially displace imports. The only effective way to reduce dependence on foreign oil is to reduce our oil demand.

Perpetuating Instability We cannot take either the price or the availability of Persian Gulf oil for granted. Our policy in recent decades has been to rely on Saudi Arabia and a handful of other oil-rich states to follow the dictates of economic rationality and keep the oil flowing. This is no longer a safe proposition. "It may not matter, so far as the price of oil is concerned, whether the Saudi regime is friendly to the West, but it certainly matters whether it is rational," according to *The Economist*. "But if a Taliban-like regime were ever to gain control of the Saudi oilfields, could it be relied on to maximise profits in a sensibly self-interested fashion? It might decide to blow up the wells, in pursuit of devout poverty and to punish the West for its corruption."[17]

Our oil dependence also limits our freedom to pursue other goals, including the fight against terrorism. For example, one industry analyst estimates that there is a 20 to 30 percent chance of an oil supply interruption if the U.S. targets terrorist organizations linked to oil-producing nations such as Iraq and Iran. The same analyst sees an 80 percent chance that U.S. oil supplies will be disrupted in the next two years.[18] If world oil production were cut by 3 to 4 million barrels per day, crude oil prices could almost double, given current demand.[19]

Finally, our own oil dependence actually tends to reinforce and perpetuate the instability of oil supplying countries. Our oil demand has given countries such as Saudi Arabia one dominant income source on which they have allowed themselves to become dependent. They have not used their oil wealth to effectively diversify their economies. They have never developed an entrepreneurial class, a strong secular educational system, or democratic political systems. As a result, they have slow rates of economic growth and high unemployment, creating conditions of domestic tension and instability. Their disaffected population becomes a threat to their own stability, and a source of recruits for international terrorism.[20]

Environmental Insecurity

Our oil dependence exacts a heavy toll on the environment. It helps to make the United States the world's largest emitter of carbon dioxide, responsible for one-fourth of the world's total global warming pollution.[21] It causes serious air and water pollution, and it is the source of constant pressure to exploit our last precious wild lands. A program to cut our oil dependence through better vehicles and better fuels would dramatically reduce these environmental depredations.

Global Warming Gasoline, used almost entirely by our inefficient passenger vehicles and light trucks, is the second largest source of U.S. CO_2 emissions, accounting for 1.1 billion metric tons of CO_2 in 2000.[22] That is nearly 20 percent of the national total and is exceeded only by emissions from coal- and natural-gas-burning electric power plants.[23] To put this in global perspective, the emissions directly attributable to our passenger vehicles exceed the *total* national CO_2 emissions of all but three countries.[24] Including all heat-trapping gases and emissions from refineries and infrastructure that produce and transport gasoline, U.S. vehicle-related emissions in 2000 totaled 1.3 billion metric tons of CO_2-equivalent.

Past increases in fuel economy standards slowed the growth in global warming emissions from the car and light-truck fleet. But with fuel economy standards stagnant and the actual fleet average at its lowest point in 20 years, passenger vehicle CO_2 emissions have grown more than 16 percent since 1990.[25] If fuel economy remains stagnant, CO_2-equivalent emissions from passenger vehicles are projected to rise to over 2 billion metric tons by 2020**.**

Better vehicles and fuels that can dramatically lower oil consumption are essential to curbing global warming. The policies recommended in this report–policies that would cut current oil consumption by our passenger-vehicle fleet in half over the next three decades–would also cut the fleet's CO_2 emissions by more than 40 percent from current levels.

Exploitation of Pristine Public Land Our insatiable oil demand creates constant pressure to drill in our remaining unspoiled wilderness areas such as the Arctic Wildlife Refuge, Utah's Redrock Canyon Country, and lands in the vicinity of Yellowstone National Park. Most federal lands with potential oil resources are already available to oil exploration and development. In fact, federal lands already account for 29 percent of U.S. crude oil production.[26] Ninety-five percent of federal public lands in the Rocky Mountain region managed by the Bureau of Land Management are open to exploration and production leasing. Similarly, more than 80 percent of estimated undiscovered, economically recoverable offshore oil resources are open to exploration.

Many once undisturbed rural areas and spectacular wild lands have been effectively industrialized by oil development, their wilderness values destroyed. Oil fields are a dense web of power lines, pipelines, waste pits, roads and processing facilities.

A program to produce better vehicles and fuels would permanently reduce short-sighted pressures to drill in and despoil these irreplaceable natural treasures. The oil savings achievable through the *Oil Security* policies are many times larger than the amount of oil economically recoverable from these special areas. As an example, raising fuel economy standards to 40 mpg by 2012 would save more oil in the next dozen years than the Arctic National Wildlife Refuge is expected to produce in 50 years.[27]

Air pollution Vehicle emissions of conventional air pollutants–especially oxides of nitrogen, hydrocarbons, and fine particles–are the major contributors to smog, soot, and toxic air pollution in metropolitan regions. Gasoline use in vehicles also results in air pollution from "upstream" sources such as refineries and the delivery of gasoline. In the short term, introducing more efficient gasoline vehicles and switching to cleaner fuels would cut upstream air pollution emissions (although not necessarily tailpipe emissions, as these have been decoupled from fuel economy in modern vehicles). A transition to hydrogen-fuel-cell vehicles would reduce both vehicle emissions and gasoline-related upstream emissions to near zero.

As vehicles have become cleaner, total emissions from oil refineries and the distribution system have become an increasingly significant component of total air pollution. "Upstream" gasoline production in 2000 resulted in the release of 848,000 tons of smog-forming chemicals and toxic air pollutants equivalent to 392,000 tons of benzene.[28] If fuel economy does not improve, these emissions could rise by 2020 to as much as 1,320,000 tons and 612,000 tons, respectively.[29]

Oil refineries have a troubled record of compliance with the Clean Air Act and a disproportionate impact on minority communities. Last year the Environmental Protection Agency (EPA) and the Department of Justice (DOJ) found that more than 80 percent of oil refineries were in violation of the Clean Air Act.[30] Fifty-seven refineries have enforcement actions pending against them, including 27 with final findings of violations.[31] Nearly half of the operating refineries are located in minority communities along the 260-mile corridor from Louisiana's Cancer Alley to Houston.[32] Cutting the vehicle fleet's oil consumption would also substantially reduce these emissions.

Oil Spills and Water Pollution Oil spills are an inevitable consequence of shipping oil from distant places, and they pose a constant threat to the land, water, wildlife, and livelihood of coastal communities. The 1989 Exxon Valdez disaster spilled 10.8 million gallons of oil into Alaska's Prince William Sound. Major spills continued to take place throughout the 1990s, including two in 1996 that released 714,000 gallons into Galveston Bay and 820,000 gallons off the coast of Rhode Island.[33] Almost 1.5 million gallons of oil were spilled into U.S. waters in 2000.[34] The oil industry should be phasing in double-hulled tankers much more quickly, and the Coast Guard must do more to implement other safety measures required under the Oil Pollution Act of 1990. But the root cause of our continuing vulnerability to catastrophic spills is our need to transport so much oil. Cutting oil demand through better vehicles and fuels would reduce the need to traffic so much oil across the seas.

Economic Insecurity

Oil dependence also exacts a costly toll on our economy. American consumers spent about $186 billion on gasoline in 2000, and if we continue with business as usual, this is expected to rise to about $260 billion by 2020.[35] Raising fuel economy standards as recommended in this report would cut our gasoline bill by $100 billion in 2020. Even after accounting for higher vehicle costs, using less gasoline would save American car owners an average of $2,200 over the life of their vehicles.[36]

Ever-rising oil imports also affect our trade balance, causing a growing transfer of wealth to oil exporting nations. The United States spent $106 billion on imported crude oil and petroleum products in 2000. This is equivalent to 29 percent of the total U.S. trade deficit, or about $378 per person.[37] By 2020, national spending on imported crude oil and petroleum products is forecast to rise to $160 billion.[38] Over the past 30 years, U.S. consumers have transferred $1.16 trillion of their wealth to oil producing countries.[39] If we continue with business as usual, Americans will transfer trillions more to foreign oil producers over the next three decades. But if we cut our oil consumption as recommended in this report, more of America's wealth will stay in this country.

Without new policies our dependence on imported oil will only continue to grow, restoring more and more market power to OPEC and Persian Gulf countries in particular. OPEC's greater strength will bring increased risks of oil price shocks and supply disruptions. Price shocks reduce economic output, and if large enough, can lead to economic recessions. Each of the three major oil price spikes of the last 30 years (1973-74, 1979-80, 1990-91) was followed by an economic recession in the United States. The cost of U.S. oil dependence, including the economic impacts of price shocks and wealth transfer, has been estimated at $3.4 trillion over the past 30 years. That amount is roughly equal to our interest payments on the national debt over that period.[40]

CHAPTER 2

A FIVE-STEP *OIL SECURITY* PROGRAM TO CUT OIL DEPENDENCE

The United States is not locked into ever-greater oil dependence. We can kick our oil addiction by following a five-step program to use American technology and know-how to produce dramatically better vehicles and fuels:

Step 1 Raise federal fuel economy standards. This is the fastest and cheapest way to reduce both the oil consumption and the global warming emissions of new vehicles powered by conventional gasoline engine technology.

Step 2 Provide tax credits to support the transition to new technology–gasoline-electric hybrids and hydrogen-fuel-cell vehicles–with double and triple the mileage of conventional cars.

Step 3 Boost the use of renewable fuels–especially ethanol made from agricultural wastes and other biomass–by steadily increasing requirements for "renewable content" in gasoline.

Step 4 Bring hydrogen-fuel-cell vehicles and clean sources of hydrogen to full-scale production by a combination of federal financial support and production requirements.

Step 5 Encourage smart growth instead of suburban sprawl to increase our transportation choices and make our communities more livable with less need for driving.

STEP 1: RAISE FUEL ECONOMY STANDARDS

The most important single near-term action Congress can take to reduce our country's oil dependence is to raise federal fuel economy standards. New legislation should ramp up standards for the combined fleet of cars and light trucks in regular steps to 40 mpg by 2012 and 55 mpg in 2020.

Past Fuel Savings Fuel economy standards were highly effective in cutting oil use in the late 1970s and the 1980s. According to last year's report from the National Academy of Sciences (NAS), *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.[41] Fuel economy for new passenger cars nearly doubled, rising from 15.8 mpg in 1975 to a peak of 28.6 in 1988.[42] Fuel economy for new light trucks increased by 50 percent, rising from 13.7 mpg in 1975 to 21.6 mpg in 1987.[43]

The NAS report estimates that in the year 2000 alone, increased fuel economy standards reduced gasoline use by 43 billion gallons, or about 2.8 million barrels of oil per day.[44] A Union of Concerned Scientists (UCS) study, *Drilling in Detroit*, places the fuel savings from CAFE standards even higher–about 60 billion gallons of gasoline, or 3.9 million barrels of oil per day, saving consumers more than $90 billion in 2000.[45]

While total fuel use by passenger vehicles has risen by 30 percent since the CAFE law was passed, the majority of this increase took place after the fuel economy standards plateaued 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.[46]

Along with the oil savings, fuel economy standards have reduced passenger vehicle emissions of CO_2, the principal global warming pollutant, by about one-third. UCS analysis indicates that fuel economy standards reduced global warming gas emissions by 650 million metric tons of CO_2-equivalent, compared to what they would have been in the year 2000 if we were stuck with 1975 fuel-economy levels.[47] In the words of the NAS report: "Because of concerns about CO_2-equivalent emissions and the level of oil imports, it is appropriate for the federal government to ensure fuel-economy levels beyond those expected to result from market forces alone."[48]

Moving to 40 MPG

Technology. Automakers have the technology to raise fuel economy standards for new cars and light trucks combined to 40 mpg by 2012. The NAS report and independent studies by the Union of Concerned Scientists (UCS) and the American Council for an Energy-Efficient Economy (ACEEE) all indicate that cars and light trucks can achieve large additional fuel savings if fuel economy standards are increased again.[49] Cost-effective technologies exist today for near-term and longer-term improvements in vehicle fuel economy.

TREATING SUVS LIKE THE CARS THEY ARE

The *Oil Security* increases in fuel economy would apply to the combined fleet of new cars and light trucks. The current fuel economy law holds SUVs and other light trucks to a lower standard than ordinary cars—20.7 mpg versus 27.5 mpg. This is a hold-over from an earlier time when there was a real difference in how light trucks were used (*e.g.*, as commercial vans and pick-ups) and when light trucks were only a small segment in the market. Over the past 20 years, however, automakers have created SUVs and other vehicles that are regulated more leniently as light trucks but are marketed and used as ordinary passenger vehicles. Light-truck sales now account for half the market and, as a result, the fuel economy of the combined car and light-truck fleet has eroded to its lowest level in 20 years. The National Academy of Sciences report found that "[t]he car/truck distinction has been stretched well beyond the original purpose."*

*National Academy of Sciences, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*, p.6-6.

Engine, drive-train, and other technologies have continued to improve, even though fuel economy standards have been flat for more than a decade. In recent years, however, vehicle makers have chosen to apply these improvements not for better gas mileage, but to increase vehicle power and size. The EPA data indicate that average car and truck 0-to-60 mph acceleration times have decreased by more than 22 percent since 1985, while weight has increased by about 20 percent and horsepower by more than 65 percent.[50] The EPA estimates show that with today's technology, we could have a combined fleet of new cars and trucks that average 27.4 mpg–that's 3.4 mpg higher than today's fleet average–if they had the same weight and 0-to-60 mph acceleration time as 1991 model year vehicles.[51] History is likely to repeat itself if fuel economy standards are not raised, with automakers using future improvements in technology to make even greater increases in size and power, rather than to improve fuel economy.

If fuel economy standards are raised, however, we can use the continuing trend of technological improvements over the next 20 years to stop the growth in oil consumption by passenger vehicles and even turn back the clock to 1990 levels. Consumers would save hundreds of billions of dollars that would have been spent on gasoline, and the impact of our driving on the environment would be cut in half.[52]

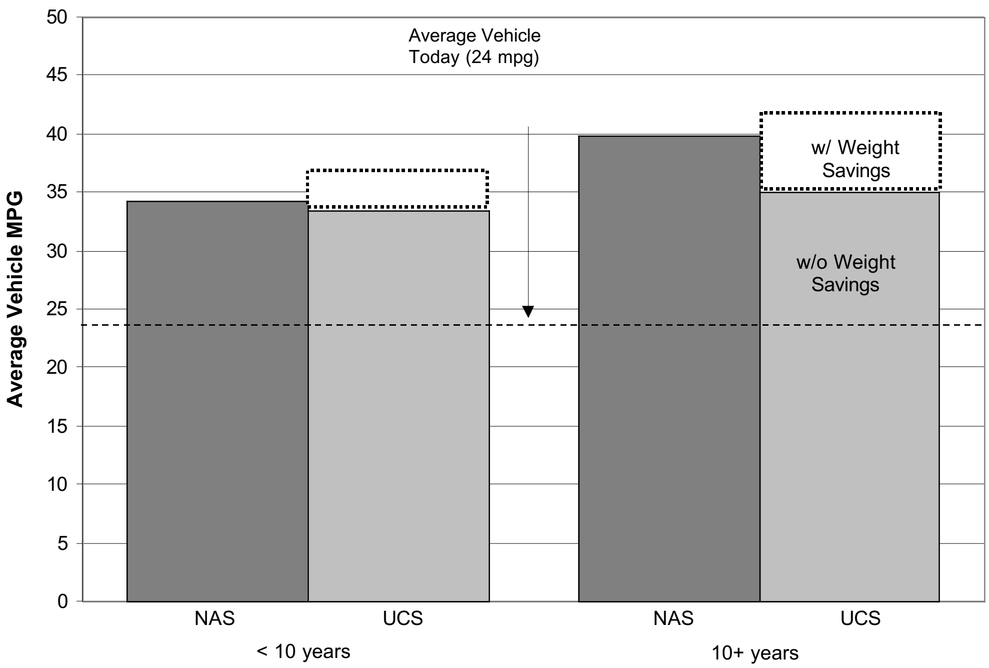
Table 1 provides a short list of conventional technologies that have already been developed by automakers that could significantly increase the fuel economy of today's cars and light trucks, many of which are already in some cars.

