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A New Energy Future

The Benefits of Energy Efficiency and Renewable Energy for Cutting America's Use of Fossil Fuels

ENVIRONMENT CALIFORNIA
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Environment California Research & Policy Center

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Table of Contents

Executive Summary **4**

Energy in America **6**

How America Uses Energy and Where it Comes From 6
America's Energy Future 8

A New Energy Future for America **9**

Reduce Energy Use in Homes, Businesses and Industry by 10% by 2025 9
Save More than One Third of the Oil We Use Today by 2025 11
Obtain One Quarter of Our Energy from Clean, Renewable Sources 14

The Benefits of a New Energy Future **21**

Methodology and Technical Discussion **25**

Executive Summary

America has the technological know-how and the resources to move away from dependence on oil and other fossil fuels and toward a cleaner, more secure New Energy Future.

America's dependence on fossil fuels poses challenges to America's environment, economic health and national security. Each of those challenges is likely to become more critical in the years to come if we continue along our present path of increasing energy use and increasing imports of energy from abroad.

A New Energy Future in which America is smarter about how we use energy and in which we tap our abundant supplies of clean, renewable, homegrown energy can address many of those challenges. Achieving that future will require America to set clear goals to guide our energy policies and to mobilize the scientific, economic and political resources we need to meet them.

This paper examines the benefits, in terms of fossil fuel savings, of achieving a New Energy Future guided by the following goals:

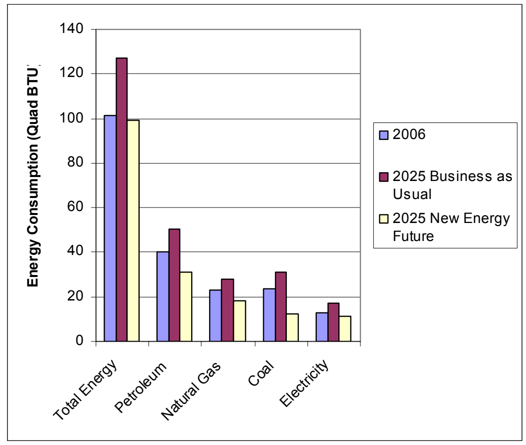
- Reduce our use of energy in our homes, businesses and industry by 10 percent by 2025.
- Save one third of the oil we use today by 2025.
- Harness clean, renewable, homegrown energy sources for at least a quarter of our energy needs by 2025.

There are many ways that America can achieve these goals. This paper lays out one plausible pathway, which we call the "New Energy Future scenario," by which the United States could achieve – and in some cases go beyond – the goals and save vast amounts of fossil fuels.

By 2025, for example, the United States could:

- Save **10.8 million barrels** of oil per day, equal to four-fifths of the amount of oil we currently import from all other nations in the world.
- Save **9.1 trillion cubic feet of natural gas** per year, nearly twice as much as is currently used annually in all of America's homes.
- Save **900 million tons of coal per year**, or about 80 percent of all the coal we consumed in the United States in 2005.
- Save **1.7 billion megawatt-hours of electricity** per year, 30 percent more than was used in all the households in America in 2005.

Fig. ES-1. Fossil Fuel and Electricity Savings Under the New Energy Future Scenario



Achieving the energy savings and renewable energy targets listed above will not be easy, but it can be done.

Reduce our use of energy in our homes, businesses and industry by 10 percent by 2025.

- Cutting our use of energy in homes, business and industry by 10 percent would require reducing the amount of energy we are projected to use in 2025 by 27 percent. Taking advantage of America's **cost-effective energy efficiency opportunities** could reduce our consumption of electricity by as much as 20 percent and natural gas by about 22 percent. Similar savings are possible for petroleum use.
- A combination of new technologies (spurred by more robust federal investment in energy saving technologies and tax incentives) and energy conservation measures could provide the remainder of the savings needed to achieve the 10 percent energy savings goal.

Save one third of the oil we use today by 2025.
Sensible steps to improve the fuel economy of our vehicles, reduce the rate of growth of vehicle travel, and replace some of the oil we use with plant-based fuels could take us well beyond the goal of saving one third of the oil we use today by 2025, providing total savings of 10.8 million barrels of oil per day.

- Increasing **fuel economy standards for cars and light trucks** to 40 miles per gallon by 2018 and to 45 miles per gallon by 2023 would yield oil savings of 2.4 million barrels per day.
- Setting **fuel economy standards for heavy-duty trucks** would save 1.1 million barrels of oil per day by 2025.
- **Changing our transportation priorities** so that the average American drives no more in 2025 than he or she does today could save 3.6 million barrels of oil per day versus projected use in 2025.
- Replacing a share of transportation fuels with **plant-based fuels like ethanol and biodiesel** would save about 1.5 million barrels of oil per day.
- Realizing 10 percent energy savings from homes, business and industry would produce another 2 million barrels per day in oil savings.

Harness clean, renewable, homegrown energy sources for at least a quarter of our energy needs by 2025.
A variety of studies and industry projections suggest that tapping America's abundant supplies of clean renewable energy could fulfill 22 percent of our energy needs by 2025 – and we could reach 25 percent renewable energy with technology advances that would enable us to fully tap our renewable potential.

- Using plant-based fuels to substitute for oil in transportation and industry could supply about 4.5 percent of our total energy use in 2025.
- **Wind power** could provide as much as 30 percent of America's electricity by 2025 and possibly more as new technologies and practices allow for us to successfully integrate more wind power into America's electricity mix.
- **Solar and geothermal power** can combine to produce another 12 percent of America's electricity, while an assortment of other renewable technologies – ranging from solar hot water heaters to geothermal heat pumps – can also make an important contribution.
- Additional renewable energy could be generated using new technologies such as wave and tidal power or by achieving technological improvements that would enable us to expand our use of other renewable energy sources.

To achieve the benefits of a New Energy Future, the United States must adopt policies designed to increase our use of renewable energy and tap America's vast potential for energy efficiency improvements. America must also increase its investment in research and development of the next generation of clean energy technologies, as well as make the investments necessary to bring those technologies into wider use.

Energy in America

America is the most technologically and economically advanced nation in the world, blessed with vast natural and intellectual resources. Our nation has a track record of responding to major challenges and achieving unthinkable goals. If any nation in the world is capable of creating an energy system that can fuel our economy while preserving our environment and our long-term security, it should be us.

But America's energy situation today is less secure than it has been in recent memory. Our domestic production of oil peaked decades ago and our production of natural gas may be peaking now. As a result, we import more of our energy than ever before, leaving our energy supplies and national security vulnerable to political instability abroad. We have ample supplies of coal, but mining it causes severe environmental damage and burning it releases large amounts of global warming pollution. Nuclear power has been tried and found wanting for economic, environmental and public safety reasons. And virtually every year, Americans consume more energy in our cars, homes and businesses.

For America to retain our economic vigor, national security and environmental health, we must build toward a New Energy Future – one based on homegrown, environmentally friendly energy sources and the sensible use of energy throughout the economy.

We have the tools to achieve a better energy future – in the technological prowess of academia and industry, the cutting-edge public policies now being pioneered in states across the country, and in our vast reserves of energy from the sun, wind and crops.

This paper presents a sketch of what such a New Energy Future might look like for the United States and estimates the benefits that would accrue – in the form of reduced fossil fuel consumption – from pursuing that path. We propose specific goals for energy savings and renewable energy development that can move America toward a more stable and secure energy future within the next two decades. And we suggest a plausible pathway (though, by no means the only plausible pathway) by which the United States could achieve or come close to achieving each of those goals.

There are many technologies, policy tools and societal changes that can improve America's energy situation while protecting the environment and public health. The New Energy Future scenario discussed in this report is not the only possible mix of technologies and policies that could achieve those goals. But it illustrates that the goal of a cleaner, more secure energy future is attainable, and shows that the pursuit of that goal can yield significant benefits for the nation.