Table 1 Existing Conventional Technology Options for Fuel-Economy Improvement

Vehicle Load Reduction	**Integrated Starter Generators**
Aerodynamic Improvements	
Rolling Resistance Improvements	**Improved Transmissions**
Safety Enhancing Mass Reduction	Five- and Six-Speed Automatic Transmissions
Accessory Load Reduction	Five-Speed Motorized Gear Shift Transmissions
Efficient Engines	Optimized Shift Schedules
Variable Valve Control Engines	Continuously Variable Transmissions
Stoichiometric Burn Gasoline Direct Injection Engines	

The American Council for an Energy-Efficient Economy (ACEEE), in one of the most recent reports analyzing fuel-economy potential, packaged together several of these technologies to investigate how far today's cars and trucks could travel on a gallon of gasoline.[53] Computer simulations of ACEEE's moderate scenario indicate that a fleet of the same mix of cars and light trucks that we saw in 2000 could achieve 36 mpg at an average added cost to the consumer of about $1,200–an amount far offset by lifetime

Figure 2. Fleet Fuel Economy Potential



Notes
a. NAS values based on sales-weighted average of individual class fuel economy estimates from NRC. *Effectiveness and Impact of CAFÉ Standards.* July 2001.
b. UCS estimates from Friedman, et al., *Drilling in Detroit*, June 2001.

gasoline savings worth more than $3,000 (see below).[54] The more advanced scenario investigated by ACEEE produced a fleet that averaged 42 mpg, a 75 percent increase above today's car and truck fuel economy for an average cost to consumers of about $1,700–more than offset by $3,900 in lifetime gasoline savings.[55] This more advanced scenario made the most extensive use of the technologies listed above and focused significant weight reduction on the heaviest vehicles in the fleet. In ACEEE's assessment, these technologies could reach full market penetration between 2010 and 2015.

Data presented in NAS's *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* report support similar conclusions regarding the technological potential for fuel-economy improvements using conventional technologies. We took the individual cost and fuel-economy results from NAS report's "Path 3" technologies for each vehicle class and estimated the average fleet-fuel economy and cost using the car and light-truck sales mix for model year 2000.[56] The result is a fleet fuel economy of 33 to 47 mpg at a retail-price increase of about $1,700 to $3,800 per vehicle using the NAS Path 3 technologies. This compares favorably to estimates by ACEEE and UCS that a fleet fuel economy of 36 to 49 mpg can be achieved at retail-price increase of about $1,200 to $3,900.[57]

Figure 2 shows the results of the NAS work for Path 2 and Path 3 technologies as well as comparable UCS and ACEEE analyses presented in *Drilling in Detroit*. The UCS and ACEEE analyses conclude that the 40 mpg standard could be reached in 10 years. The

NAS report, which assumed more constraints on light-truck weight reduction, 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.

The UCS and ACEEE estimates of the available fuel-economy improvement are somewhat higher than those of the NAS panel. Based on a comparison of the analyses, we conclude that the NAS panel underestimated the fuel-economy benefit of some technology combinations because it did not undertake detailed vehicle modeling needed to capture positive synergistic effects between such technologies. Another reason for the difference between the assessments is that the UCS analysis includes some safety-enhancing weight reductions for the light-truck class that enable higher levels of fuel economy to be reached at lower costs.[58] The NAS panel, however, assumed vehicle weight would either increase or stay the same as today, thus missing out on the potential fuel-economy improvements of targeted mass reductions.[59]

None of the results summarized above rely on the use of diesel engines or fuel. Today's diesels need not, and should not, be used to meet increased fuel economy standards. Today's diesel vehicles continue to emit unacceptable levels of cancer-causing soot particles and smog-forming gases. Some automakers point to European acceptance of diesels, but that approach is based on lower air quality standards and is bad for public health. Gasoline engine technology can meet increased fuel economy standards without forcing Americans to accept increases in diesel air pollution.[60]

Oil Savings Raising fuel economy standards in steps to 40 mpg by 2012 would yield a cumulative savings of 125 billion gallons of gasoline by the end of that year. This is about one full year's worth of gasoline at current consumption rates. It also represents 25 times the gasoline savings that would be achieved under the meager fuel-economy provisions of the House energy bill, H.R. 4. In 2012 alone, we would save about 1.9 million barrels of oil per day. In comparison, this is more than we imported from Saudi Arabia last year (1.7 million barrels per day) and more than three times the amount of oil we imported from Iraq.[61]

By the end of 2013, we would have saved a cumulative total of 158 billion gallons of gasoline, or 3.77 billion barrels of oil. In other words, the amount of oil saved in just eleven years of increasing CAFE standards would exceed the amount that U.S. Geological Service estimates to be economically recoverable from the Arctic National Wildlife Refuge over the entire 50-year life of that field at today's oil prices (3.2 billion barrels).[62]

Pollution Reductions By 2012, the annual reduction in global warming gas emissions from cars and light trucks would reach 320 million metric tons of CO_2-equivalent gases. Potentially cancer-causing emissions from cars and trucks could be cut by the equivalent of 93,500 tons of benzene in 2012, while the emissions of nitrogen oxides and hydrocarbons, the key smog-forming pollutants, could be cut by 202,000 tons annually in that same year.

Cost Savings A 40 mpg standard would also save thousands of dollars for individual consumers and billions of dollars across the economy as a whole. In a follow-up report to the ACEEE fuel-economy study, UCS has shown that a fleet of vehicles averaging 36 mpg in ACEEE's moderate scenario would save consumers more than $3,000 on gasoline costs over the life of the vehicle, for a net savings of about $1,900, taking into account the higher initial vehicle cost. Further, an advanced scenario fleet that achieves 42 mpg would save consumers $3,900 on gasoline costs, resulting in a net savings of $2,200. Table 2 summarizes gasoline cost savings and pollution reductions for individual vehicles classes. As a result of these fuel cost savings, the net cost of reducing CO_2 emissions would be minus $54/metric ton.[63] In other words, consumers would save money while reducing our oil dependence and our contribution to global warming.

Table 2 Fuel Economy and Lifetime Savings from Existing Conventional Technologies

	CAFE-Rated Fuel Economy[a,b] (mpg)	Cost of Fuel-Economy Improvement[a]	Lifetime Fuel Cost Savings[c]	Net Savings	Global Warming Gas Reductions (metric tons)
Small Car	48.4	$1,125	$2,595	$ 1,470	27
Family Car	45.8	$1,292	$3,590	$ 2,298	38
Pickup	33.8	$2,291	$3,964	$ 1,673	42
Minivan	41.3	$2,134	$4,534	$ 2,400	48
SUV	40.1	$2,087	$5,346	$ 3,259	56
Fleet Average	**41.8**	**$1,693**	**$3,900**	**$2,207**	**41**

a. Source: DeCicco, An, and 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.
b. CAFE fuel economy reduced by 20 percent to account for the difference between real-world fuel economy and CAFE fuel-economy test results. This shortfall has also been accounted for in the analysis in Chapter 3.
c. Assumes a 15-year, 170,000-mile vehicle lifetime and a 5 percent discount rate. Average life based on scrappage rates from Davis 2000. Vehicle mileage based on 1995 National Personal Transportation Survey data.

The NAS report suggests somewhat higher vehicle costs than UCS and ACEEE to achieve higher levels of fuel economy. But even the data presented in the NAS report show that consumers would reap substantial net savings. Table 3 presents a summary of the data presented in the NAS report for their "average cost, average fuel economy" case for the NAS Path 3 technologies. Also included in the table is a column that lists UCS's analysis of the resulting lifetime consumer savings.[64] Lifetime consumer savings are calculated from NAS data as the difference between the incremental vehicle cost and the net present value of lifetime fuel savings.[65] The table indicates that consumers' fuel savings exceed the cost of the fuel-economy improvements by $360 to $2,500, depending on the vehicle class.

In the last section of the table, UCS has combined the results for each individual vehicle class to calculate a fleet-average fuel economy and net savings. The fuel economy of a fleet made up of the "average fuel economy, average cost" vehicles from the NAS

Table 3 Attributes of NAS Path 3 Case

			Average		
	Base mpg	Base Adj mpg	FE(mpg)	Incremental Cost	Net Savings
Cars					
Subcompact	31.2	30.1	46.13	$2,055	$358
Compact	27.9	27.0	41.94	$2,125	$635
Mid Size	24.9	24.1	41.05	$3,252	$354
Large	21.2	20.5	37.59	$3,655	$1,034
Light Trucks					
Small SUVs	26.0	25.1	43.7	$2,762	$812
Mid SUVs	21.1	20.4	36.22	$3,515	$1,003
Large SUVs	17.7	17.1	32.71	$3,417	$2,497
Small Pick-ups	22.6	21.8	39.98	$3,480	$930
Large Pick-ups	18.1	17.5	32.33	$3,137	$2,407
Mini Van	22.1	21.4	39.41	$3,137	$1,379
Average Car			43.6	$2,308	$454
Average Light Truck			36.1	$3,299	$1,453
All			39.8	$2,765	$ 915

Notes:
a. Source: National Academy of Sciences/National Research Council, *Effectiveness and Impact of CAFE Standards*, July 2001.
b. Results are for the NAS Path 3 “average cost, average fuel economy” scenario.
c. Attributes for average car, average light truck, and “all” are sales-weighted average results based on UCS analysis of current market shares for each class of vehicle.

Path 3 scenario is 39.8 mpg, with an associated incremental retail cost of $2,765 per vehicle. When using a discount rate of 5 percent, the cost of a 40-mpg fleet will more than pay for itself over a vehicle’s life, even netting consumers a savings of nearly $1,000 per vehicle.

These savings can be aggregated through the use of a vehicle-stock turnover model to determine the national impact of ramping up the U.S. passenger car and truck fleet to 40 mpg by 2012.[66] Overall, the U.S. economy would see net savings of $12.6 billion in 2012 alone, based on the individual vehicle cost savings data presented in *Drilling in Detroit*.[67]

These savings would fuel economic growth and the creation of thousands of new jobs across the U.S. economy. Operating on a level playing field of higher fuel economy standards, automakers will offer consumers vehicles that are even more attractive than today’s because they yield a net savings in lower gasoline cost. UCS has estimated that 40,000 new jobs could be created in the auto industry because the incorporation of fuel-saving technologies means that the industry will be making and selling higher value products. In other sectors of the U.S. economy, another 30,000 new jobs could be created as consumers see more money in their pockets and business expenses fall as a result of lower fuel costs.[68]

Stepping Up to 55 MPG

Technology A standard of 55 mpg by 2020 is also 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. Fuel-cell vehicles, discussed later, could take fuel economy even further.

To provide a single reference point, we assess below a fleet that was composed primarily of gasoline-electric hybrid vehicles. (As earlier, this would not include use of diesel engines.) This represents a very practical scenario considering that Honda and Toyota have already introduced hybrids to the U.S. market. Two more hybrids are expected this year–a Honda Civic and a Ford Escape SUV. All other automakers anticipate bringing hybrids to the road within the next few years.

The Toyota Prius is a five-seat compact car rated at 52 mpg in the city and 45 mpg on the highway. The Honda Insight is rated at 61 mpg in the city and 68 mpg on the highway. Honda's hybrid Civic, expected in spring in 2002, will be rated around 50 mpg combined city/highway. These vehicles are unique in that, unlike conventional gasoline-engine vehicles with higher fuel economy, hybrids also have certain performance and convenience benefits inherently associated with the technology. Because they incorporate electric motors, hybrids have better acceleration at low speeds when compared to conventional vehicles. In addition, because hybrids carry their own high voltage electricity source, consumers can have access to more on-board consumer electronics, including those that could operate either in the home or in the car. These features create additional selling points for consumers beyond the fuel-economy benefits.

In *Drilling in Detroit,* UCS concludes that by 2015 automakers will have reached sufficient economies of scale and traveled far enough down the manufacturing learning curve to produce hybrids whose lifetime gasoline savings offset their extra front-end cost. The UCS analysis used ACEEE values for early hybrids and then, starting in 2015, assumed a cost reduction of 6 percent and a further fuel economy increase of 2 to 3 percent.[69] With these future changes, the cost of these hybrid electric vehicles will be more than offset by the lifetime gasoline savings**.**

Sales of hybrids before 2015 would be boosted by the *Oil Security* vehicle tax credits–the CLEAR Act (S.760)–discussed in the next section. Buyers of gasoline-electric hybrids would get a tax credit of $2,000 to $3,500, ensuring that consumers see a financial benefit to purchasing the vehicles, thus driving up hybrids' production volumes and driving down their costs in the long run.

Oil Savings Raising fuel economy standards to 55 mpg by 2020 (building on 40 mpg by 2012) would yield a cumulative savings of almost 590 billion gallons of gasoline by the end of that year. This equals almost five years' consumption of gasoline at current usage rates. It is more than four times the oil recoverable from the Arctic National Wildlife Refuge over its 50 to 60 year lifetime. In 2020 alone, we would save about 4.8 million barrels of oil per day. For comparison, this is almost double the amount of oil we imported from the Persian Gulf last year (2.5 million barrels per day).[70]

Pollution Reductions By 2020, the annual reduction in global warming gas emissions from cars and light trucks would reach 813 million metric tons of CO_2-equivalent gases. Toxic air-pollutant emissions from cars and trucks could be cut by the equivalent of 240,500 tons of benzene in 2012, while the emissions of nitrogen oxides and hydrocarbons, the key smog-forming pollutants, could be cut by up to 519,500 tons annually in that same year.

Cost Savings Fuel economy and cost results from ACEEE are presented in Table 4, along with savings calculations performed in follow-up analysis by UCS. The savings results in Table 4 include the proposed CLEAR Act tax credits for hybrids in their early years. Net savings are projected by 2015 without accounting for tax credits, since we project that gasoline savings would fully cover incremental vehicle costs by then.

Table 4 Fuel Economy and Lifetime Savings from Hybrid Electric Vehicles

	CAFE-Rated Fuel Economy[a] (mpg)	Cost of Fuel-Economy Improvement[b]	Lifetime Fuel Cost Savings[c]	Potential CLEAR ACT Tax Credit	Potential Net Savings (Equivalent Rebate)
Small Car	63.5	$4,331	$3,675	$3,500	$2,844
Family Car	59.3	$5,098	$4,683	$3,500	$3,085
Pickup	44.2	$6,526	$5,494	$3,000	$1,968
Minivan	54.6	$5,818	$5,831	$3,500	$3,513
SUV	53.4	$5,472	$6,711	$3,000	$4,239
Fleet Average	**54.8**	**$5,291**	**$5,147**	**$3,293**	**$3,149**

Notes
a. Source: DeCicco, J., F. An, M. Ross, *Technical Options for Improving the Fuel Economy of US Cars and Light Trucks by 2010–2015,* American Council for an Energy-Efficient Economy, 2001.
b. CAFE fuel economy reduced by 20 percent to account for the difference between real-world fuel economy and CAFE fuel-economy test results. This shortfall has also been accounted for in the analysis in Chapter 3.
c. Assumes a 15-year, 170,000-mile vehicle lifetime. Average life based on scrappage rates from Davis, 2000. Vehicle mileage based on 1995 NPTS data. Based on an average gasoline cost of $1.40 per gallon (AEO 2001).

Better Replacement Tires

In addition to raising fuel economy standards for new vehicles, Congress could take another simple step that would cut overall gasoline consumption by all U.S. vehicles by about 3 percent when fully phased in: require replacement tires to be at least as fuel efficient as original equipment tires.

Automakers equip new cars with low-friction tires to help them meet current fuel economy standards. Most replacement tires now on the market create more drag as they roll than original equipment tires do. Their higher "rolling resistance" increases the car's gas consumption. There are no standards or efficiency labels for replacement tires, and so most consumers unwittingly buy higher-friction, less efficient tires when their originals wear out.

The National Highway Traffic Safety Administration estimates that fuel-efficient tires would cost consumers no more than $5 per tire.[71] Michelin has put that figure at less than $2.50 per tire.[72] Even using the higher figure, the average driver would recoup the additional expense in fuel savings in just one year, and would save an additional $90 over the 40,000-mile life of the tires.

A standard for replacement-tire rolling resistance would improve the fuel economy of vehicles already on the road and prevent the fuel economy of new vehicles from degrading over time. In an earlier study, *A Responsible Energy Policy for the 21st Century,* NRDC determined that better tires by themselves would cut overall gasoline consumption by 3 percent, saving 5 billion barrels of oil over the next 50 years. For comparison, this is 70 percent more than the total amount of economically recoverable oil that is likely available from the Arctic Refuge over that period.[73]

Safety and the 40 and 55 mpg Fleets

Standards of 40 mpg by 2012 and 55 mpg by 2020 can be achieved without sacrificing safety–indeed increasing in overall crash safety–while maintaining the size, performance, and the various features that consumers expect. All of the changes evaluated by the NAS panel in its Path 3 case improve fuel economy while either increasing or maintaining vehicle safety performance compared to today's models. The NAS analysis focused almost exclusively on improved engines and transmissions and reduced aerodynamic drag and tire rolling resistance–changes that have no impact on safety. In addition, the NAS analysis included additional safety equipment, which added weight to seven out of the ten vehicles they analyzed.

Analyses by ACEEE and UCS likewise relied on improved engines and transmissions to achieve higher fuel-economy levels, but also incorporated weight reductions in the heaviest vehicles: SUVs, pickups, minivans, and very large cars. The key to maintaining or improving the safety of these models is in their design–using high-strength, lightweight materials allows vehicles to reduce their weight and retain their size while achieving enhanced crash management performance. Using better design and engineering to reduce the weight, but not size, and to improve crash resistance, holds the greatest potential for saving lives while improving fuel economy.

While automakers often claim otherwise, heavier vehicles do not inherently mean safer highways. The NAS report found that reducing the weight of the heaviest vehicles in the fleet would actually improve overall safety on our roads by reducing the extreme damage that currently occurs when the heaviest vehicles collide with lighter ones.[74] The heaviest vehicles (especially those with high-mounted, rigid chassis) pose a greater risk to occupants of ordinary cars, as well as to motorcyclists, bicyclists, and pedestrians. With the boom in SUV sales, the weight disparity between vehicles has increased, undermining overall safety, not improving it. The NAS panel concluded that if the weight of larger vehicles were reduced: "Larger vehicles would then be less damaging (aggressive) in crashes with all other vehicles and thus pose less risk to other drivers on the road."[75]

STEP 2: PROVIDE TAX CREDITS FOR ADVANCED-TECHNOLOGY VEHICLES

Tax credits to support the transition to new technology–gasoline-electric hybrids and hydrogen-fuel-cell vehicles–are an important complement to raising fuel economy standards. All major automobile manufacturers are conducting research and development on advanced-technology vehicles. Two gasoline-electric hybrid models are already on the market in the United States, with several additional models planned for the near future. While still representing well under 1 percent of the new vehicle market, sales of the current two hybrid models are exceeding manufacturers' initial expectations.

Congress should provide tax credits to help accelerate the ramp up of these critical new technologies–gasoline-electric hybrids and hydrogen-fuel-cell vehicles–from small-scale production to true mass production.

Tax credits should also be provided to support development of a hydrogen fueling infrastructure (see Step 4).

Providing tax incentives to consumers for a limited period of time for buying or leasing these new vehicle technologies will help offset the higher costs associated with initial production. As they gain market share and production volumes increase, the cost differential between these vehicles and conventional vehicles will be reduced or eliminated.

Pass the CLEAR Act

Senators Orrin Hatch (R-Utah) and John Rockefeller (D-W. Virginia) have introduced legislation to accomplish this goal. Called the Clean Efficient Automobiles Resulting From Advanced Car Technologies (CLEAR) Act (S.760), the bill would provide tax credits to purchasers of advanced-technology vehicles based on a sliding scale linked to the vehicles' performance in reducing oil consumption and air pollution. The CLEAR Act includes these incentives:

Hybrid Vehicle Incentives Gasoline-electric hybrids use electronic controls to integrate an electric drive with an internal combustion engine. The bill would provide a credit of up to $1,000 based on the fraction of the vehicle's maximum available power that comes from the electric motor. This "technology" portion of the tax credit starts at $250 for a hybrid that can get at least 5 percent of its maximum power from the electric motor and increases to $1000 for a hybrid that can get at least 30 percent of its maximum power from its electric motor.

An additional "performance" credit is provided ranging from $500, for a vehicle that is 25 percent more fuel efficient than the average vehicle in its class, to $3000, for a vehicle that is at least 2.5 times as fuel efficient as its class average.

Thus a "mild hybrid" car in the 2500 pound weight class that gets 5 percent of its maximum power from electric drive and has a fuel economy of 38.4 miles per gallon (compared to a class average of 30.7) would receive a total tax credit of $750. A more fully hybridized car of the same size that gets 30 percent of its maximum power from electric drive and achieves a fuel economy of 62 mpg (twice the fuel economy of its class) would get a tax credit of $3000.

To be eligible for the credit, hybrid vehicles must meet or beat the average emission standards for smog-forming pollutants applicable to new passenger cars. The credit would be available for 6 years to accelerate consumer demand as these vehicles become available in the market and set the stage for sustainable growth in production volumes.

Fuel-cell Vehicle Incentives Hydrogen fuel cells are the most promising long-term technology, using no oil and potentially producing zero or near-zero CO_2 emissions. The CLEAR bill would provide a base credit of $4,000 for all fuel cell powered light-duty vehicles. An additional performance credit is provided, ranging from $1000 for a vehicle that is 50 percent more efficient (measured as energy use per mile) than the average vehicle in its class, up to $4,000 for a vehicle that is three times as efficient as its class average. The credit would be available for 10 years to accelerate market introduction of this technology. Low volume production is expected to begin in the 2005 to 2007 timeframe.

Alternative Fuel Incentives A key hurdle to overcome in commercializing hydrogen-fuel-cell vehicles is establishing a fueling infrastructure. For nearly a century, fuel providers have invested heavily in a system to distribute gasoline and diesel. To encourage the installation of distribution points for hydrogen and other alternative fuels, retail distributors would earn a credit of $0.50 for every gasoline-gallon-equivalent of alternative fuel sold.[76] The credit would be available for six years and would support the distribution of these fuels as vehicle volume grows.[77]

The bill extends for 10 years an existing $100,000 tax deduction for the costs of alternative-fuel sites that are available to the public. A new credit that runs up to $30,000 is included for actual costs of constructing such facilities.

Broad Support The CLEAR Act has the support of a broad set of groups, including some automobile manufacturers, environmental organizations, and members of the alternative fuel industry. Ford Motor Company, Honda, and Toyota are among the key automotive industry supporters. Environmental supporters include NRDC and UCS as well as Environmental Defense and the American Council for an Energy-Efficient Economy. Supporters from the alternative-fuel industry include the Natural Gas Vehicle Coalition, the Propane Vehicle Council, the American Methanol Institute, and the Electric Vehicle Association of the Americas. Both the Bush and the Clinton administrations have also supported the concept of tax credits for advanced-technology vehicles.

Unfortunately, other automakers have sought to water down the legislation to give tax credits to buyers of vehicle designs that would not achieve nearly as much efficiency improvement or pollution reduction. As part of the House energy bill (H.R.4), they succeeded in distorting the incentives for hybrid vehicles by giving excessive credit for minor improvements to the most gas-guzzling SUVs and by deleting the requirement that qualifying vehicles achieve low emissions of smog-forming pollutants. Senators Hatch and Rockefeller and other sponsors of the legislation have thus far refused to go along with these changes and are pushing to include the original CLEAR Act in any comprehensive energy legislation considered by the Senate. The legislation will continue to have broad support only if the strong performance requirements of the original proposal are retained.

STEP 3: MOVE BEYOND OIL-BASED FUEL: BIOMASS ETHANOL

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. No matter how fuel efficient our vehicles become, we can do more to reduce their dependence on oil. An effective oil replacement and oil security program for the future should include requirements for an increasing share of total transportation fuel to be made in an environmentally responsible manner from energy resources other than oil. The two most promising fuels that meet these criteria are biomass ethanol and hydrogen. (Hydrogen is discussed in the next section, on fuel-cell vehicles.)

More than 1.6 billion gallons of fuel ethanol were used in the United States in 2000, mostly in the form of gasohol (90 percent gasoline, 10 percent ethanol). Almost all the ethanol currently produced in the United Sates is made from corn, but new technology breakthroughs have opened the door to efficiently making ethanol from agricultural wastes and other biomass sources that have been untapped until now. This new biomass-ethanol technology promises large oil savings and reductions in global warming pollution, and a new income stream for farmers. Congress should take two steps to speed biomass ethanol's entry into the market:

- Jump start biomass-ethanol production by offering matching grants for construction of the first five innovative biomass-ethanol plants by 2005
- Ramp up the "renewable content" of gasoline by adopting–and expanding–the renewable fuels provisions proposed by Senator Daschle in S.1766

Jump Starting Biomass-Ethanol Production

Congress should provide matching grants of up to 50 percent of construction costs for the first five commercial-scale facilities that produce biomass ethanol from agricultural wastes and other waste materials using new technological breakthroughs developed in federal research laboratories. Biomass ethanol produced with this new technology would generate far greater oil savings and environmental benefits than those currently offered by ethanol produced from corn.[78] Raw materials for biomass ethanol (e.g., corn stalks, rice hulls, portions of municipal solid waste streams) are also much cheaper than corn.

At the heart of this new technology, developed over the last decade at the National Renewable Energy Laboratory and elsewhere, are enzymes that can break down cellulose and hemicellulose into sugars, as well as yeasts and bacteria that can ferment five-carbon and six-carbon sugars in the same vessel. These advances now make it possible to turn biomass into ethanol fuel without adding expensive stages to the processing facility.

Biomass-ethanol production is now on the verge of full-scale commercialization. Several companies are attempting to develop this technology commercially.[79] The economics of the technology look quite promising. A study conducted for the California Energy Commission concluded that the state would see returns of $1 billion if it invested $500 million to help establish a 200-million-gallon per-year biomass-ethanol industry by 2010.[80] Yet private investment thus far has been held back by perceptions of the remaining technological and market risks. Federal and state support for early commercial applications of biomass-ethanol technology would play a key role in overcoming the technological and market risks that have made private investors reluctant to finance these innovative projects.

Federal matching grants to build the first five biomass-ethanol refineries would help overcome these perceived market risks and jump-start commercial-scale production using this new technology. A forecast by the Energy Information Administration indicates that biomass could become the primary feedstock for ethanol production by 2020. The Energy Information Administration (EIA) projects that with successful commercialization of advanced biomass-to-ethanol technology, and with a continuation of current policies (including the existing federal tax exemption for ethanol worth 54-cents per gallon), biomass-ethanol production would reach 2.8 billion gallons by 2020 out of a total ethanol market of about 3.5 billion gallons.[81] This would reduce oil consumption by a further 56 million barrels per year, above and beyond the oil savings from higher fuel economy standards.

Ramping Up "Renewable Content"

Oil savings from biomass-ethanol production could be raised substantially by 2020 with additional policy support. Congress should start by enacting the renewable fuels provisions of S.1766, the comprehensive energy bill introduced by Senator Daschle. This bill would require motor fuel to contain an increasing percentage of renewable fuel–principally ethanol–as the troubled fuel additive MTBE is replaced (MTBE has effectively reduced air pollution but unfortunately, it also contaminates groundwater).[82] The bill would culminate in production and use of 5 billion gallons of renewable fuel by 2012.

Recognizing its environmental advantages, the bill would treat each gallon of biomass ethanol as equivalent to 1.5 gallons of corn ethanol for purposes of meeting its "renewable content" requirement. Given this added incentive for biomass-ethanol production, it is reasonable to assume that one-third of the ethanol produced to meet the bill's targets would be made from biomass feedstocks rather than corn.

Even more oil could be saved if energy legislation continued to ramp up the use of fuels made from renewable and other non-oil resources after 2012. In order to give all such fuels (including hydrogen) an equal footing, the measuring stick after 2012 might best be structured in terms of annual reductions in the full-fuel-cycle emissions of CO_2 from motor fuel. By 2012, the renewable fuels component of S.1766 would have achieved a full-fuel-cycle CO_2 reduction of approximately 1 percent per gasoline-gallon-equivalent of fuel supplied.[83] The required reduction should then rise by .5 percent per year, reaching 5 percent by 2020.

While a range of renewable, non-oil fuels could be used to meet this requirement, it could be met by producing 10 billion gallons of biomass ethanol in 2020. Scaling up biomass-ethanol production to this volume could be accomplished by using a combination of agricultural residues, municipal solid waste and dedicated energy crops (switchgrass), according to Oak Ridge National Laboratory.[84] Most of this ethanol would likely still be used in the form of gasohol, which does not require any changes in vehicles or fueling stations. Some of the ethanol may also be distributed through pumps dispensing E85 (85 percent ethanol, 15 percent gasoline), which can be used in "flexible fuel" vehicles equipped with inexpensive fuel sensors that adjust for the difference in combustion characteristics between gasoline and ethanol.

Beyond 2020 the pace of reducing oil consumption and CO_2 emissions would accelerate, primarily due to rapid increases in the market share of hydrogen-fuel-cell vehicles.[85] Additional biomass supplies would likely be used to produce hydrogen for these vehicles, probably by integrating hydrogen production capabilities into "biorefineries" capable of producing ethanol, hydrogen, and electricity in varying quantities in response to market conditions (see next section).