A quick look at America's current energy situation and its likely future direction under "business as usual" conditions demonstrates that the United States has a lot of work to do to improve its energy security and faces many tough challenges ahead.

How America Uses Energy and Where it Comes From

ENERGY USE IN AMERICA TODAY

America is by far the world's largest consumer of energy. The United States consumed about 22 percent of all the energy used in the world in 2004.[1] We use more energy each year than all the nations of Western Europe combined, and we use about two-thirds more energy than China (though China's consumption of energy is rising fast).[2] (See Fig. 1.)

Fig. 1. World's Top 10 Energy Consuming Countries, 2004[3]

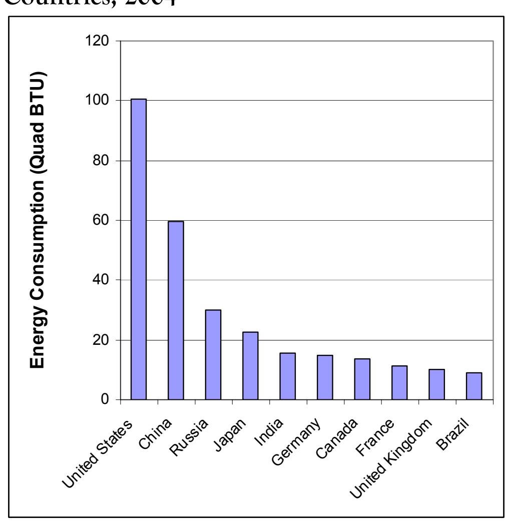
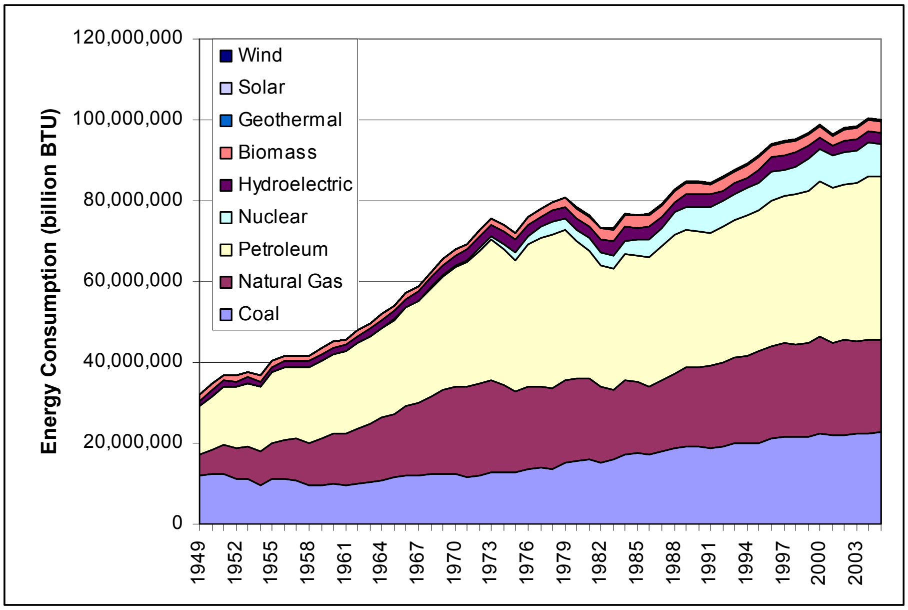


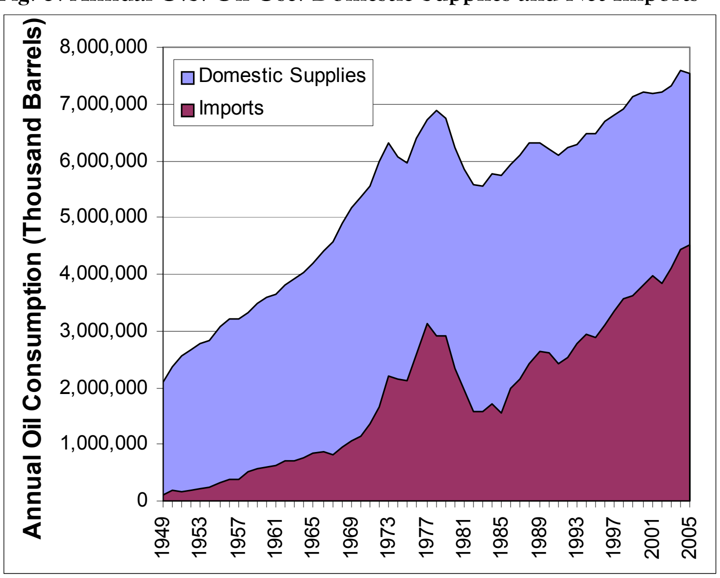
Fig. 2. U.S. Energy Use by Source



Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2005*, 27 July 2006.

While we use energy more efficiently than we did back in the 1960s and 1970s, we still waste far more energy than many of our peers in the industrialized world. Per unit of economic output, America's economy is twice as energy-intensive as that of Germany and nearly three times as energy-intensive as that of Japan.[4]

Fig. 3. Annual U.S. Oil Use: Domestic Supplies and Net Imports



Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2005*, 27 July 2006

The vast majority of the energy we use – about 86 percent – comes from fossil fuels, with 40 percent of our energy coming from petroleum and about 23 percent each from coal and natural gas. (See Fig. 2.) Despite America's vast potential for energy from the sun, wind, crops and other renewable sources, renewable energy currently accounts for a mere 6 percent of our total energy use.[5]

Where does our energy go? About 40 percent of it is used to fuel power plants that supply electricity to power our homes, businesses and industry. Another 28 percent is used to power our transportation system, with most of that energy used to fuel personal cars, light trucks and SUVs. Industry directly consumes about 21 percent of our energy, not counting electricity produced from electric power plants and consumed by industrial facilities. Home and business energy consumption rounds out the picture.

America's rising consumption of energy has left us increasingly dependent on imports. Since 1990, America's consumption of energy has increased by 18 percent, but our imports of energy have more than doubled. Today, America relies on foreign nations for nearly 30 percent of the energy we use, with a whopping 60 percent of our oil now imported from overseas.[6] (See Fig. 3, previous page.)

America's Energy Future

Our dependence on fossil fuels poses a number of challenges to America's future. But each of those challenges is likely to become more critical in the years to come if we continue along our present path.

According to the U.S. Department of Energy's forecasts of future energy supply and consumption, America will use approximately 27 percent more energy in 2025 than we do today.[7] We will use 25 percent more oil, 22 percent more natural gas, and 32 percent more coal. And while we will also use 36 percent more renewable energy, that increase won't be enough to make a serious dent in our nation's energy problems.

Over time, more and more of our energy will come from overseas. Under the "business as usual" version of the future represented in the Department of Energy's projections, we will import 26 percent more oil in 2025 than we do today, and our imports of Middle East oil will increase by 22 percent.[8] Along with our continued dependence on foreign oil, we will develop an increasing dependence on other nations for natural gas. Today, we get about 18 percent of our natural gas from other countries, with the vast majority of those imports coming from Canada. By 2025, according to the Department of Energy, we will be getting one quarter of our natural gas from other countries, with most of the imports coming not from neighboring nations like Canada and Mexico, but from overseas nations via tankers carrying liquefied natural gas.[9]

The economic and environmental challenges that come with our reliance on fossil fuels will increase as well. According to the Department of Energy forecasts, the burning of fossil fuels in America will result in a 27 percent increase in our emissions of carbon dioxide, the leading gas responsible for global warming, by 2025. Because America is already the world's leading emitter of global warming gases, such an increase would make it virtually impossible for the world to achieve the emission reductions that scientists tell us are needed to forestall the worst impacts of global warming.[10] At the same time, fossil fuel dependence will continue to take money out of Americans' pocketbooks, with Americans spending $200 billion more on fossil fuels and nuclear energy than we do today (and that estimate is based on the optimistic assumption that oil prices will *drop*, not rise, compared to today's levels).[11]

THE NEED FOR A NEW ENERGY FUTURE

America can choose another path for our energy future. We do not have to live a future in which our economy and security are compromised by our dependence on other nations for fossil fuels, or a future in which global warming and other environmental problems caused by energy use are allowed to continue unchecked.