STEP 4: FORGE AN OIL-FREE FUTURE: HYDROGEN-FUEL CELLS

Hydrogen-powered fuel cells are the ideal vehicle powerplant technology. They use no oil at all and promise near-zero emissions of pollutants that cause smog and global warming. A fully optimized hydrogen-powered fuel cell would likely use two-thirds less energy than today's average car–none of it coming from oil–equivalent to the efficiency of a car getting about 80 miles per gallon of gasoline.[86]

Fuel cells were first developed for the Apollo spacecraft that fulfilled President Kennedy's 10-year mission to put men on the moon. Now we need to mobilize American know-how to put hydrogen-fuel cells into millions of cars and SUVs.

In January 2002 the Department of Energy announced a new hydrogen-fuel-cell program, called Freedom Car, in cooperation with U.S. automakers.[87] But Freedom Car calls only for more research and development spending. As presently structured, the automakers would receive billions of dollars in federal research funding over the next decade without committing to place a single fuel-cell vehicle on the market. Another R&D program, by itself, will not save any oil.

A real program to harness the power of American industry to launch hydrogen-fuel cells requires a coordinated schedule of requirements and incentives for automakers and fuel providers to bring fuel-cell vehicles and hydrogen fuel to full-scale production before the end of this decade. Specifically, Congress should:

- Set production schedules for ramping up to at least 100,000 hydrogen-fuel-cell vehicles by 2010, and 2.5 million by 2020, along with targets for hydrogen-fueling stations to serve them.
- Provide tax credits to vehicle buyers and fuel providers to "buy down" the initially higher cost of the fuel-cell vehicles and the hydrogen-fueling infrastructure.
- Continue federal support for hydrogen-fuel-cell R&D focused on further improving technology for on-board hydrogen storage and for clean hydrogen production.

Bringing Fuel Cells Out of the Lab and Onto the Road

With the economies of scale of high-volume production and with an adequate fueling infrastructure, fuel-cell vehicles could be competitive with gasoline models in terms of

How Does a Fuel Cell Work?

A fuel cell is a device that produces electricity without combustion, directly from the reaction of hydrogen and oxygen. The electrochemical reaction begins when hydrogen enters one side of the fuel cell, where it is separated into an electron and a proton ion. The ions move through a membrane (called a proton exchange membrane) to combine with oxygen on the other side, making water. The electrons, which cannot pass through the membrane, leave the fuel cell as electric current, powering the vehicle's electric motor. The motor drives the wheels of the car.

Source: Union of Concerned Scientists, "Fact Sheet: How a Fuel Cell Powers a Car," www.ucsusa.org.

cost and performance. Now we need a national-scale effort to put fuel cells on the road within this decade. This program has three key components.

First, Congress should require automakers and fuel providers to bring fuel-cell vehicles and hydrogen fuel to the market on a coordinated schedule. Second, to support these efforts, Congress should provide tax incentives to help both industries meet their marketing targets. Third, Congress should continue to support enhanced federal R&D to accelerate development of on-board hydrogen storage technology and to promote larger-scale facilities for clean hydrogen production.

Producing Fuel-Cell Vehicles Federal law should direct automakers to begin producing and selling at least 20,000 hydrogen-fuel-cell vehicles (or any other vehicle technology that saves as much oil) in 2006. By 2010, automakers should be required to make and sell at least 100,000 such vehicles. This number should increase in regular intervals to at least 600,000 vehicles by 2015 and to at least 2.5 million vehicles by 2020. These numbers translate into about 0.6 percent of current passenger vehicle sales in 2010, rising to about 15 percent in 2020.[88] The applicable number of vehicles for each manufacturer would be determined as a percentage of its sales of cars and light trucks.[89]

The sale of these vehicles should be targeted to specific regions of the country in the initial years, in order to coordinate with requirements to provide hydrogen fueling stations. California is already paving the way with its emission standards and a government-industry partnership to promote the entry of fuel cells into the market.[90] The first vehicles could be concentrated in centrally refueled fleets, allowing a launch of fuel cells in a controlled environment where one fueling station can serve large numbers of vehicles. Marketing of fuel-cell vehicles to individual purchasers could be concentrated at first in several regional markets, such as the Los Angeles area and other densely populated regions with severe smog and soot air pollution problems. Focusing fuel-cell sales in this way would facilitate development of the new fuel infrastructure.

Providing Hydrogen Fuel At the same time, federal law should assure that fuel providers create an adequate number of hydrogen-refueling stations in areas targeted for fuel-cell sales. Oil companies should be required to offer hydrogen fueling capability at an increasing percentage of their existing gasoline stations in those regions–the required percentage should rise in regular steps to 10 percent.[91] Initial government and private sector efforts could be focused on regions that are preparing for early entry into the

FILL'ER UP WITH HYDROGEN

An early choice must be made whether fuel-cell vehicles should be fueled directly with hydrogen or with some other fuel–methanol or gasoline–that is converted to hydrogen on-board the vehicle.

Moving directly to hydrogen is the quickest, cleanest, and most secure route to a market launch of fuel cells this decade. Using gasoline would create more smog, toxic emissions, and CO_2 pollution, erasing much of the environmental benefit of the fuel-cell path. Methanol's emissions are somewhat better than gasoline, but not as good as hydrogen.

While hydrogen requires a new fuel infrastructure, this will be cheaper than the complex and expensive "reformers" needed on-board each vehicle to convert methanol or gasoline to hydrogen–an estimated added cost for gasoline of $1,600-$4,500 per vehicle, far more than the cost of hydrogen infrastructure (estimated at less than $800 per vehicle).[1] Perfecting on-board reformer technology (akin to putting a mini-refinery under a car's hood) also could delay fuel cells by a decade.

Using gasoline or methanol would perpetuate our reliance on foreign energy supplies. Gasoline, of course, would prolong our dependence on oil imports. Methanol would likely be produced abroad from remote sources of natural gas and then imported. In contrast, hydrogen can be produced directly from a variety of secure domestic resources. (See discussion on hydrogen production options.)

market. Providing hydrogen in other areas would be required once fuel-cell-vehicle sales in such areas reached designated levels. Legislation should encourage partnerships to coordinate marketing steps during the early phases of introducing fuel-cell vehicles, so that automakers could gain greater certainty that fuel suppliers will provide adequate hydrogen infrastructure, and vice versa.

The infrastructure investments needed to supply hydrogen are significant, but modest in comparison to the value of fuels and vehicles. With adequate planning and policy support, fueling infrastructure will not be an obstacle to the *Oil Security* path.

Initially, hydrogen would probably be produced in small, decentralized facilities using small-scale steam reformers to extract hydrogen from natural gas. As the on-road fuel-cell fleet grows, the primary fuel source would shift from natural gas toward other resources. Renewable sources of hydrogen are likely to become cost-effective by 2020, starting with biomass-derived hydrogen and eventually electrolysis from renewably-generated electricity. Biomass-derived hydrogen could be co-produced in biomass-ethanol plants. Once hydrogen sales reach the volume to support larger-scale, centralized production, facilities might become more economical, in which case an extensive delivery infrastructure will be needed, similar to the existing network of natural gas pipelines. To take advantage of economies of scale, much of this new infrastructure could likely be located in or near existing oil refineries and use portions of existing infrastructure (e.g., existing pipeline rights-of-way). (See below for more on hydrogen production options.)

Tax Incentives to Spur Investments Congress should also provide tax incentives to support introduction of both fuel-cell vehicles and hydrogen-fueling infrastructure during the initial years of the program. Tax incentives for fuel cells and hydrogen fueling are contained in S.760 (the CLEAR Act), discussed earlier in this chapter. The CLEAR Act would provide:

- A federal income tax credit for purchasers of hydrogen-fuel-cell vehicles, ranging from $4,000 to $8,000, depending on the vehicle's fuel efficiency
- A 10-year extension of an existing $100,000 tax deduction available to alternative fuels retail distributors , plus a credit of up to $30,000 for actual costs of installing alternative fuel sites available to the public
- A 6-year tax credit for retail distributors of alternative fuels equal to $0.50 for every gallon of gasoline-equivalent sold.

Targeted R&D The final element of a serious federal program is to continue targeted federal R&D support for key technologies to reduce the cost and improve the performance of hydrogen fuel vehicles, especially on-board hydrogen storage technologies.[92] Federal R&D programs to support gasoline fuel-cell strategies should be eliminated or significantly reduced.

Hydrogen Production Options

Hydrogen can be produced from a variety of non-oil energy resources, ranging from solar power to coal. Hydrogen is currently made primarily by steam-reforming natural gas and this is likely to be the initial source of hydrogen for fuel-cell vehicles. As demand increases, other options for making hydrogen will be developed that could be economically competitive and environmentally acceptable. These include steam-reforming biomass; electrolysis (splitting water) using electricity generated by wind turbines or solar cells; and possibly steam reforming coal with carbon dioxide sequestration. Each of these processes is described briefly in the following sections.

Hydrogen from Natural Gas The technology for producing hydrogen from natural gas is well developed and quite efficient. First the fuel (mostly CH_4 in the case of natural gas) is partially burned (partially oxidized), producing hydrogen (H_2) and carbon monoxide (CO). Second, the carbon monoxide reacts with steam (H_2O) to produce carbon dioxide (CO_2) and more hydrogen. The result is carbon dioxide and hydrogen, including both the original hydrogen from the fuel and additional hydrogen from water. (The net yield from the reaction is $CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$.) The overall efficiency of this process can be as high as 80 percent, meaning that 1.25 million Btus of natural gas are needed to produce 1 million Btus of hydrogen fuel. Currently about 1 trillion cubic feet of natural gas are steam reformed annually to produce hydrogen for use in chemical plants and oil refineries. Steam-reforming natural gas is likely to remain the primary source of hydrogen for fuel-cell vehicles at least until total hydrogen demand increases substantially.

A fuel-cell vehicle running on hydrogen produced from natural gas offers huge benefits compared with a conventional gasoline vehicle. The oil security benefit is clear: oil use is totally eliminated. Smog-forming tailpipe emissions are also eliminated. Even if the CO_2 produced in making the fuel is emitted to the atmosphere, overall global warming pollution per mile traveled is reduced by 40 to 60 percent compared with a conventional gasoline-powered vehicle.[93]

Hydrogen from Biomass Hydrogen can be produced from biomass derived from crop wastes or dedicated energy crops grown on previously cultivated marginal agricultural lands. As discussed earlier, advances in biochemistry are making it possible to produce ethanol from cellulosic materials. Another portion of the biomass (known as lignen), however, resists biological processing. Lignen and other byproducts of ethanol production are typically burned on site to produce process heat and electricity. It is also possible to gasify these materials and then produce hydrogen through steam reforming, as described above for natural gas.

Producing hydrogen from biomass yields much lower full-fuel-cycle CO_2 emissions than producing it from natural gas. The only emissions would be associated with any fertilizers and oil-based tractor fuel used to grow the crops and any oil-based fuel used to transport the material to the processing plant. There is even the potential for net carbon uptake (sequestration) if areas are reforested to supply the biomass on a sustainable basis, or if the CO_2 produced by steam reforming is disposed of geologically (see below). Hydrogen produced from dedicated biomass energy crops is expected to be about one-third more expensive to produce than hydrogen from natural gas with carbon dioxide disposal to achieve equivalent emissions.[94] The economics of using biomass are likely to be improved by designing flexible "biorefineries" capable of converting a wide range of biological feedstocks into a variable mixture of products, including ethanol, electricity, and hydrogen.

Hydrogen from Wind and Solar Renewable energy critics sometimes quip that you can't run your car with wind or solar power. In fact you can. It is without question technically feasible to produce all the hydrogen needed to supply our transportation system by splitting water using electricity generated with renewable energy sources, such as wind and solar. Feeding direct current through water yields hydrogen gas at the negative terminal and oxygen at the positive terminal. This process, known as electrolysis, can be applied at scales ranging from a desktop to a refinery. It offers the promise of a renewable and virtually zero-emissions fuel cycle to power our mobility.

The cost of producing hydrogen through electrolysis is determined by the cost of electricity and the capital cost of the electrolysis equipment (known as the electrolyzer).[95] Cost-effective electrolytic hydrogen production facilities might take advantage of off-peak electricity from large wind farms. Lowering the costs and improving the performance of electrolyzers should be a high priority for federal R&D.

Hydrogen from Coal? Traditional methods of burning coal to produce electricity are responsible for our most pressing environmental problems, ranging from deadly inhalable fine particles to the devastating threat of global warming. Coal has a future only if we can find ways to use it that are genuinely clean. That means employing fundamentally new technologies capable of dramatically reducing emissions of all the major pollutants traditionally associated with coal combustion, including CO_2. Hydrogen production offers that possibility, due to an interesting convergence of interests in the transportation and electricity sectors.

The key to coal's future, if there is one, is gasification technology. A promising new technology for generating electricity from coal, called Integrated Gasification Combined Cycle (IGCC) has recently been demonstrated commercially. Building on highly efficient natural-gas combined-cycle power plants, IGCC units operate by partially oxidizing coal to produce a gaseous mixture of hydrogen and carbon monoxide that is then burned in a gas turbine to produce electricity. Waste heat from the gas turbine is recovered to generate more electricity in a steam turbine to boost efficiency (hence the term "combined cycle").

Once coal has been gasified, it is also possible to steam reform the coal-derived mixture of hydrogen and carbon monoxide to generate more hydrogen and carbon dioxide. Because coal is cheaper than other fuels with equivalent energy content, this approach could be a very cost-effective way to produce hydrogen.[96]

It will be essential, however, to find a sound way to dispose of the CO_2 if hydrogen production from coal is to be environmentally acceptable. Of the options proposed to date, geologic disposal appears to be the most economically and environmentally viable.[97] (In contrast, deep ocean disposal poses serious ecological risks, and over time ocean circulation would bring some of the injected CO_2 back to the atmosphere.) CO_2 can be injected into active oil and gas reservoirs to enhance oil recovery. More than 20 million metric tons per year of CO_2 already are used for this purpose in the United States, producing about 0.2 million barrels of oil per day.

Unfortunately, most of this CO_2 comes not from existing factories and power plants, but instead is pumped from natural CO_2 deposits. Incentives to switch to CO_2 from fuel burning could be provided by placing a cap on power plant emissions, as proposed by the Clean Power Act (S.556), sponsored by Senators Jeffords and Leiberman. Tax credits for injecting CO_2 derived from power plants could enhance domestic oil production and reduce global warming pollution at the same time.

Significant additional disposal capacity will be available in depleted oil and gas fields where enhanced oil recovery is not viable. Over the longer term, deep saline formations potentially could hold billions of tons of CO_2 in the United States.[98]

For all these options, it will be essential to demonstrate that injected CO_2 can be successfully bottled up over very long periods, and to conduct long-term monitoring for leakage. Limits on CO_2 emissions will remain essential to ensure that the atmosphere is not used as the dumping ground.

STEP 5: PROMOTE SMART GROWTH AND TRANSPORTATION CHOICES

Pursuing smart growth as an alternative to more suburban sprawl and expanding Americans' transportation options are further ways to save oil. Sprawl is one of the reasons for the rapid rate of increase in our gasoline consumption over the past two decades. As metropolitan areas have spread out helter-skelter, most Americans find themselves driving ever longer distances in steadily worsening traffic congestion, while watching farms and forests disappear underneath new strip malls. With homes, workplaces, schools, and stores located far apart, Americans have little choice but to drive.