America has the tools to build a New Energy Future using our technological know-how and the ample, clean, renewable energy sources available right here at home. Achieving a better energy future for America, however, requires that we set goals and then mobilize the scientific, economic and political resources we need to meet them.

A New Energy Future for America could begin with these three steps:

- Reduce our use of energy in our homes, businesses and industry by 10 percent by 2025.
- Save one third of the oil we use today by 2025.
- Harness clean, renewable, homegrown energy sources for at least a quarter of our energy needs by 2025.

To achieve those goals, we will need to increase our investment in clean energy research and development and shift our policies and practices to encourage the swift deployment of clean energy technologies throughout our economy. The following sections of this paper describe what a New Energy Future might look like for America, and the benefits it would bring for our economy, environment and society.

A New Energy Future for America

A New Energy Future for America begins with setting clear goals for our nation's future economic and environmental health. The challenges facing America are large, and the goals we set must be ambitious enough to meet those challenges.

In the section that follows, we lay out a New Energy Future scenario under which America could achieve the goals of reducing energy consumption, cutting our dependence on oil, and getting 25 percent or more of our energy from clean, homegrown renewable resources. We also estimate the savings in reduced fossil fuel consumption that would result from that scenario.

The New Energy Future scenario represents a plausible pathway by which America could achieve these goals. But it is not the only such pathway, nor is it necessarily the most likely one. Many energy-saving and renewable energy technologies – such as those that would create transportation fuels from energy crops and plant wastes – are in their infancy and judging the degree to which they can contribute to America's future energy needs is difficult at present. Similarly, new technologies will emerge over the next two decades that will improve the way America produces and consumes energy.

The scenario presented in this paper, however, shows that each of the goals described here – for energy savings, reduced dependence on oil, and increased use of renewable resources – are within America's reach if we apply our resources and technological know-how to the task. And it shows that such a course would save vast amounts of energy, and begin to break America's dependence on fossil fuels while creating a cleaner, more secure economy for the future.

Reduce Energy Use in Homes, Businesses and Industry by 10% by 2025

The first step toward a New Energy Future for America is to use energy more wisely. Virtually everywhere one looks in America – from our homes to our offices to our industrial facilities – there are opportunities to use energy more efficiently through the application of new technologies and sensible conservation practices.

In constructing our New Energy Future scenario, we first assume that America takes full advantage of all the energy efficiency opportunities that are cost-effective today – that is, those that pay for themselves over time. Over the past few years, several state and federal government agencies, as well as experts in the non-profit world and academia, have studied America's energy consuming habits and the state of technology to identify ways we can cost-effectively save energy.

The American Council for an Energy-Efficient Economy (ACEEE), the nation's foremost non-profit experts on energy efficiency technologies and policy, surveyed the results of a number of these studies in 2004. On average, the studies identified cost-effective energy efficiency opportunities sufficient to cut electricity use by 20 percent and natural gas use by 22 percent.[12] The studies generally found greater potential for energy efficiency savings in homes and businesses and somewhat lower potential for the industrial sector. For the sake of simplicity, however, we assume that the economic potential for energy efficiency savings is the same in all three sectors.

The studies did not look specifically at petroleum use, but it is likely that similar or greater savings can be had in petroleum use in homes and businesses, since oil is used for many of the same purposes as natural gas. Industry is a different story, since oil is mainly used as a feedstock in the manufacture of products such as plastics, chemicals and asphalt and not as an energy source. Even in industry, however, the potential for oil savings through more efficient practices is significant; by recycling plastics and asphalt pavement, increasing the fuel efficiency of construction and agricultural equipment, and reducing energy waste in factories, ACEEE found that industrial petroleum use could be cost-effectively reduced by 18 percent or more.[13]

The estimates of cost-effective energy efficiency savings provide a good rough guide for the degree of energy savings available in the United States between now and 2025. While some of the energy efficient technologies included in the studies cited by ACEEE may already be included in the Department of Energy's "business as usual" projections of the future, other new efficiency technologies are likely to emerge or to see their costs decline over time. In addition, several of the studies were published early in this decade, before the dramatic run-up in natural gas and electricity prices. It is likely that some energy efficient technologies that were not cost-effective a few years ago would pay for themselves today.

Cutting our consumption of electricity by 20 percent, natural gas by 22 percent, and oil by 18-22 percent would appear to surpass our goal of reducing home, business and industrial energy use by 10 percent by 2025. But remember that we're planning for the future, and that by 2025 there will likely be many more Americans – along with more computers, TVs and other kinds of energy-consuming equipment.

The U.S. Department of Energy projects that we will use 23 percent more energy in our homes, businesses and industry in 2025 than we will in 2006. Achieving the 10 percent energy savings goal would therefore require us to cut energy consumption by 27 percent versus projected 2025 levels. So, taking advantage of all of the cost-effective energy efficiency opportunities available today would get us close to the goal of reducing home, business and industrial energy use by 10 percent below today's levels, but not quite there. However, there are ways to fill the gap. Continuing improvements in energy efficient technologies – perhaps sparked by an increase in federal clean energy research and development spending – could allow for the United States to achieve further cost-effective gains in efficiency in the years to come.

Another option for closing the gap is to promote conservation of energy. Conservation has long been an effective way to save energy in an emergency. The energy crises of the 1970s, for example, prompted massive changes in individual behavior. The U.S. Department of Energy estimated that changes in behavior by residential energy consumers (e.g. lowering thermostats) saved 1 quadrillion BTUs, or about 6 percent of what residential energy consumption would have been in 1986 without conservation measures.[14]

Government action can help encourage conservation behavior and improved energy efficiency. For example, during the Western energy crisis of 2000-2001, the state of California embarked on an ambitious energy-saving strategy that shaved more than 6 percent off the state's electricity consumption within a single year.[15] Key to the success of the campaign were large, timely investments in energy efficiency improvements and a strong public education effort, which included financial rewards for customers who sharply reduced their electricity consumption.

Cutting home, business and industrial energy consumption by 10 percent by 2025 would save vast amounts of energy compared with the amount of energy we would use in 2025 if we continue on a business as usual path.

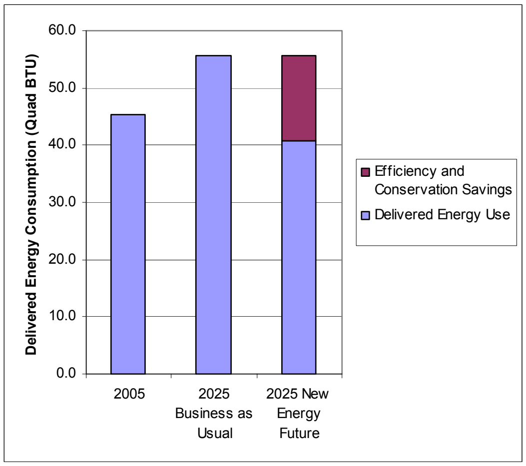
Those savings would amount to:

- More than 1.8 million barrels per day of oil, or about four-fifths of what we import each year from the Persian Gulf.[16]
- More than 4,500,000 million cubic feet of natural gas, equivalent to 92 percent of the natural gas used in all American homes in 2005.[17]
- More than 28 million tons of coal, enough to fill rail cars stretching nearly the entire way from New York to Los Angeles.[18]
- More than 1.7 billion kilowatt-hours of electricity – more electricity than was used in all American homes in 2005.[19] Reducing our consumption of electricity also reduces the use of the fuels needed to generate that electricity, like coal, natural gas and nuclear power.