Public frustration with this state of affairs has given rise to the smart growth movement–a demand for planning more thoughtfully where new roads and new development should be located, for saving open space, and for reviving older communities. Tired of road congestion, more Americans are taking to public transit than ever before, and they are demanding better transportation options. Innovation at the community level is chronicled in NRDC's recent book, *Solving Sprawl*.[99]

Federal strategies to support smart growth and better transportation choices save oil by reducing the total amount we drive. Congress took initial steps in the last two rounds of transportation legislation, but much more can be done.[100] To achieve greater oil savings and pollution reductions, the federal government should take these additional steps:

- Congress should give public transit commuters tax benefits equivalent to workplace parking space subsidies that drivers now enjoy.
- Congress should adopt "pay-as-you-drive insurance" legislation to make a portion of automobile insurance costs depend on how much you drive.
- Fannie Mae should aggressively promote a new "location efficient" mortgage lending policy that rewards building and buying homes located near public transit.
- Congress should increase support for smart-growth strategies and public transit investments in the next round of transportation legislation.

Equal Treatment for All Commuters

Congress should pass the Commuter Benefits Equity Act (H.R. 318). This act would equalize tax benefits for public transportation users to the same level now enjoyed by drivers, who benefit from free parking spaces. This bill would raise the tax-free fringe benefit that employers may offer their transit-riding and car-pooling workers from $100 per month to $175 per month, the same benefit currently available for parking. By providing parity between commuting choices, the bill would encourage many employees to shift away from driving alone to transit or car-pooling alternatives. The impact on travel could be significant: a study in Minneapolis-St. Paul found that more than one in ten employees shifted from driving to using some other way of commuting when offered tax-free commuter benefits equal to those provided in the form of free parking.[101]

Pay-as-You-Drive Insurance

Automobile insurance costs about as much as gasoline for most drivers, but insurance costs are currently paid in a lump sum. Pay-as-you-drive insurance would change this by collecting part of one's auto insurance at the pump, as an add-on to each gallon purchased. This reflects the fact that accident risk depends, in part, on how many miles a car is driven.[102] One study has estimated that if only one-quarter of insurance premiums were collected this way, the gasoline surcharge would be 25 to 50 cents per gallon.[103]

The Texas Department of Insurance has just proposed new rules to create a pay-as-you-drive option for drivers in that state, and Progressive Auto Insurance has already run a pilot pay-as-you-drive program, with positive results.[104] Congress should enact legislation to adopt this system nationwide.

The oil savings and environmental benefits from pay-as-you-drive insurance come from the reduction in driving induced by carrying some insurance costs in the price paid at the pump.

Although the total cost of driving would not change for the average driver, this reform would benefit motorists in two ways. First, the costs of insurance would go down for low mileage drivers, reflecting the fact that they cannot cause an automobile accident when they are not driving. Second, the problem of uninsured drivers would be reduced because some insurance payments would be automatically collected from all drivers–whether they carry a proper policy or not) at the gas pump.

Location Efficient Mortgages[sm]

Another incentive for smart growth is the Location Efficient Mortgage[sm] developed by NRDC and others. The concept is simple: homes located near public transportation and in areas of greater density allow families to get where they need to go to work, schools, and stores–with less driving and lower transportation costs. Families that need to spend less on transportation can put more money toward a mortgage. As a result, mortgage lending rules should give more favorable lending terms to families buying these homes, by qualifying them to carry bigger mortgages.

The cost of transportation is not incidental. Nineteen cents out of every dollar of median household spending goes toward transportation.[105] For many families, owning and maintaining an automobile is more costly than using public transportation. Commuting to work using public transportation typically costs $189 to $2,077 per year depending on fares, surcharges, and discounts.[106] Owning a private vehicle costs $4,826 to $9,685 per year, depending on the size of the car and mileage driven.[107]

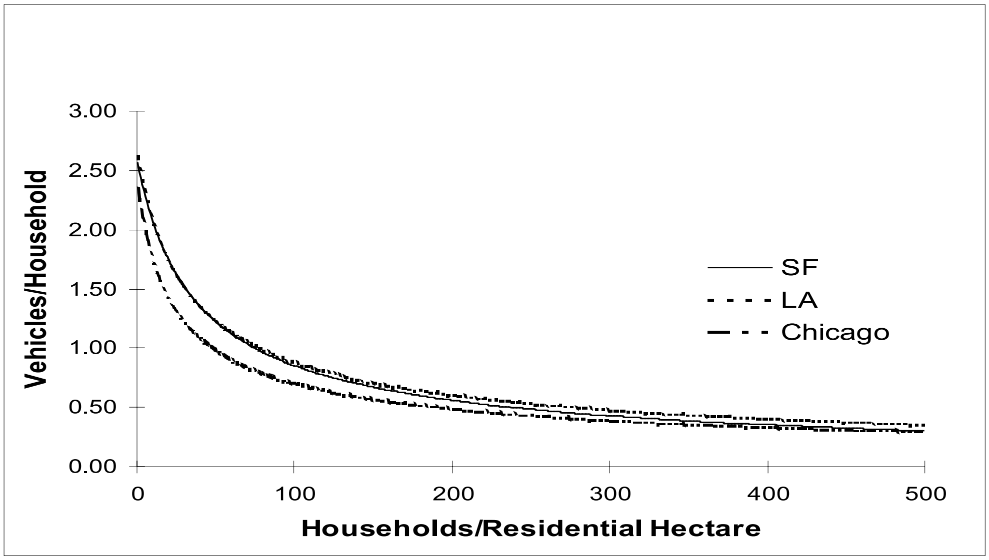
In areas with smart-growth characteristics such as the efficient use of land, families find it less necessary to drive, and automobile ownership levels are lower (see Figure 3).[108] Similarly, the EPA has found in recent studies that "infill" development and redevelopment of older suburbs would reduce vehicle miles traveled (VMT) per capita by about 15 to 60 percent (depending on the metropolitan area studied) compared to typical sprawl development.[109]

Because of its role in setting home-mortgage lending policies and practices, Fannie Mae has a critical opportunity to help location efficient mortgages take off as a financing tool. Currently the location efficient mortgage is a stand-alone product, competing with the dozens of other mortgage concepts promoted by Fannie Mae. Instead, Fannie Mae should build in location efficiency as a feature of all of its existing loan products. These actions by the nation's mortgage giant would go a long way to popularize the concept of location efficiency with bankers, builders, and home-buyers.

The Next Round of Transportation Legislation

With the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, Congress took a first step away from straight "highway bills." The latest federal

Figure 3 Auto Ownership vs. Residential Density



transportation legislation, the Transportation Equity Act for the 21st Century (TEA-21) was passed in 1998 and is due for reauthorization in 2003. Both the Senate Environment and Public Works Committee and the House Transportation and Infrastructure Committee are planning hearings on the next transportation bill.

New transportation legislation must build on the smart-growth promises of ISTEA and TEA-21. A larger share of funding is needed for public transportation improvements, and initiatives such as the Transportation Enhancements, Congestion Mitigation Air Quality Improvement, and Surface Transportation Programs need to be reformed and reauthorized. Oversubscribed programs such as New Starts (funding for new fixed-guideway systems and extensions) should be expanded to provide funds for new rail lines in places enjoying rapidly growing transit ridership, such as Salt Lake City and Dallas. Encouragement for more transit-oriented development and re-development of older areas should be a part of any reauthorization.

These steps by the federal government would support and encourage continued innovation at the state and local levels, paying dividends in reduced driving and big oil savings. And people would spend less of their lives commuting on congested roads. This will mean less smog and global warming pollution, and better protection for farmland and forests in urban areas.

CHAPTER 3

OIL SAVINGS AND POLLUTION REDUCTIONS FROM THE *OIL SECURITY* PROGRAM

To demonstrate the impact of different policy choices on our nation's oil use and our environment, we constructed a model of the U.S. light-duty vehicle sector. Calibrated to the government's recent projections embodied in the Energy Information Administration's Annual Energy Outlook, this tool allows us to estimate gasoline, oil, and pollution impacts of policy-driven technology introduction. Details of the model are set out in Appendix A of the UCS study, *Drilling in Detroit*.[110] This section discusses the key scenarios and results of our modeling.

SCENARIOS

Business as Usual

The baseline scenario assumes a business-as-usual approach to transportation. In this scenario, no policies are enacted to improve fuel economy, and automakers are not encouraged in any way to alter current trends. Although new vehicle efficiency has been declining steadily for the past 15 years, we assume that under the business-as-usual case, passenger vehicles maintain today's average of 24.1 mpg for the future.[111] Further, we assume that the trend toward increased light-truck sales continues until the new passenger-vehicle fleet will be composed of 50 percent cars and 50 percent light trucks.[112] There is early evidence that the point of equal sales volumes has already been reached for model year 2001. We assume that truck sales will not exceed car sales in the future, although such a result is possible (and would increase base-case fuel use and emissions over that assumed here).

CAFE Increases

We evaluate CAFE increases for the new-vehicle fleet in two major steps: reaching 40 mpg by 2012 and 55 mpg by 2020. Recent studies—including those by the National Academy of Sciences, the American Council for an Energy-Efficient Economy, and the Union of Concerned Scientists/Center for Auto Safety—indicate that the 40 mpg level is achievable through improvements to conventional vehicle technologies over the next 10 to 15 years that are cost-effective and that will not degrade (and will likely enhance) the overall safety of the on-road fleet.[113] The 55 mpg target would likely require more extensive technological improvements. We have assumed a fleet composed of gasoline-electric hybrid vehicles, but this target could be met with different combinations of hybrids and additional improvements to conventional vehicle technologies.

For all scenarios where fuel-economy increases, we adjust fleet vehicle-miles traveled relative to the baseline using a rebound effect of 10 percent.[114] The rebound effect represents an increase in travel as the cost of driving drops due to vehicle-fuel-economy increases.

Renewable Fuel Standard

As described previously, a renewable fuel standard (RFS) could raise use of alternative fuels such as ethanol from today's level of 1.6 billion gallons to 5 billion gallons by 2012 and 10 billion gallons by 2020. We follow the RFS schedule for 2003 to 2012 as proposed in S.1766 and continue a linear ramp to 10 billion gallons by 2020. In estimating heat-trapping emissions from a future gallon of ethanol, we assume that corn-based ethanol production will continue to improve in efficiency and yield over the coming years, such that by 2015 per-gallon CO_2-equivalent emissions from corn-ethanol production and use will be nearly 7 percent lower than today. We also assume that ethanol produced from cellulosic biomass will begin to enter the market near the end of this decade, capturing one-third of the ethanol market by 2012 and 100 percent by 2020.

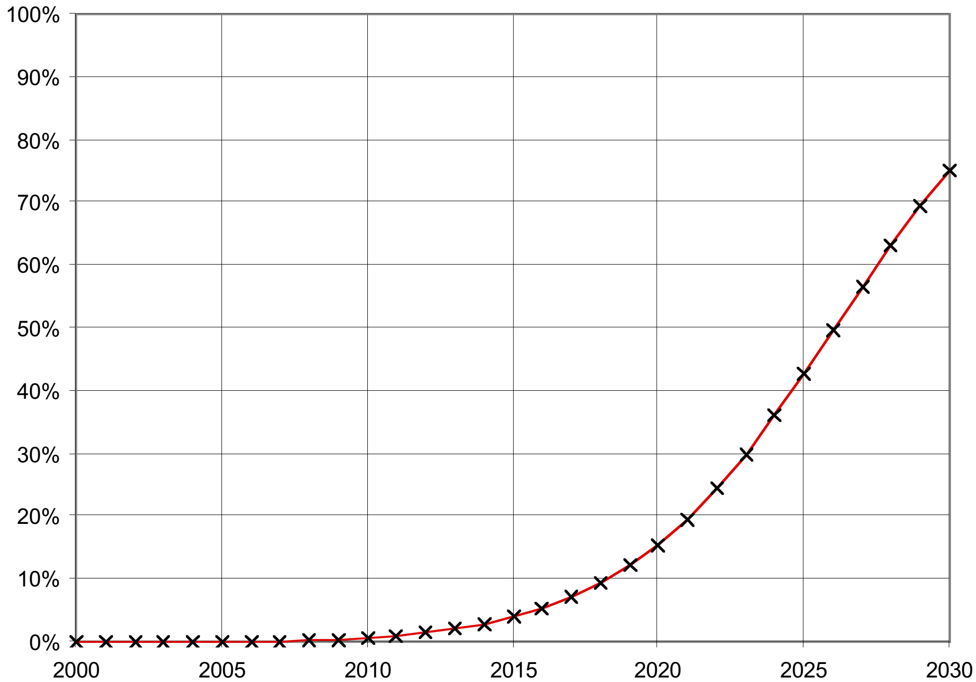
By 2012, assuming one-third of the RFS would be met through sales of lower-carbon biomass ethanol, the RFS would ensure that the average gallon of fuel sold in the United States would yield 1 percent less global warming pollution than today.[115] By 2020, with all ethanol being manufactured from biomass rather than corn, the CO_2-equivalent content of motor fuel would be over 5 percent lower.

Beyond 2020, the RFS could continue its increase through a volume-based sales requirement or limits on fuel carbon content. We did not model the RFS directly beyond 2020, however, since we estimate that continued growth in renewable fuels demand will be driven by the emerging hydrogen fuel-cell vehicle market. Assuming a rapid introduction of fuel-cell vehicles, and assuming that three-quarters of the hydrogen used to power them is derived from renewable resources by 2030, the average CO_2-equivalent content of U.S. motor fuel would be 20 percent below today's levels.

Fuel-Cell Vehicles

As a result of strong government requirements and incentives, we estimate that production of fuel-cell passenger vehicles would reach 100,000 per year by 2010, increasing to 15 percent of the vehicle market by 2020. Federal fuel-cell vehicle sales requirements through 2020 would be sufficient to launch the market, after which we expect the technology to capture 75 percent of all vehicle sales by 2030 as costs continue to drop and complimentary fuels policies ensure that hydrogen infrastructure is available nationally (see Figure 4). This is an aggressive, but achievable introduction rate for fuel cells. It roughly parallels the rate with which diesel technology entered the passenger vehicle

Figure 4. Fuel-Cell Vehicle Market Penetration



market in France.[116] Of course, fuel cells represent a far more significant shift in both vehicle technology and fuel infrastructure than diesel, but aggressive requirements and support from government would be able to accelerate fuel cell's diffusion rate.

For the purposes of modeling fuel and emission savings, we assume a hydrogen fuel-cell vehicle will be three times more efficient than today's cars (measured as energy use per mile). Although fuel cells emit no CO_2 from the tailpipe, some heat-trapping emissions result from the manufacture and delivery of hydrogen to the vehicle. When hydrogen is manufactured from natural gas, we estimate that future fuel-cell vehicles will reduce global warming emissions by roughly 60 percent compared to today's cars per mile traveled. When hydrogen is made via electrolysis from renewable sources, the per-mile savings will total 94 percent.

In the 2006 to 2020 time frame, we assume that hydrogen will be manufactured at the filling station from natural gas using small-scale steam reformers. We assume renewable hydrogen begins after 2020, with biomass hydrogen growing rapidly on the foundation of a biomass-ethanol industry to 50 percent of all hydrogen produced by 2030, and electrolytic hydrogen from renewable electricity to 25 percent.