Achieving the 10 percent energy savings goal will require new public policies, new technologies, and a commitment on the part of government, business and ordinary Americans. Among the steps that can help us get there are the following:

- Set strong energy efficiency standards for household and commercial appliances.
- Strengthen building energy codes. New homes meeting Energy Star home standards, for example, use 15 percent less energy than homes meeting the most

Fig. 4. Energy Savings from Achieving a 10 Percent Reduction in Home, Business and Industry Energy Use by 2025



aggressive residential building energy codes and provide even greater savings in states with older, less up-to-date building codes.[20] In addition, some builders are now constructing "zero energy" homes that combine energy efficient technologies with on-site renewable energy production to virtually eliminate the need for fossil fuel energy purchases.

- Require utilities to meet growing energy needs through energy efficiency improvements before building new power plants.
- Establish tax incentives for investments in energy efficiency.
- Expand and invest in energy efficiency programs to help homeowners and businesses install the latest technologies in their homes and businesses.
- Invest in research and development of new energy efficiency technologies.
- Educate the public about the benefits of conserving energy and strategies for reducing energy use.

Save More than One Third of the Oil We Use Today by 2025

America's dependence on oil – particularly foreign oil – is one of the biggest challenges to a secure energy future for the nation. But there are many sensible tools America can use to break that dependence over the next two decades.

Achieving the goal of saving more than one third of the oil we use today by 2025 would cut America's petroleum consumption by 7 million barrels per day – or more than twice as much as we currently import from the Middle East. That is a lot of oil, but it is actually a conservative vision of what we can save if we apply our technological know-how and embrace balanced transportation policies that offer Americans more choices for how to get from place to place.

For our New Energy Future scenario, we anticipate that the United States can go well beyond the 7 million barrel per day goal and save more than 10 million barrels of oil per day using sensible strategies to improve the fuel efficiency of our cars and trucks, reduce the rate of growth in vehicle travel, and substitute renewable energy sources and materials for many of the purposes for which we now use oil.

The first step toward achieving that goal is to hit our target for reducing energy use in homes, businesses and industry by 10 percent. By achieving that goal alone, we can cut our consumption of oil by more than 1.8 million barrels per day. And since a small amount of oil is used to generate electricity, achieving our energy savings target would yield additional savings of 280,000 barrels per day from averted petroleum consumption in power plants. That adds up to more than 2 million barrels per day of oil savings, getting us more than a quarter of the way to the 7 million barrel per day goal without touching the largest source of oil consumption in the United States: transportation.

IMPROVING VEHICLE FUEL ECONOMY

One of the best ways to cut our oil consumption is to make our cars and trucks go farther on a gallon of gas. Automakers have access to a range of technologies – including advanced transmissions, improved electronics, and energy-saving engine designs – that can dramatically improve the fuel economy of today's vehicles. But, despite the availability of those technologies, today's vehicles are actually less fuel efficient than those built two decades ago, due to automakers' unstinting efforts to sell consumers larger and more powerful vehicles (like SUVs) and their failure to deploy energy-efficient technologies in more than a handful of the vehicles they sell.[21]

As a result, more American drivers find themselves in a bind as they cope with higher prices at the pump and few choices of truly energy-efficient cars in the showroom. Studies completed over the last few years show that it doesn't have to be that way; automakers have the technology to achieve fuel economy standards of 40 miles per gallon or more over the next decade and doing so would save consumers money over the long term in avoided fuel costs.[22] Interestingly, those studies show that major improvements in fuel economy can be had even *without* the widespread use of hybrid vehicle technology. Adding hybrids into the mix would eventually allow automakers to achieve fuel economy standards of 45 miles per gallon or more.[23]

For our New Energy Future scenario, we assume that America can increase average fuel economy standards for both cars and light trucks to 40 miles per gallon by 2018 and, with the use of hybrid vehicles and other more advanced efficiency technologies, to 45 miles per gallon by 2023. Hitting those targets would result in America using about 2.4 million barrels of oil a day less than we would under business as usual conditions.[24]

Americans' personal cars and SUVs aren't the only vehicles that can be made to go farther on less energy. Great potential exists for improving the fuel economy of the heavy-duty trucks that carry freight on America's highways. Unlike cars and SUVs, tractor-trailers are not currently subject to any federal fuel economy standards. But like those vehicles, the fuel economy of tractor-trailers has been on the decline for the last decade.[25]

Manufacturers have the technology to make tractor-trailers far more efficient than they are today. ACEEE estimates that heavy-duty trucks could be made to get 58 percent better fuel economy than today's models – and that the investment in more efficient vehicles would be more than paid for by the savings in fuel costs over time.[26]

The New Energy Future scenario assumes that new federal fuel economy standards for heavy-duty trucks result in a 50 percent improvement in fuel economy for those vehicles by 2020. Implementing those standards would save about 1.1 million barrels of oil per day in 2025.

REDUCING GROWTH IN VEHICLE TRAVEL

Americans are driving more miles in our cars and SUVs than ever before. In 1980, the average American drove a car or light truck about 6,200 miles per year. By 2004, the average American was driving nearly 50 percent more miles per year.[27] And, if we continue on our current, business-as-usual path, the average American will be driving 2,000 more miles per year in 2025 than he or she does today.[28] To save large amounts of oil versus business as usual projections, Americans simply need to not drive more than we do today (acknowledging that vehicle travel will continue to increase somewhat due to population growth).

Many Americans are already looking for alternatives to daily commutes that have grown increasingly expensive due to high gas prices and increasingly frustrating due to mounting congestion. But for many of us, alternatives to driving are few. Transit service may be inconvenient, unreliable or altogether unavailable. Employers may not provide the same support for employees who wish to telecommute, carpool, or walk or bike to work as they do for employees who drive. And many Americans now live in communities where a car is needed to complete even the simplest of daily tasks.

Americans need more and better transportation choices. Federal, state and local governments should create a balanced transportation policy that keeps our roads and bridges in good repair while expanding the number of Americans with the option to take transit, carpool, telecommute, walk or bike. At the same time, we need to encourage efficient land-use policies that allow people to access jobs, shops, schools and recreational opportunities without the use of a car.

By achieving a national goal of holding per-capita vehicle travel to today's levels, America could save the equivalent of 3.6 million barrels of oil per day.

MAKING USE OF BIOFUELS

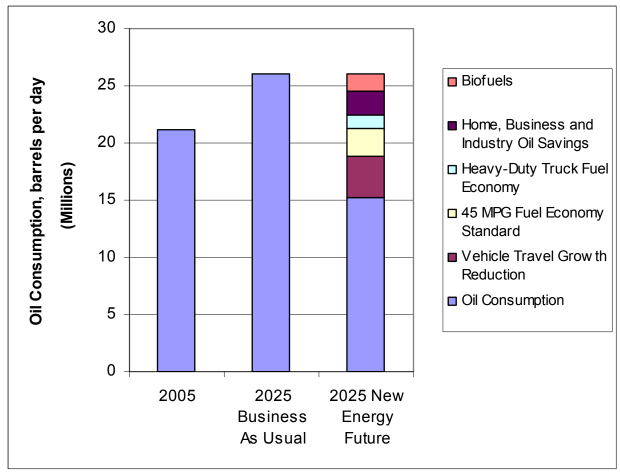
The final step in achieving large savings in oil use is to find other fuels and materials to do the jobs in our economy that oil does today. The best candidates are "biofuels" such as ethanol and biodiesel, and plant-based feedstocks for the petrochemical industry. Plant-based fuels and products will likely never replace petroleum entirely – at least not unless we cut our petroleum use way back from current levels. But they can be part of the solution, particularly if they are produced in ways that use as little fossil energy as possible and are protective of the environment.

Not all biofuels are the same. Today, most of our ethanol comes from corn, which is fairly energy-intensive to grow and process into biofuels. Many experts believe that we will reap the greatest energy-saving potential from specially grown "energy crops" like switchgrass and from plant wastes. At the moment, however, the technology for processing energy crops and plant wastes into biofuels is in the early stages of development. Not surprisingly then, expert estimates of how fast and how large a role biofuels can play in our energy future vary widely, as they grapple with uncertainty over how feedstocks for biofuels will be grown, how they will be processed, and how they will be delivered to and used by consumers.