Travel Reduction It is somewhat more difficult to translate the smart growth policies we propose into direct reductions in vehicle travel. The values we use in our modeling rely on earlier work estimating the vehicle-miles-traveled reductions achievable through transportation-control measures in areas facing air-quality constraints, as well as policies to support better infrastructure planning, parking subsidy reform, auto insurance reform, location-efficient mortgages, increased transit funding, and improved pedestrian and bicycle access.[117] We adapted these previous estimates, which describe potential VMT reductions for the period 1991 through 2030, to the present analysis by simply delaying introduction until 2003. Based on this approach, we assume demand strategies will reduce vehicle travel by 2.8 percent by 2010, 8 percent by 2020, and 13.1 percent by 2030.

RESULTS

Business as Usual

Rising vehicle travel and stagnant fuel economy will cause fuel use to grow at unprecedented rates over the coming three decades. Since 1970, the total number of miles traveled by cars and trucks has more than doubled, thanks to a growing population, rising vehicle ownership, and increasing travel demand. Projections for the future indicate that vehicle miles will continue to grow at near historic rates, so that travel will rise by an additional 75 percent by 2030.

With stagnant new-vehicle fuel economy but sustained travel increases, fuel use over the coming decades is estimated to grow 90 percent, to 230 billion gallons per year, by 2030. The rate of this increase would be twice that seen in recent history: during the period of 1975 to 2000, fuel use rose at an annual average rate of 1 percent, whereas future fuel use could rise at a rate of 2.1 percent per year through 2030.

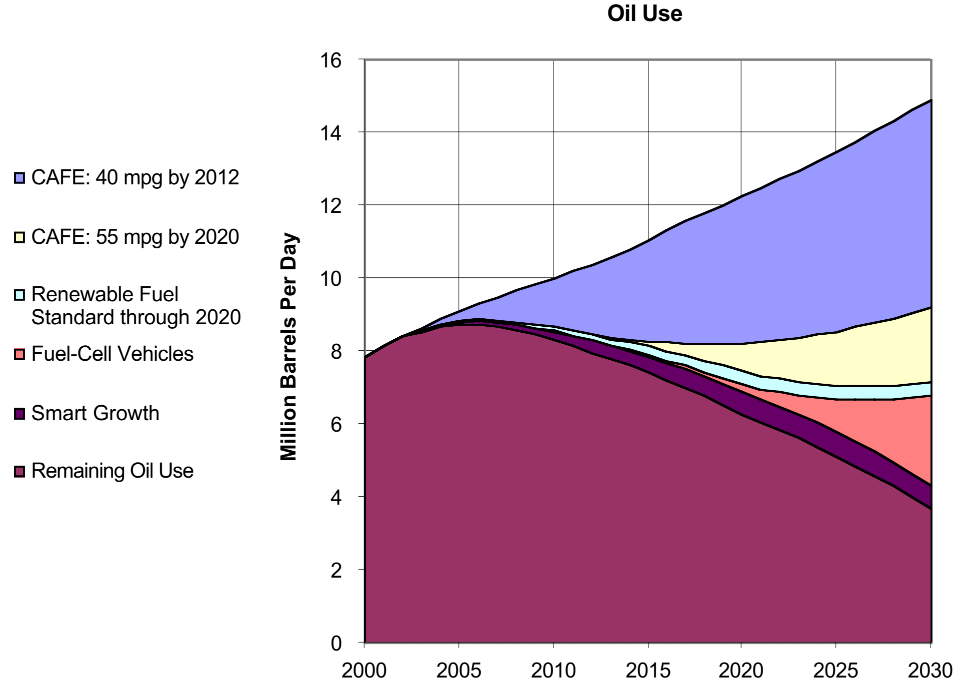
Rising gasoline consumption will exacerbate the economic and environmental impacts of driving. If fuel economy standards are not strengthened, the national motor fuel bill will continue to increase, reaching $260 billion per year by 2020.[118] U.S. oil consumption will also continue to rise as our vehicles burn ever more gasoline. Passenger vehicles will be responsible for 45 percent of our consumption of oil and other petroleum products by 2020. At current projections of domestic production rates, we will meet nearly all of this increased demand through imports, and our reliance on foreign oil will grow to nearly two-thirds of our consumption by 2020.

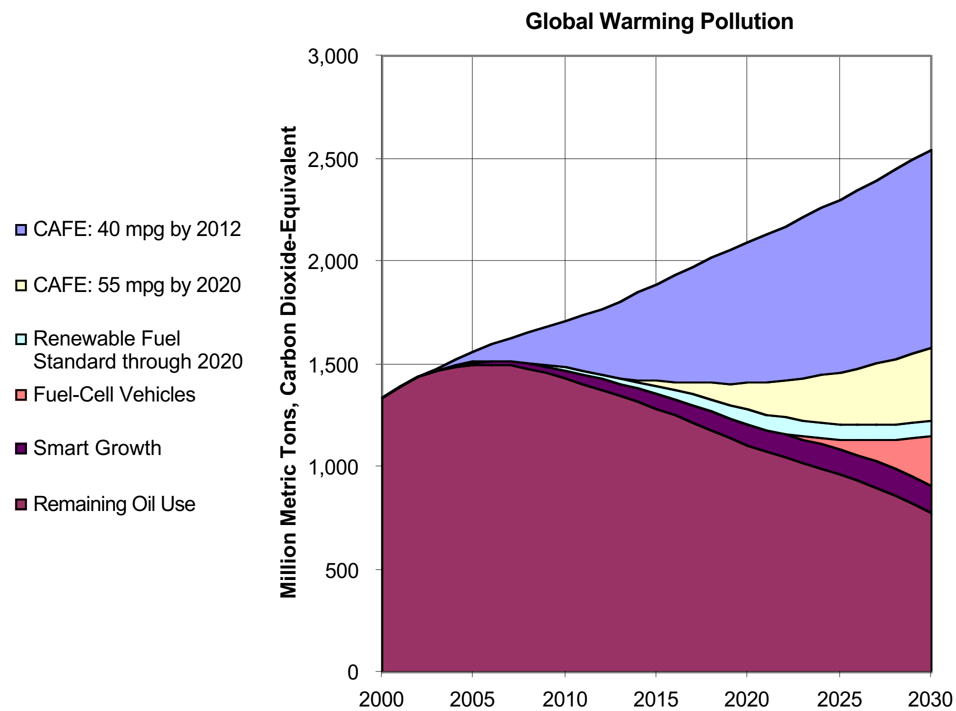
Emissions of global warming pollution will follow energy use under the business-as-usual scenario. In the year 2000, full-fuel-cycle heat-trapping emissions totaled 1340 million metric tons of CO_2-equivalent emissions. We estimate base-case emissions of these heat-trapping gases will grow 28 percent by 2010, 55 percent by 2020, and 90 percent by 2030.

Oil Security Policies

The *Oil Security* package of policies to promote efficient vehicles, advanced technology, renewable fuels, and travel reduction could stem the tide of increased oil use and CO_2 emissions from transportation. By 2013, ten years after it goes into effect, the *Oil Security* package could return vehicle oil use to year 2000 levels. By 2020, oil use could be 20 percent lower; by 2030, over 50 percent lower. Global warming pollution reductions would also be significant from the *Oil Security* scenario, although somewhat lower than oil savings due to the fact that most of the renewable fuels pathways—while virtually eliminating oil use—release some global warming polluition over their fuel cycle. As a result, emissions are reduced 18 percent by 2020 and 42 percent by 2030 from year 2000 levels (see Figure 5).

Figure 5 Oil Use and Global Warming Pollution from U.S, Passenger Vehicles





Individual Policies

The major savings associated with the *Oil Security* path are built, first and foremost, on the near-term efficiency gains achievable through increases in fuel economy standards. Higher fuel economy standards deliver very early *Oil Security* and environmental benefits, as shown by the 40 mpg by 2012 and (to a lesser extent) 55 mpg by 2020 results (see Figure 5). However, these efficiency gains will eventually be overcome by increasing vehicle travel if fuel economy standards do not continue to increase.

A renewable fuels standard (RFS) delivers early oil savings as well. We modeled the RFS as if it ends in 2020, when renewably-derived hydrogen begins to enter the fuels market en masse. In reality, the RFS and fuel-cell policies are linked, as higher levels of renewable fuel penetration could be coupled with the introduction of fuel-cell vehicles running on hydrogen. The fuel-cell scenario similarly could be coupled to CAFE increases beyond the 55 mpg level in 2020, as high-efficiency fuel cells enter the market and deliver the equivalent of a 65 mpg fleet by 2030. Taken together, the high efficiency and non-petroleum fuel use of fuel-cell vehicles would build on the savings associated with vehicle efficiency, continuing the decline in oil use to 45 percent below current levels by 2030.

Finally, travel reduction will round out the savings associated with the *Oil Security* pathway. We modeled the benefits of travel reduction last, which tends to underestimate its potential impact as a stand-alone policy. This is because a mile not driven in an efficient vehicle saves less fuel than a mile avoided from an inefficient vehicle.[119]

To deliver a 50 percent oil savings over today's levels by 2030 without travel reduction, fuel-cell vehicle penetration would have to reach 85 percent of the market, versus 75 percent in the *Oil Security* scenario. Without the renewable fuels standard, fuel-cell vehicles would have to exceed 90 percent of the vehicle market in 2030 in order to deliver a 50 percent oil savings.

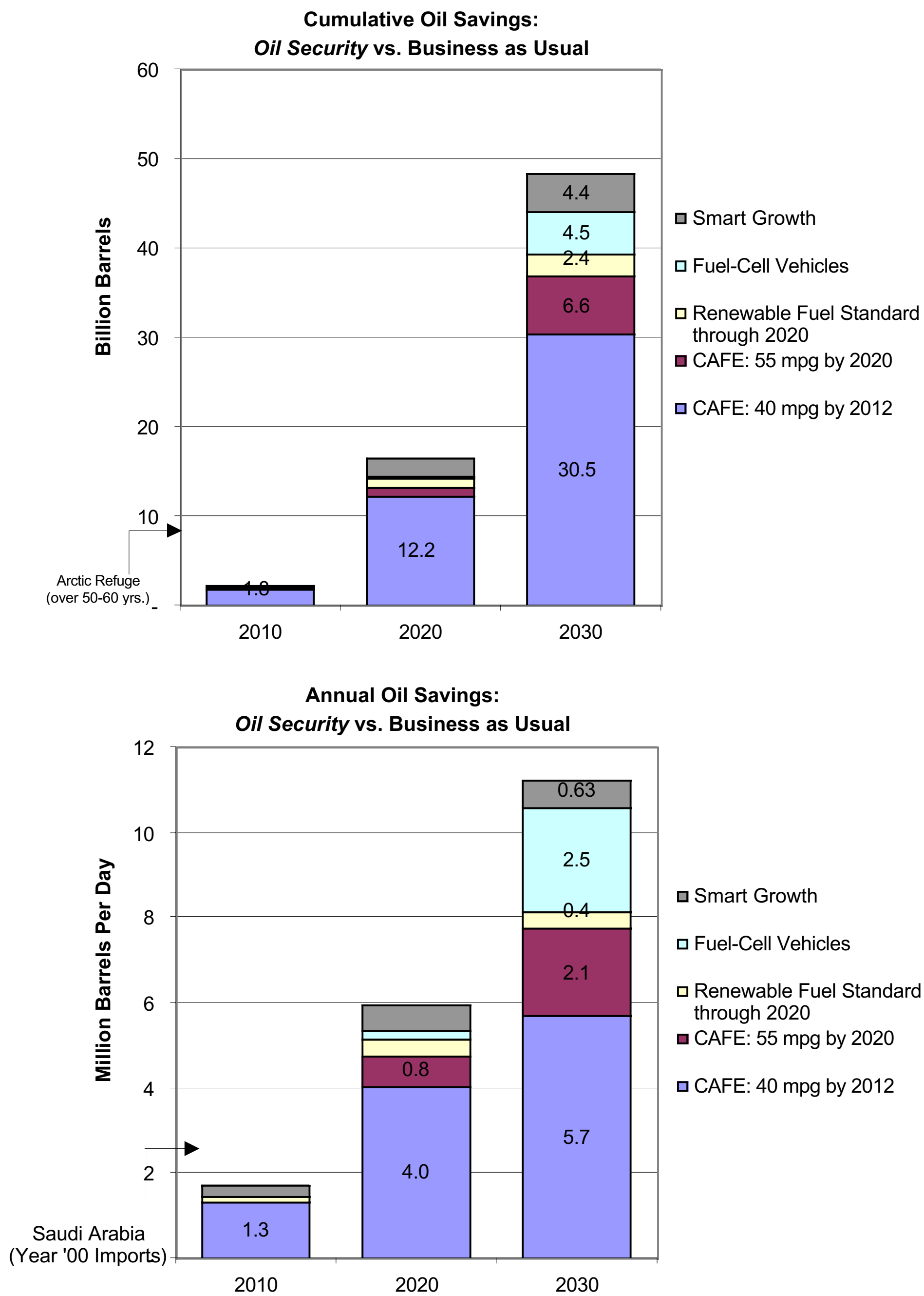
Oil Savings

Because the business-as-usual scenario involved rapidly increasing fuel use over the next three decades (to nearly 15 million barrels per day by 2030), achieving a 50 percent reduction over today's oil use of nearly 8 million barrels per day in 2000, requires major oil savings: about 11 million barrels per day in 2030. Such deep cuts are achievable using the technologies, fuels, and policies envisioned by the *Oil Security* path (see Figure 6). Under this scenario, we will be saving more oil each day by 2010 than we currently import from Saudi Arabia.[120] By 2020, we will be saving more oil daily than we currently import from all OPEC countries combined. And, by 2030, we will be saving more oil daily than we currently import altogether. Of course, one would expect imports to rise under the business-as-usual scenario, but these comparisons emphasize the large dent that efficiency and renewables can make in our oil dependence.