For our New Energy Future scenario, we make several assumptions about the future role of biofuels and bio-based products in our economy. First, we assume that America is able to produce about 27 billion gallons of ethanol per year by 2025 – with about half of that ethanol coming from energy crops and plant wastes – enough to replace about 22 percent of gasoline use in cars and light trucks in that year.[29] (Recall that we've already reduced gasoline consumption through improved fuel economy and reduced growth in driving. If we followed a "business as usual" course, ethanol would make up a smaller percentage of our gasoline consumption.) We also assume that we can produce about 5.5 billion gallons of biodiesel per year by 2025, enough to replace about 16 percent of the diesel used in heavy-duty trucks in that year.[30] Ethanol and biodiesel production at those levels would produce approximately 2.7 quadrillion BTU of energy by 2025, well within the amount of biofuels that some observers believe could be produced within that time frame.[31] (See page 14 for an illustration of what a quadrillion BTU of energy represents.) By achieving these biofuels targets, we could save about 1.5 million barrels of oil per day.

Adding it all up, under our New Energy Future scenario, America would use about 10.8 million barrels of oil per day less than we would if we continue on with business as usual. (See Fig. 5.) That represents about four-fifths of the oil the United States currently imports each year from all the other countries of the world, combined.

Fig. 5. Energy Savings from Achieving the Oil Savings Goal



In other words, by adopting an aggressive series of strategies to reduce our use of oil today, America can significantly boost its energy independence and improve its security in the decades to come.

Changes in public policy can advance America's progress toward reducing its consumption of oil. Among the steps the nation can take are the following:

- Increase fuel economy standards for cars, light trucks and SUVs to 40 miles per gallon and set strong fuel economy standards for heavy-duty trucks.
- Set goals for the use of plant-based fuels like ethanol and biodiesel – and enact policies that ensure that those fuels are developed cleanly and sustainably.
- Invest in expanded and improved public transit service, promote "smart growth" practices that reduce the need for driving, and encourage other transportation choices like telecommuting, carpooling, biking and walking.

- Invest in research and development of new technologies that can further reduce our use of oil.

Obtain One Quarter of Our Energy from Clean, Renewable Sources

America has vast potential to take advantage of natural forces – the movement of wind and water and the energy provided by the sun – to power our economy. The Great Plains has been dubbed the "Saudi Arabia of wind" for its vast, high-quality wind resource, and many of our offshore areas are similarly blessed with strong, consistent winds. America has similar potential to generate energy from the sun – solar photovoltaic panels placed on 7 percent of the area currently covered by cities and residences would be enough to generate all of America's electricity.[32]

Taking advantage of renewable energy requires technology – turbines to harness the wind, photovoltaic panels to capture the sun's energy, and others. Renewable energy technologies range from the tried and true, such as passive solar heating and lighting of homes, to the new and experimental, such as systems to generate energy from waves and tides. But if America is going to break its dependence on fossil fuels, we will need to implement the technologies we already have to harness renewable energy, while investing in research and development in an effort to create new and better technologies for the decades ahead.

Our New Energy Future scenario includes many renewable technologies, ranging from small-scale technologies capable of providing energy for a single home to large power plants that generate electricity for thousands. In constructing this scenario, we endeavored to identify the maximum potential for various technologies that could be achieved with a "pedal to the metal" push to develop renewable energy over the next two decades. Nonetheless, there remains uncertainty about the future potential for some renewable energy technologies. Thus, the New Energy Future scenario should be viewed as illustrative of the types of technologies that could be used to achieve the 25 percent renewable energy goal and not as a prescriptive "roadmap" laying out the exact path for how to get there.

We begin by reviewing technologies that can allow us to make direct use of renewable energy in our homes and businesses, and then turn to technologies that use renewable energy to generate electricity. By pushing hard to maximize our use of renewable energy technologies, we can get very close to our goal of having clean renewable sources supply 25 percent of America's energy by 2025.

DIRECT USES OF RENEWABLE ENERGY

In 2025, the Department of Energy projects that we will be using about 127 quadrillion BTUs of energy. About 93 quads of that energy is "delivered energy" – energy we actually use in homes, businesses and vehicles. (The rest is energy "lost" in the production and transmission

WHAT'S A QUAD?

A British Thermal Unit (BTU) of energy is technically the amount of energy needed to raise the temperature of one pound of water by one degree Fahrenheit. Using a measure like the BTU allows us to compare fuels based on their energy value. For example, instead of having to explain the difference in energy content between a barrel of oil and a similar quantity of coal, we can use BTUs as a common means of measurement. This is particularly important in evaluating the New Energy Future target of replacing one quarter of America's total energy consumption with renewables.

On a national scale, the amount of energy we use is so large that it is described in terms of quadrillion (or "quad") BTUs. In 2005, the United States consumed just under 100 quads of all forms of energy. So, one can picture a quad as roughly equal to 1 percent of the amount of energy currently used in America every year, or enough energy to power the entire country for three and a half days. Achieving a target that would reduce our fossil fuel use by 0.5 quads would, therefore, cut our energy use by about 0.5 percent compared to today's levels of consumption.

of electricity.) By cutting our consumption of oil and reducing home, business and industrial use of energy to 10 percent below today's levels, we can cut our need for delivered energy by about 30 percent, to a little more than 65 quads. Therefore, to achieve our 25 percent renewables goal, we would need to obtain about 16.3 quads of delivered energy from clean renewable sources. (See "What's a Quad?" page 14.)

America already uses some renewable energy directly, most of it in the form of biomass. By 2025, the Department of Energy projects that we will be obtaining about 2.6 quads of energy from those sources, even under business-as-usual conditions. By using more biofuels in our cars and trucks (see page 12), we can double our use of renewables to about 5.3 quads by 2025. And by adding in the renewable energy sources described in the following section, we can increase our direct use of renewable energy to 8.5 quads.

Passive Solar Heating and Lighting and Solar Hot Water

For thousands of years, skilled builders have known how to take maximum advantage of the sun's heat and light. In Ancient Greece, for example, cities were designed so that every home had a southern exposure, thus maximizing the amount of solar energy available to heat homes.[33] Today, however, improved building materials and building techniques allow homeowners and businesses to take advantage of solar energy as never before. "Passive solar" building design uses strategic placement of windows, proper site orientation and intelligent design of building interiors to maximize the use of solar energy to heat and light homes and businesses. The U.S. Department of Energy estimates that new office buildings using a combination of passive solar design and energy efficiency technologies can reduce energy costs by 30 to 50 percent versus the national average.[34] Similar savings are possible for homes.

We do not include an estimate for the amount of solar energy that can be gained through passive solar design because such estimates are difficult to make. Passive solar design, however, can help to achieve the goal of reducing energy use in homes, business and industry by 10 percent over the next two decades.

Solar water heating is another way to capture the sun's energy economically. Roof-mounted solar collectors allow solar energy to be captured and used to heat household water. Solar hot water systems generally can reduce fossil fuel use for water heating by about two-thirds.[35] Even if we assume that solar water heaters reduce energy consumption for water heating by only half, installing solar water heaters on 40 percent of America's homes would cut energy use by about 0.51 quads by 2025.[36] Solar water heaters can also provide hot water for commercial and industrial use, thus producing further reductions in energy consumption.