The *Oil Security* path will also deliver tremendous savings in oil consumption over time. From 2003 through 2030, this scenario will save a cumulative 48 billion barrels of oil. By 2012, we will have saved more oil in less than ten years than the Arctic National Wildlife Refuge can economically produce during its 50 to 60 year lifespan.[121]

The bulk of the oil savings associated with the *Oil Security* path comes from vehicle efficiency, which delivers vital near-term savings. More than two-thirds of the annual savings and three-quarters of the cumulative savings by 2030 come from gasoline vehicle efficiency gains. Conventional-vehicle improvements alone (i.e., 40 mpg by 2012)

Figure 6 Oil Savings from U.S. Passenger Vehicles



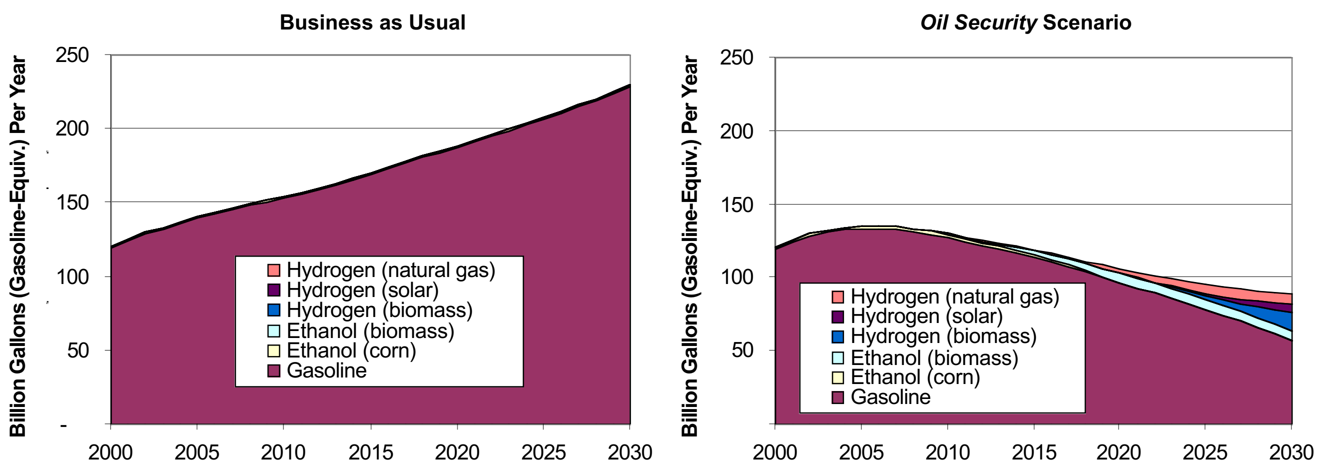
account for one-half of the annual savings and nearly two-thirds of the cumulative savings by 2030. This result emphasizes the importance of raising CAFE standards immediately to take advantage of technologies ready for the market today. Some have argued that waiting for fuel cells to overtake the vehicle market is the prudent strategy for energy independence. While fuel cells are critical for continued oil savings beyond 2020, an aggressive fuel-cell strategy *alone* cannot wean us off of oil over the next 30 years.

Fuel Use

The *Oil Security* policies engender a dramatic shift in our fuel use patterns (see Figure 7). Not only does it save large volumes of fuel via efficiency gains, it begins to shift our fuel mix away from oil and toward more sustainable renewable fuels. By 2010, more than 2 percent of our fuel use (on an energy basis) would come from non-petroleum sources—versus1 percent today.[122] By 2020, that fraction would increase to 9 percent, jumping to 36 percent by 2030 as hydrogen fuel enters the market in large volume.

We assume that by 2030 most of the non-petroleum fuel could be derived from renewable resources, resulting in large savings in CO_2 emissions. Compared to today, the average gallon-equivalent fuel used in passenger vehicles would yield 20 percent less global warming pollution than today. The CO_2-equivalent intensity of fuel would be reduced by 1 percent by 2012, and 6 percent by 2020 in the *Oil Security* path.

Figure 7 Fuel Use by U.S. Passenger Vehicles



APPENDIX

SCENARIO MODEL

To evaluate the oil, gasoline, and CO_2-equivalent emissions savings from the various scenarios, we developed and calibrated a stock model covering the period from 2000 to 2030. This model uses the annual sales and fuel economy of new vehicles, along with other key input data, to predict annual fleet gasoline use.

Our baseline model is calibrated against the *Annual Energy Outlook 200*1 report by the Energy Information Administration (EIA).[123] Annual fleet energy use is kept to within +/–2.5 percent of the AEO results, using their new vehicle fuel-economy values as inputs.[124]

Key Input Data Includes:

Annual New Car and Light-Truck Sales Annual sales from 2000 to 2020 are based on EIA AEO 2001; projections to 2030 assume sales grow roughly 1 percent per year thereafter. Sales from previous years are based on Ward's 2000.[125]

New Car and Light-Truck CAFE Fuel Economy Fuel economy for 1965 to 2001 is based on Ward's 2000 and Heavenrich and Hellman 2000.[126] Fuel economy for 2002 and beyond is determined separately for each scenario.

Vehicle-Miles Traveled as a Function of Vehicle Age The 1995 National Personal Transportation Survey provides the most recent breakdown of vehicle mileage versus age. The data used in our model is based on a sample size of more than 30,000 vehicles ranging in model year from 1970 to 1996.[127] In order to match the AEO 2001 projections, we also assumed an annual growth rate of 1 percent per vehicle for the combined fleet vehicle-miles traveled.

Vehicle-miles traveled have also been increased in the cases where fuel economy is raised over the baseline values. This increase accounts for a potential rebound effect of 10 percent, which accounts for the tendency of people to drive more if the cost per mile of driving drops. Our assumed value implies that if the fuel economy goes up 100 percent, the cost of driving goes down 50 percent, and people will drive 5 percent more than they would have otherwise.

Car and Light-Truck Survival Rates Survival rates are based on Davis 2000.[128] The median life of a 1990 model-year car is reported to be 14 years, while the median life of a 1990 model year light truck is reported to be 15.2 years. Trends in Davis 2000 suggest that these survival rates are increasing for cars and decreasing for light trucks. Combined data suggest an average lifetime of over 16 years for 1990 model cars and light trucks.

Real-World vs. CAFE-Certified Fuel Economy Values for the relative difference between real-world and CAFE fuel economy are taken from EIA 2000 for 1999 through

2020.[129] These values vary between 17 percent and 19.6 percent. Changes in traffic congestion and vehicle-use patterns are not included in these values.

Emission Rates Emissions associated with gasoline production and delivery, so-called upstream emissions, are based on the latest available version of a model developed by Argonne National Laboratory, GREET 1.6β.[130] The model uses average national emission rates and efficiencies to estimate emissions of key pollutants throughout the fuel cycle for various types of gasoline and alternative fuels. This report assumes that federal reformulated gasoline is used nationally, since environmental rules are forcing more conventional gasoline blends out of the market. In actuality, there is broad variation in the types of fuels used in the United States, but the emissions differences associated with their production are relatively small. GREET accounts for several heat-trapping gases—including methane, nitrous oxide, and carbon dioxide—expressing the results as CO_2-equivalent emissions based on their relative radiative forcing (Figure A.1).

Key output data include: total number of vehicles, total number of vehicle-miles traveled for the fleet, and fleet fuel economy. Oil use is calculated from gasoline consumption, assuming gasoline is produced at an efficiency of 90 percent and accounting for the 10 percent difference in density between gasoline and oil. The two effects cancel each other out, and the result is a 1:1 ratio of gasoline gallons to oil gallons.

Figure A.1 Fuel-Cycle Emissions of Heat-Trapping Gases (kg CO_2-equivalent/gallon gasoline-equivalent)

	Reformulated Gasoline (oil)	Naphtha (oil)	Naptha (imported n.gas)	MeOH (imported n.gas)	Ethanol (Corn, Today)	Ethanol (Corn, Future)	Ethanol (Woody Biomass)	Ethanol (Herbaceous Biomass)
Upstream	2.54	1.65	3.06	2.96	-1.02	-1.69	-9.36	-7.03
Tailpipe	8.57	8.52	8.28	8.17	8.53	8.53	8.53	8.53
Total	11.10	10.18	11.34	11.14	7.51	6.85	-0.82	1.50

	Reformulated Gasoline (oil)	Hydrogen (refueling station)	Hydrogen (electrolysis, ng elec.)	Hydrogen (electrolysis, US mix)	Hydrogen (electrolysis, PV)	Liquid H2 (central plant)	Gaseous H2 (central plant)	Gaseous H2 (central plant, C sequester)
Upstream	2.54	12.66	30.30	32.39	2.11	15.41	10.47	2.04
Tailpipe	8.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	11.10	12.66	30.30	32.39	2.11	15.41	10.47	2.04

Source: Based on GREET 1.6β.

ENDNOTES

[1] CO_2-equivalence is a way of accounting for all heat-trapping (greenhouse) gases on a common metric, weighted by their "global warming potential." The vast majority of the reductions are of CO_2 itself, but also included are reductions of methane and nitrous oxide. CO_2-equivalent refers to the total of all greenhouse gases,.

[2] Lashof , D., Silva, P., *A Responsible Energy Policy for the 21st Century*. Natural Resources Defense Council. February 2001. Clemmer, S. et al., *Clean Energy Blueprint*, Union of Concerned Scientists, October 2001.

[3] Energy Information Administration, (EIA) *U.S. Crude Oil, Natural Gas and Natural Gas Liquid Resources, 1999 Annual Report,* DOE/EIA-0216 (99), December 2000.

[4] Lashof, Daniel, Silva, Patricio, *A Responsible Energy Policy for the 21st Century,* NRDC, February 2001, p. 7.

[5] Friedman, D., Mark, J., Monahan, P., Nash, C., Ditlow, C., *Drilling in Detroit: Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles*, Union of Concerned Scientists, Cambridge, MA, 2001.

[6] EIA, *Annual Energy Review 2000*, August 2001. Table 5.7. Total net petroleum imports are 51.6 percent of consumption.

[7] Ibid., Table 5.7.

[8] Ibid., Diagram 2.

[9] Friedman et al.

[10] Heavenrich and Hellman, *Light-Duty Automotive Technology and Fuel Economy Trends 1975 Through 2000* (Ann Arbor: US Environmental Protection Agency, 2000)

[11] EIA, *Annual Energy Outlook 2002,* DOE/EIA-0383 (2002), December 2001, p.5.

[12] EIA, *Energy Situation Analysis Report,* November 8, 2001, http://www.eia.doe.gov/emeu/security/esar/esar.html#oil.

[13] International Energy Agency, *World Energy Outlook: Assessing Today's Supplies to Fuel Tomorrow's Growth - 2001 Insights,* p. 38, Table 2.1.

[14] Ibid. p. 40.

[15] Energy Information Administration, *Annual Energy Review 2000,* Table 5.1 Petroleum Overview, 1949-2000. http://www.eia.doe.gov /aer/ep/overview.html.

[16] Lashof, D., Silva, P., *A Responsible Energy Policy for the 21st Century,* Natural Resources Defense Council, February 2001.

[17] "Addicted to Oil," *The Economist*, Dec. 15, 2001, p. 9.

[18] J. Marshall Adkins, managing director for energy research, Raymond James & Associates, cited in "Oil: investors have it wrong: demand may not fall, but supply will," *BusinessWeek*, October 8, 2001, p. 28.

[19] Ibid.

[20] James Suroweicki, "The Real Price of Oil," *The New Yorker*, Dec.12, 2001. Thomas Friedman, "Dear Saudi Arabia," *The New York Times*, Dec. 12, 2001, p. A31; Thomas Friedman, "Breaking the Circle," *The New York Times*, Nov. 16, 2001, p. A25.

[21] Carbon Dioxide Information and Analysis Center, Oak Ridge National Laboratory, http://cdiac.esd.ornl.gov/trends /emis/top98.tot accessed on January 4, 2002.

[22] EIA, "Emissions of Greenhouse Gases in the United States: 2000," November 2001, p. 22. Motor gasoline accounts for 59 percent of total transportation emissions of 1,888 million metric tons of carbon dioxide in 2000.

[23] Ibid, p. 19, for total U.S. carbon dioxide emissions, and at page 23 for emissions from coal- and gas-fired electricity generation.

[24] Only Japan, Russia, and China have total 1998 CO_2 emissions from fossil-fuel combustion, cement production, and gas flaring that exceed those from U.S. passenger vehicles and light trucks. Source: Carbon Dioxide Information and Analysis Center, Oak Ridge National Laboratory, http://cdiac.esd.ornl.gov/trends /emis/top98.tot accessed on January 4, 2002.

[25] Environmental Protection Agency (EPA), *Inventory of U.S. CO_2-equivalent Emissions and Sinks: 1990-1999*, April 2001.

[26] EIA, *Annual Energy Review 2000*, Figure 1.14 at page 30.

[27] Refer to Chapter 3.

[28] Friedman, et al., p.22. The production, refining, and delivery of each gallon of gasoline in the United States emit an estimated 6.4 grams (0.014 pounds) of smog-forming pollution, see Wang, M. Q., *GREET 1.5—Transportation Fuel-Cycle Model, Volume 1: Methodologies, Development, and Use,* Argonne National Laboratory (ANL/ESD-39), 1999. Upstream activities also release harmful toxic pollution into the air that poses a major health hazard near refineries, along distribution routes, and at gasoline stations. For every gallon of gasoline delivered, 2.9 grams (0.0065 pounds) of benzene-equivalent toxic emissions (i.e., weighted according to cancer potency and including diesel PM emissions) are produced, see *ibid*., and Winebrake, J., D. He, and M. Wang (2000), "Fuel-Cycle Emissions for Conventional and Alternative Fuel Vehicles: An Assessment of Air Toxics*,"* Argonne National Laboratory (ANL/ESD-44)

[29] These estimates assume that air pollution increases linearly with gasoline demand, and that additional gasoline supply is refined domestically. The projected emissions increases in the U.S. would be lower if refineries are required to improve their air pollution controls, or if refined fuels are imported from abroad.

[30] John Biers, "Nation's Refineries Thinking Expansion," *The Times-Picayun*e, May 17, 2001, p. A-4.

[31] Christine Todd Whitman, EPA Administrator, letter to Senator Inhofe, May 14, 2001.

[32] Earthjustice, "New Source Review" factsheet, 2001.]

[33] NRDC, *A Decade After the Exxon Valdez: Inadequate Federal Action on Oil Spill Prevention,* March 1999.

[34] US Coast Guard, "Polluting Incident Compendium: Cumulative Data and Graphics for Oil Spills, 1973-2000." http://www.uscg.mil/hq/gm/nmc/response/stats/summary.htm, accessed December 20, 2001.

[35] Friedman, et al., Table 4. This calculation assumes an average gasoline price of $1.40 per gallon.

[36] Ibid.

[37] The 29 percent figure is based on a trade deficit of $369 billion in 2000 (U.S. Department of Commerce, U.S. Census Bureau, January 3, 2001, http://www.census. gov/foreigntrade/statistics/ misc/gands.pdf). The $378 figure is based on a total resident population of 281,421,906 (U.S. Department of Commerce, U.S. Census Bureau, internet release date: December 28, 2000.)

[38] EIA, *Annual Energy Outlook 2002,* DOE/EIA-0383 (2002), December 2001, Table A11.

[39] Green, D. and N. Tishchishyna, *Costs of Oil Dependence: A 2000 Update, Oak Ridge National Laboratory, U.S. Department of Energy*, May 2000. ORNL/TM-2000/152. Figure is in undiscounted 1998 dollars.

[40] Ibid., figure is in 1998 dollars.

[41] National Research Council (NRC), *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (2001), National Academy of Sciences (NAS), page 2-3.

[42] Hellman, K., Heavenrich, R.*, Light-Duty Automotive Technology and Fuel Economy Trends 1975 Through 2001,* EPA420-R-01-008, Advanced Technology Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, September 2001. p. 6.

[43] Ibid. p.7.

[44] NRC, p. 2-13.

[45] Friedman, et al., p. 8.

[46] NRC, page 2-3.

[47] Friedman, et al., p. 8.

[48] NRC , p. 6-6.

[49] Friedman, et al. DeCicco, An, and 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.

[50] Calculations based on data in Hellman and Heavenrich, p. 11.

[51] Hellman and Heavenrich, p. 53.

[52] Friedman et al., p. 41.

[53] DeCicco, et al.

[54] Based on data in DeCicco, et al. p. 42.

[55] Ibid.

[56] NRC, pp. 3-24. Sales mix by class from Hellman and Heavenrich.

[57] Friedman et. al, pages 84-87, includes moderate application of Hybrid Electric Vehicle technology to reach 49 mpg.