Geothermal Heat Pumps

Unlike the air around us, the earth tends to maintain a fairly steady temperature over the course of the year. Geothermal heat pumps use this stability in temperature to provide heating and cooling to homes and businesses. In winter, a geothermal heat pump exchanges the heat contained in the earth with the cool air inside a home, reducing the need for fossil fuels or electricity to provide heat. In summer, the process is reversed, with the warmth inside a home being exchanged with the cooler ground. Geothermal heat pumps can reduce energy consumption by 40 to 70 percent compared with other means of space heating.[37] Expanding the number of geothermal heat pumps in operation to account for 10 percent of the residential and commercial heating market could save 0.62 quads of energy by 2025.[38]

Landfill Methane and Manure Digesters

Methane is the primary ingredient in natural gas. It is also a product of the anaerobic (without oxygen) decomposition of organic materials like food waste and animal manure and a potent greenhouse gas contributing to global warming. There are many environmentally friendly ways to reduce methane emissions, including aerobic composting of organic material and proper use of manure as fertilizer for farm crops. However, much of America's household organic waste is currently buried in landfills, while the manure from large farms is often treated as a waste product or used in environmentally damaging ways. Capturing the methane releases from landfills, and using manure digesters to process the waste from large farms can provide a small, but significant amount of energy – about 0.15

quads – that can substitute for valuable natural gas, and reduce to some degree the environmental impacts of farming and waste disposal practices.[39]

Biomass for Industry

Plant-based material already provides a significant amount of energy to American industry. In 2003, industrial users consumed about 1.5 quads worth of energy from wood and waste materials.[40] However, there is great potential for industrial users (as well as electric power plants) to make greater use of plant-based energy sources, both as energy sources and as feedstocks for the creation of chemicals, plastics and other products.

The Biomass Research & Development Technical Advisory Committee, which advises the U.S. government on biomass-related issues, has set a target of obtaining 2.1 quads of additional industrial energy from biomass by 2030 – a goal that could be reached through the cultivation of energy crops and use of forest industry wastes.[41] The committee also set a goal of significantly increasing the use of biomass for electricity generation. Our New Energy Future scenario assumes that the use of biomass for energy in American industry increases by 1.6 quads over the next two decades.

Plant-based materials can also be used as substitutes for petroleum-based materials in the manufacture of chemicals, plastics and other products. One of the most interesting proposals for the use of biomass is the design and creation of "biorefineries" in which plant-based materials are distilled into a variety of products, including fuel and product feedstocks, at one integrated facility.[42] The Biomass Research & Development Technical Advisory Committee has set a target of obtaining 18 percent of America's chemicals from

A CRASH COURSE IN ELECTRICITY MEASUREMENT UNITS

There are two measurements that are commonly used in discussions of electricity production and use.

The first measurement is the **watt** and its related units, the **kilowatt** (1,000 watts), **megawatt** (1 million watts), and **gigawatt** (1 billion watts). The watt is a measure of power, or the rate at which work is performed or energy is consumed or produced. The key thing to remember about the watt is that it measures electricity consumption at one moment in time. So, a household with ten 100-watt light bulbs burning would, at that moment, be consuming 1 kilowatt of power. A neighborhood or town with 10,000 such light bulbs burning would be consuming 1 megawatt of power. Most electric power plants have their generating capacity measured in megawatts, with a typical coal-fired power plant capable of producing about 500 megawatts of electricity. All of America's power plants put together can generate about 1,000 gigawatts of power.

The second important measurement is the **watt-hour** (as well as the **kilowatt-hour**, **megawatt-hour** and **gigawatt-hour**). If a watt measures the amount of power consumed or produced at one time, then the watt-hour measures energy production or consumption over a period of time. To continue the example above, if a household keeps ten 100-watt light bulbs burning for one hour, it has just consumed one kilowatt-hour of electricity. The average American household consumes about 10 megawatt-hours of electricity over the course of a year. Electricity consumption from all American households for a year is about 1.3 billion megawatt-hours, or 1.3 million gigawatt-hours.

The connection between watts and watt-hours becomes important when comparing the electricity generating potential of various types of power plants. A 1-megawatt power plant that operates 100 percent of the time and at 100 percent of its capacity would generate 8,760 megawatt-hours of power in a year (8,760=24 hours x 365 days). But no power plant operates at 100 percent of its capacity all the time. A typical coal-fired power plant, for example, might operate at an average capacity of 70 percent over the course of the year, while a solar photovoltaic panel might operate at an average capacity of 18 percent (since PV panels generate no power at night and some days are less sunny than others). Thus, it would take more than 3 megawatts of solar PV generating capacity to replace 1 megawatt of coal-fired generation.

biobased materials by 2020 and 25 percent by 2030.[43] Assuming that we can use biomass to replace about 20 percent of the petroleum we currently use for feedstocks in industry, we could save an additional 0.27 quads of energy by 2025.

RENEWABLE SOURCES OF ELECTRICITY GENERATION

By aggressively implementing the renewable energy technologies above and expanding our use of plant-based fuels for transportation, on top of the renewable energy we are already projected to use under business-as-usual conditions, we can get slightly more than halfway to our goal of obtaining 25 percent of America's energy from renewable sources by 2025. The remainder of our renewable energy – about 8.2 quads, the equivalent of about 2.4 billion megawatt-hours of electricity – would need to come from renewable energy sources used to generate electricity. (See "A Crash Course in Electricity Measurement Units," page 16.) If other forms of renewable energy – particularly plant-based biomass – can be developed more quickly, the need for additional renewable electricity to meet the 25 percent goal would be less.

The U.S. Department of Energy projects that we will obtain about 440 million megawatt-hours of electricity from renewable resources in 2025, leaving us to identify about 1.85 billion megawatt-hours of new renewable electricity. That level of generation also represents about 57 percent of the electricity we are projected to use in 2025 under our New Energy Future scenario.

The idea of getting more than half of our electricity from new renewable sources by 2025 might appear to be a fantasy, and it is certainly a very ambitious goal. But advances in renewable energy technologies bring that goal within sight. And a national commitment to advancing renewable energy could bring the goal within our reach.

Wind Power

Wind power is perhaps the technology with the greatest potential to provide large amounts of clean, renewable energy in the next two decades. Wind turbines are already a cost-competitive source of electricity in some parts of the country, and wind power installations in the United States have boomed in the last several years – recently topping the 10 gigawatt mark.[44] America isn't alone in experiencing rapid development of wind power; indeed, European nations like Germany and Spain have seen even faster growth in their wind industries and now have more wind generating capacity than the United States.[45]

But while the wind industry has grown dramatically in recent years, we have barely begun to scratch the surface of wind's potential. A study conducted for the National Renewable Energy Laboratory estimates that, with consistent and strong policy support, the United States could develop 480 gigawatts of cost-effective wind power capacity by 2025 (equivalent to nearly half of America's current electricity generating capacity) – and that is without tapping the vast wind resource off America's coasts.[46] If we could fully tap our onshore potential, Americans could be getting as much as 1.25 billion megawatt-hours of electricity from the wind by 2025 – bringing us most of the way to our 1.85 billion megawatt-hour goal.

But we may not be able to tap all of that wind power capacity, at least not right now. Wind power, like some other forms of renewable energy, is an intermittent resource. That means that wind turbines generate electricity only when the wind is blowing. Since we have not yet figured out a cost-effective way to store the electricity generated by wind turbines, wind power must be balanced on the electric grid by other sources of "baseload" power (which generate electricity all the time) or by smaller, natural gas-fired power plants that can be switched on and off to provide electricity when the wind is not blowing.

Nations such as Denmark have shown that it is possible to obtain as much as 20 percent of their electricity supplies from the wind (and even more at certain times and places), while wind industry analysts suggest it is possible to have up to 40 percent wind power as part of a smoothly functioning electricity grid.[47] For our New Energy Future scenario, we assume that, with intelligent planning and integration of wind power into the nation's electricity grid, wind power could provide up to 30 percent of America's electricity by 2025, contributing about 900 million megawatt-hours of electricity to America's economy and getting us nearly halfway to the 1.85 billion megawatt-hour goal.[48]

Solar Photovoltaics

The sun's energy can directly provide electricity for home or business use through the use of solar photovoltaic (PV) panels. As is the case with wind power, energy from solar PV systems is intermittent. Homes and businesses with PV systems use them to generate electricity when the sun is shining, selling any extra electricity back into the grid, and then using electricity from the grid to obtain power at night. But solar PV is a particularly valuable contributor to the overall electric grid since it provides power at times when demand is highest (when the sun is shining and air conditioning use is high) and when electricity is the most expensive to produce.