[58] The NAS panel concluded that reducing the weight of the heavier light trucks while maintaining the weight of the lighter vehicles would enhance overall safety. NRC, pp. 4-22.

[59] The NAS report included what was termed "weight reductions" of 5 percent in 3 out of the 10 vehicle types in their Path 3 scenario. However, this followed an analytical assumption *adding* a 5 percent weight increase to all 10 of the vehicles to account for future safety regulations. The net result of the NAS assumptions was an overall increase in fleet weight, rather than any weight savings.

[60] Hwang, R. et al., *Clean Getaway: Towards Safe and Efficient Vehicles,* pp. 7-9. Natural Resources Defense Council, 2001.

[61] Energy Information Administration, *Petroleum Supply Annual 2000*, U.S. Department of Energy, www.eia.doe.gov.

[62] US Geological Survey (USGS), *Arctic National Wildlife Refuge, 1002 Area, Petroeum Assessment, 1998.* US Department of Interior. USGS Fact Sheet FS-040-98. May 1998.

[63] Average savings from Table 1 are $2,207 over the vehicle life. Average reduction in global warming gases is 41 metric tons. Dividing the cost of reducing the emissions (which is a negative number since its actually a savings) by the amount saved, -$2,207÷ 41 metric tons, results in a net "cost" of -$54 per metric ton of global warming gases.

[64] NRC, p. 3-24. and, Friedman, D., UCS Senate Testimony: *Statement Of:The Union Of Concerned Scientists Before The:Committee On Commerce, Science, And Transportation, United States Senate*. December 6, 2001.

[65] The net present value of the fuel cost savings is based on NAS assumptions of a 14 year vehicle lifetime with the vehicle traveling 15,600 miles the first year, declining at a rate of 4.5 percent per year thereafter. UCS assumes a discount rate of 5 percent, which is the real discount rate corresponding to an 8 percent new car loan (i.e. the 8 percent car loan adjusted for inflation). In the NAS report a 12 percent real discount rate, which corresponds to a 15.4 percent loan rate that is more in line with a credit card interest rate. The base adjusted fuel economy presented by the NAS is lower than the vehicle's current base fuel economy due to the assumed need for an increase in weight of 5 percent to account for future safety and emission standard requirements. This base adjusted value has been used for all calculations.

[66] For details on a similar analysis see: Friedman et al., *Drilling in Detroit,* pp. 33-43, and pp. 89-94.

[67] Friedman, D., Testimony before the Senate Committee on Commerce, Science, and Transportation, Dec. 6, 2001.

[68] Friedman et al., *Drilling in Detroit*, p. 45.

[69] Based on early hybrids models, ACEEE analyzed the potential for using gasoline-electric hybrid technology throughout the fleet. The results indicate that the average hybrid-electric car could reach 61.2 mpg at an incremental retail cost of about $4,800. DeCicco, et al. p. 42. Another analysis, from MIT, shows the potential for an advanced hybrid-electric passenger car to reach a fuel economy nearly 16 percent higher at about a 19 percent lower cost: 70.8 mpg at an incremental retail cost of $3,900. Weiss, M., Heywood, J., Drake, E., Schafer, A., AuYeung, F., *On the Road in 2020: A life-cycle analysis of new automobile technologies*. Energy Laboratory Report # MIT EL 00-003. Energy Laboratory, Massachusetts Institute of Technology, Massachusetts. October 2000. ACEEE also projects a 48.8 mpg average fuel economy for gasoline-electric hybrid light trucks at an incremental retail cost of about $5,800. The fleet average fuel economy for the ACEEE hybrids would be about 54.8 mpg at a retail price increase of about $5,300.

[70] Energy Information Administration, *Petroleum Supply Annual 2000*, U.S. Department of Energy, www.eia.doe.gov.

[71] U.S. Department of Transportation National Highway Traffic Safety Administration, Consumer Information Regulations Uniform Tire Quality Grading Standards, 60 Fed. Reg. 27472 (May 24, 1995).

72 Comments of Clarence Hermann, Michelin, submitted in response to U.S. Department of Transportation National Highway Traffic Safety Administration, Consumer Information Regulations Uniform Tire Quality Grading Standards: Request for Comments 59 Fed.Reg. [49 CFR Part 575] (April 25, 1994).

[73] Lashof, Daniel and Silva, Patricio, "A Responsible Energy Policy for the 21st Century," p.9.

[74] NRC, p. 4-22.

[75] NRC, p. 6-5.

[76] One gallon of gasoline contains 114,000 Btus of energy. A gasoline gallon

equivalent is the quantity of alternative fuel that contains 114,000 Btus of energy.

[77] Note that ethanol retains its existing credit of $0.54 per gallon, which is equivalent to $0.82 per gasoline gallon equivalent.

[78] Argonne National Laboratory has conducted one of the most complete and credible "full-fuel-cycle" assessments for conventional gasoline, corn ethanol, and a variety of other fuels, considering all stages of the production and consumption process. That study finds that full-fuel-cycle emissions of global warming pollution from a car running on corn-based gasohol would be only 2 percent lower than from the same car running on conventional gasoline. Wang, M.Q., 1999. GREET 1.5 Transportation Fuel-Cycle Model. Argonne National Laboratory ANL/ESD-39 (August).

[79] Furthest along is BC International, which is in the final stages of securing financing to build a facility in Jennings, Louisiana, that would make 20 million gallons of ethanol per year from rice hulls. The same company is developing similar projects to supply ethanol in California to replace MTBE.

[80] California Energy Commission, 2001. Costs and Benefits of a Biomass-to-Ethanol Production Industry in California. P500-01-002 (March).

[81] DiPardo, Joeseph. 2000. Outlook for Biomass Ethanol Production and Demand. Energy Information Administration. Available at http://www.eia.doe.gov/oiaf/analysispaper/pdf/biomass.pdf

[82] Air quality regulations must ensure that clean air benefits are maintained as MTBE is replaced and ethanol use increases. Blending ethanol with gasoline can increase emissions due to fuel evaporation, but this can be avoided by reducing the vapor pressure of the gasoline part of the blend. Increased emissions can still occur if gasohol mixes with regular gasoline in vehicle fuel tanks. This problem could be avoided by using ethanol in the winter, when fuel evaporation does not degrade air quality, and by ensuring that all fuel within a given region has a similar ethanol content.

[83] One gallon of ethanol contains 84,500 Btus of energy. Thus 1.5 gallons of ethanol are equal to one gasoline gallon equivalent.

[84] Walsh, Marie, et al., *Biomass Feedstock Availability in the United States: 1999 State Level Analysis*, ORNL, 2000. Available at http://bioenergy.ornl.gov/resourcedata/. More than enough biomass is estimated to be available at a delivered price of less than $40/dry ton to produce 10 billion gallons of ethanol.

[85] The clean fuel policy for this period could be restructured to accelerate the emission reduction requirement expressed as a percentage of the fuel supplied, or to switch to an overall cap on the total carbon dioxide emissions associated with producing and using transportation fuels. The latter approach adds complexity, but has the advantage of integrating the effects of better vehicles and better fuels to limit total emissions.

[86] Mark, Jason, *Zeroing Out Pollution, The Promise of* Fuel-cell vehicles, Union of Concerned Scientists, May 1996.

[87] Banerjee, N. and Hakim, D., "U.S. Ends Car Plan on Gas Efficiency; Looks to Fuel Cells," *New York Times,* January 9, 2002.

[88] Passenger vehicles are defined here as cars, SUVs, pickups, and minivans less than 8500 pounds. Current passenger vehicle sales are about 17 million per year.

[89] To maximize flexibility and lower costs, manufacturers would be allowed to bank and trade credits for producing more than the required number of fuel-cell vehicles in a given year.

[90] California's zero emission vehicle requirements, along with similar requirements in New York, Massachusetts, and Vermont, will result in sales of about 10,000 fuel cells by 2010 and 50,000 fuel-cell vehicles by 2020. These four states comprise 18 percent of total U.S. passenger vehicle sales, roughly 3 million new passenger vehicles per year. The 2010 vehicle production levels described here could be achieved by accelerating the deployment of fuel cells in these states to approximately 3 percent of new vehicle sales. The 2.5 million level could be achieved by rapidly expanding the market in these states and by replicating the market launch in other states.

[91] Based on the current percentage of gasoline stations that offer diesel fuel, the California Fuel Cell Partnership found that about 500 hydrogen fueling stations will be needed across three of California's major metropolitan areas—Los Angeles, San Francisco/Bay Area, and Sacramento—when statewide fuel-cell vehicle sales volume reaches 40,000 vehicles per year, or when roughly 75,000 fuel-cell vehicles are on the road. This represents about 10 percent of the number of gasoline stations in those three metropolitan areas. California Fuel Cell Partnership, *Bringing* Fuel-cell vehicles *to Market: Scenarios and Challenges with Fuel Alternatives*, October 2001.

[92] In addition, a complementary focused and enhanced federal R&D program is needed to develop hydrogen production facilities and other important infrastructure components, such as pipelines (see policy recommendations in chapter "Moving Beyond Oil Based Fuel")

[93]See Figure FCV-1.

[94] Ogden, Williams and Larson, *Toward a Hydrogen-Based Transportation System,* final draft, 8 May 2001.

[95] Williams, Robert H., *Nuclear and Alternative Energy Supply Options for an Environmentally Constrained World*, Prepared for the Nuclear Control Institute Conference, 2001.

[96]Ibid.

[97] Holloway, Sam, *Storage of Fossil Fuel-Derived Carbon Dioxide Beneath the Surface of the Earth, Annual Review of Energy and the Environment* 26:145-166.

[98] Holloway, op cit.

[99] Benfield, K. Terris, Jutka, Vorsanger, Nancy, *Solving Sprawl: Models of Smart Growth in Communities Across America* (New York: NRDC, 2001).

[100] Intermodal Surface Transportation Efficiency Act, Pub. L. No. 102-240, 105 Stat. 1914 (1991); Transportation Equity Act for the 21st Century, Pub. L. 105-178, 112 Stat. 107 (1998).

[101] 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).

[102] Only a portion of insurance costs would be collected this way, because some of risk factors that insurance covers have no relationship to miles.

[103] Interlaboratory Working Group, *Scenarios for a Clean Energy Future*. Oak Ridge National Laboratory, ORNL/CON-476 p. 6-23. November 2000.

[104] Stuntz, T., "Per-mile auto insurance unveiled; Commissioner is expected to approve plan early next year," *Dallas Morning News*, Dec. 18, 2001.

[105] Bureau of Labor Statistics, Consumer Expenditures Survey Data, 1999.

[106] American Public Transit Association, "2001 Public Transportation Fact Book."

[107] American Automobile Association and Runzheimer International, *Your Driving Costs*, 1999 Edition. (Mileage range 10,000-20,000.)

[108] Holtzclaw, J. et al., "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use–Studies in Chicago, Los Angeles and San Francisco," Transportation Planning and Technology, Vol. 25, # 1, Jan. 2002.

[109] Environmental Protection Agency, "Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality" (EPA 231-R-01-002, Jan. 2001.)

[110] See Appendix A for details and Friedman, et al.

[111] In their forecasts, EIA projects a small change in fuel economy such that the vehicle fleet reaches 27.5 mpg, a 14.5 percent increase, by 2020. Without external pressure, this increase seems unlikely given their assumption that oil prices will actually drop slightly over the next two decades.

[112] All of the alternate scenarios use the same fleet sales and car/light-truck sales mix as this baseline scenario.

[113] National Academy of Sciences, *Effectiveness and Impact of CAFE Standards*, 2001. DeCicco, J., F. An, M. Ross, *Technical Options for Improving the Fuel Economy of US Cars and Light Trucks by 2010–2015.* Washington, D.C.: American Council for an Energy-Efficient Economy. 2001. Friedman et al., UCS.

[114] Greene, David L., "Why CAFE Worked." *Energy Policy*, vol. 26, no. 8, 595–613. Great Britain: Elsevier Science Ltd., 1998. In Greene 1998, an estimate of 10 percent in the short run and 20 percent in the long run is evaluated based on other literature results developed from past data. It is unclear, however, that past trends will apply to future fuel-economy improvements. The marginal reduction in per-mile cost decreases as fuel economy is improved, and thus the impact should also be reduced versus past effects. In addition, as capital costs begin to far outweigh fuel costs, the continuing impact from operating costs on driving decisions should be reduced. As a result, we use the short-run value for the lifetime of the vehicle.

[115] Measured as full fuel cycle emissions of greenhouse gases per gasoline-equivalent gallon, equal to the sum of carbon contained in the fuel and the carbon-equivalent emissions associated with manufacturing and delivering the fuel. See Appendix A for emission rates for each fuel modeled.

[116] Diesel vehicles captured nearly half the new vehicle market in the span of 20 years. We assume that fuel cells, starting in 2007, would reach a 50 percent market share by 2026.

[117] DeCicco and Mark, *Meeting the Energy and Climate Challenge for Transportation in the United States,* Energy Policy. Vol. 26, No. 5, 1998, pp. 395-412.

[118] The Energy Information Administration does not estimate fuel prices or oil imports past 2020, so we are unable to predict fuel costs and oil imports beyond 2020 for the business-as-usual case.

[119] For example, we estimate that travel reduction saves an addition 0.63 mmbpd in 2030 over the preceding efficiency, advanced technology, and renewable fuel policies. Had travel reduction been modeled first, it would have been shown to save 1.97 mmbpd in 2030.

[120] Energy Information Administration, *Petroleum Supply Annual,* 2000

[121] Based on the $20/barrel volume estimate from: United States Geological Survey., "Arctic National Wildlife Refuge, 1002 Area, Petroleum Assessment, 1998," USGS Fact Sheet FS-040-98, 1998.

[122] Different fuels have differing energy contents per gallon. For example, a gallon of ethanol contains two-thirds the energy of a gallon of gasoline. For consistency, we express all results on a gasoline gallon-equivalent basis. Thus, 5 billion gallons of ethanol (the 2012 RFS target) is actually 3.4 billion gallons of gasoline-equivalent gallons.

[123] Energy Information Administration, *Annual Energy Outlook 2001*, US Department of Energy, 2000.

[124] EIA has since published an updated forecast, *The Annual Energy Outlook 2002*. Compared to the forecast we calibrated our model to, the update projects slightly higher VMT, which would tend to increase base-case fuel consumption and show larger savings due to the efficiency and renewable fuels policies modeled here.

[125] Ward's Communications, *Ward's Motor Vehicle Facts & Figures TM 2000.* Southfield, Mich.: Ward's Communications, 2000.

[126] Heavenrich, Robert M., and Karl H. Hellman. *Light-Duty Automotive Technology and Fuel Economy Trends 1975 Through 2000.* Ann Arbor: US Environmental Protection Agency, EPA420-R-00-008. 2000.

[127] *www.cta. ornl.gov/npts/1995/doc/index.shtml*

[128] Davis, Stacy C., *Transportation Energy Data Book*, Oak Ridge, Tenn.: Oak Ridge National Laboratory. ORNL-6959, 2000.

[129] EIA, 2000.

[130] *www.anl.gov*. For model details, see: Wang, M. Q., *GREET 1.5—Transportation Fuel-Cycle Model, Volume 1: Methodologies, Development, and Use*, Argonne, Ill.: Argonne National Laboratory, ANL/ESD-39, 1999.