For most Americans, however, PV systems remain relatively expensive compared to buying electricity from the grid. While PV installations have increased at a steady clip in recent years, there remain only 365 megawatts of PV capacity installed in the United States.[49]

The good news, however, is that the cost of PV systems has declined at an average rate of about 4 percent per year over the last 15 years.[50] And the cost is likely to keep going down as the industry gets larger and achieves economies of scale. Recognizing this, countries like Germany and states like California have recently made strong commitments to solar power, helping to subsidize the cost of PV systems now in anticipation that PV will become cost-competitive in the near future. California alone has targeted 3 gigawatts (GW) of solar PV capacity over the next decade as part of its "million solar roofs" program.[51]

The solar industry has set a goal of having just over 100 gigawatts (GW) of PV systems installed by 2025.[52] Should the industry achieve that goal, the United States would be generating more than 164 million megawatt-hours of solar power by 2025.

Concentrating Solar Power Plants

Solar PV panels are not the only way to convert solar energy into electricity. In the southwestern United States, utilities and government agencies have constructed several large-scale power plants that use the sun's energy to generate electricity through the capture of heat.

Concentrating power plants use mirrors to focus solar energy, much in the same way that a child might use a magnifying glass to scorch a blade of grass. The solar energy is used to heat a receiving fluid, which is then used to turn a turbine or power an engine to generate electricity. Concentrating solar power plants have one major advantage over photovoltaics, in that the heat energy they create can be more easily stored and used to provide electricity when the sun is not shining or at night.

To date, most solar concentrating plants in the United States have been experimental, but that is beginning to change. Over the past year, utilities in the Southwest have committed to building more than 1 gigawatt of new concentrating solar power plants.[53] By some accounts, the United States could develop as much as 20 gigawatts of generating capacity by 2025.[54] Assuming that the 20 gigawatt target is met, the United States could obtain about 66 million megawatt-hours of electricity from concentrating solar power in 2025.

Geothermal

As described earlier, the earth's natural heat storage provides a potential small-scale energy source for homes and businesses. But geothermal energy also provides large-scale potential for the generation of electricity, through the harnessing of super-heated water buried beneath the earth's surface, particularly in the southwestern United States. America already generates about 14 million megawatt-hours of electricity each year from geothermal energy.[55] Much greater potential exists for the tapping of geothermal energy, with experts suggesting that we could achieve 25 gigawatts of geothermal generating capacity – an increase of 19 gigawatts over the amount of capacity projected for 2025 under business as usual conditions.[56] If we can achieve that goal, America could generate as much as 177 million megawatt-hours from new geothermal energy by 2025.

Wave and Tidal Power

A tremendous amount of energy exists just off our shores in the movement of ocean waters. The power of moving water has been harnessed for hundreds of years by water-powered mills along streams and by hydroelectric dams. Now, new technologies hold the promise of harnessing power from waves and tidal movements without doing damage to marine ecosystems. Among those technologies are submerged turbines, similar to wind turbines, that spin at low speeds as water moves into and out of tidal areas. Because the technology is relatively new, we do not include an estimate for future generation of electricity from wave and tidal power in our New Energy Future scenario. But wave and tidal technologies are among those that hold the potential to increase the availability of renewable energy.

MEETING THE 25 PERCENT RENEWABLE ENERGY GOAL

Recall from above that, to meet our 25 percent renewable energy goal, we will need to obtain about 57 percent of the electricity we use in 2025 from new renewable sources. That translates into about 1.85 million megawatt-hours of electricity. Under our New Energy Future scenario, aggressively harnessing the potential for wind, solar, and geothermal power would result in the generation of more than 1.2 million megawatt-hours of new, clean renewable electricity. Together with the other sources of renewable energy identified here, this level of renewable electricity generation would result in America getting 22 percent of its delivered energy from renewable sources in 2025 – close to our 25 percent goal, but not quite there.

There are, however, many opportunities to fill that gap. First, as noted earlier, there is ample potential for wind power generation beyond the 30 percent of America's electricity we allow to come from wind in our New Energy Future scenario. If, through research and development of new methods of power storage and intelligent integration of wind power into the grid, we can take advantage of more of America's wind potential, both on land and offshore, we could generate enough electricity to achieve the 25 percent renewable energy goal. Second, other new technologies – like tidal and wave power – have the potential to make a major contribution to our energy needs, even though that potential is difficult to quantify right now. Finally, technological improvements in any of the other renewable technologies discussed – or greater use of biofuels (see page 12) – could result in the 25 percent goal being achieved.

Again, it is important to note that the New Energy Future scenario presented here is illustrative of the types of technologies that could be employed to achieve the goal of deriving 25 percent of America's energy from renewable sources by 2025. It is not a definitive roadmap for how to get there. New technologies, or technological breakthroughs in current technologies, could change the renewable energy landscape dramatically between now and 2025.

Achieving the 25 percent renewable energy goal, however, would deliver significant benefits for the United States.

BENEFITS OF REACHING THE GOAL

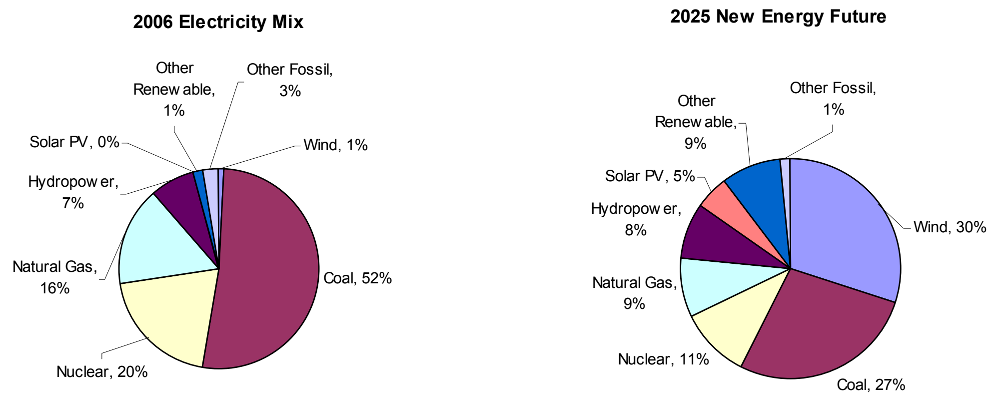
Expanding our use of renewable energy would have a major impact on America's energy future. How that impact is translated into energy savings depends largely on which sources of electricity are replaced by new renewable power generation. For our New Energy Future scenario, we first assume that the amount of power generated by each fuel is the same in 2025 as it is projected to be in 2006 (except for renewable sources, which we allow to grow to their 2025 projected levels). In other words, we assume that there is no growth or change to America's current electricity mix. Second, we assume that renewables replace America's major sources of electricity – coal, petroleum, natural gas and nuclear – in proportion to the degree to which those sources contribute to America's electricity mix.

The result of achieving the 25 percent renewable energy goal would be a dramatic reduction in our dependence on fossil fuels and nuclear power for electricity. By 2025, we would save:

- 449 million short tons of coal per year, equivalent to about 40 percent of the coal America used in 2005.[57]
- 2,590,000 million cubic feet of natural gas, nearly as much as is currently used in commercial establishments nationwide.[58]

Should the United States achieve both the 25 percent renewable energy goal and the 10 percent energy savings goal for homes, businesses and industry, by 2025 America's electricity mix would be vastly different from today. Renewable energy sources would supplant much of the fossil and

Fig. 6 (a-b). U.S. Electricity Generation Mix in 2006 and in 2025 Under New Energy Future Scenario



nuclear fuels we currently use to generate electricity. (See Fig. 6, a-b.)

Even greater savings in fossil fuels would be obtained from renewable energy used directly in homes, business, industry and transportation. Because these technologies supplant a variety of fuels in a variety of settings, we do not estimate the fossil fuel savings from those technologies here.

There are a variety of ways that the United States can promote the development of renewable energy:

- Enact a national renewable energy standard, similar to those already in place in 20 states, that would require a minimum percentage of the nation's electricity to come from renewable sources.
- Use renewable fuel standards and other policies to encourage the use of plant-based fuels for transportation and to transition to fuels made from plant wastes and energy crops like switchgrass.
- Increase research and development funding to develop the next generation of renewable energy technologies.
- Provide tax incentives for the installation of solar panels and other forms of distributed renewable energy.
- Require utilities to prioritize renewable energy development over the construction of conventional power plants to satisfy electricity demand.
- Enact a strong economy-wide cap on global warming emissions, which would provide an incentive to switch from fossil fuels to renewable sources of energy.

The Benefits of a New Energy Future

Improving the energy efficiency of our economy, slashing our use of oil, and boosting our use of renewable energy would go a long way toward addressing America's energy problems and creating a cleaner, more secure New Energy Future for the United States.

There are many ways to achieve these goals. The New Energy Future scenario described in this paper presents one such vision. But the fossil fuel savings that would result from that scenario demonstrate that the United States would benefit greatly from pursuing clean energy policies and technologies.

By achieving the goals set out in this paper – saving one third of the oil we use today; cutting home, business and industry energy use by 10 percent below today's levels; and obtaining 25 percent of our energy from clean renewable sources by 2025 – using the technologies contained in our New Energy Future scenario, America could:

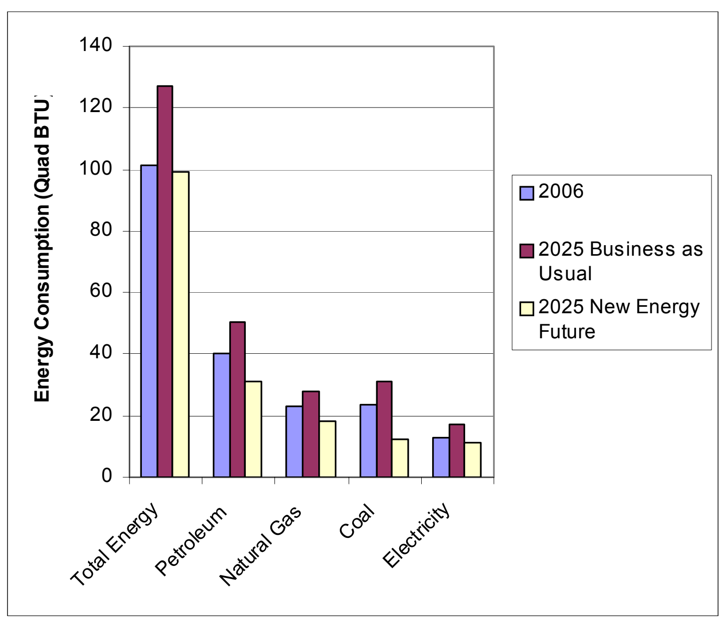
- **Save 10.8 million barrels of oil per day**, equal to four-fifths of the amount of oil we currently import from all other nations in the world.[59]
- **Save 9.1 trillion cubic feet of natural gas per year**, nearly twice as much as we currently use in American homes.[60]
- **Save nearly 900 million tons of coal per year**, or about 80 percent of all the coal we consumed in the United States in 2005.[61]
- **Save 1.7 billion megawatt-hours of electricity per year**, 30 percent more than was used in all the households in America in 2005.[62] (See Fig. 7.)

The benefits that would result from this New Energy Future would be significant:

- **Greater energy security** – Going beyond our oil savings goal to save more than 10 million barrels per day of oil would save enough petroleum to replace four-fifths of our current imports. America will still need to import some oil to satisfy our energy needs, since oil production in the United States has been declining for decades and will likely decline further still. But we will no longer need to be beholden to faraway nations for vast amounts of vital energy supplies. In addition, by dramatically reducing our consumption of natural gas, we can avoid a repeat of our history with oil in which imports (delivered, in this case, in the form of liquefied natural gas) come to make up a larger and larger segment of our energy supplies over time.

- **Reduced need for polluting power plants** – Under the New Energy Future scenario, the need for major additions of coal, natural gas and nuclear power plants would be eliminated. Instead, by saving energy and expanding our use of renewable energy sources, we would be able to begin taking the dirtiest, most

Fig. 7. Fossil Fuel and Electricity Consumption Under New Energy Future Scenario



dangerous and least efficient power plants offline for good. Although we may still need to build some small fossil fuel power plants (particularly natural gas "peaking" plants to supply power to balance wind and solar resources), the days of massive investments in new conventional power plants would come to an end.

- **Dramatically reduced emissions of global warming pollutants** – In addition to being the world's leading energy consumer, America is the world's leading source of global warming pollution. By cutting our use of fossil fuels – particularly heavy-polluting coal – America could drastically reduce its emissions of global warming pollution and be able to assert leadership in the worldwide effort to forestall the worst impacts of global warming.

- **Reduced pollution and environmental damage** – Energy production and use are responsible for massive amounts of environmental damage. Oil spills, the destruction of landscapes and waterways due to coal mining, the disruption of wildlife habitat due to oil and gas drilling, and health-threatening air pollution in our cities are all environmental and public health side effects of our addiction to fossil fuels. Nuclear power generates highly radioactive waste with no good disposal option. By embracing energy efficiency and renewable energy, we can reduce much of the pollution and environmental damage that results from our current energy system. Of course, any source of energy brings with it environmental impacts, and we will need firm rules to ensure that renewable energy technologies do as little damage as possible to the environment. But it is hard to imagine that well-designed renewable energy technologies can do more damage to our land, water and air than our current fossil fuel-based economy.

- **Technological and economic leadership** – By developing and implementing energy efficiency and renewable energy technologies sufficient to meet these goals, the United States can become the global leader in new energy technologies. The technologies and practices we develop will be in increasing demand in a world responding to energy supply challenges and the threats posed by global warming. In addition, energy efficiency and renewable energy have been demonstrated to be potent job-creators, particularly in comparison to the business-as-usual alternative in which we continue to send more dollars overseas for purchases of oil and other fossil fuels.[63] European nations like Spain, Germany and Denmark, as well as Japan, have taken over global leadership in the renewable energy industry from the United States, thanks in large part to their aggressive investments in expanding solar and wind power generation. By achieving the goals of the New Energy Future platform, America can regain its position of global leadership, with long-term benefits for our economy.

These benefits are not limited to the specific mix of technologies included in the New Energy Future scenario. Indeed, other combinations of energy efficiency and renewable energy technologies could deliver similar or greater benefits. The important thing is for the United States to commit to the *goals* of the New Energy Future platform – cutting energy use by 10 percent, cutting oil use by one third of today's consumption, and achieving 25 percent renewable energy by 2025 – and marshal all the resources necessary to get us there.

GETTING THERE

Achieving the New Energy Future goals for energy savings, reduced oil consumption, and increased renewable energy use will require a concerted push from all parts of society. The degree of commitment, effort and investment required will be similar to those put forward by Americans in response to other great challenges ranging from the industrialization effort during World War II to the space program. But, like those efforts, the effort will be more than paid back over time through increased energy security and a healthier environment.

To achieve the goal of a New Energy Future, we will need the following:

New Technologies

America has reason to be optimistic that energy savings and renewable energy can put the nation on a sound energy footing for the decades to come. Still, there are thorny technological problems that could slow our path toward a New Energy Future. Spending $3 billion per year on federal clean energy research and development over the next decade – about four times the amount we spend today – would help us develop the next wave of energy efficiency and renewable energy technologies.

There is no shortage of worthy topics for clean energy research and development. Among them:

- Developing the next wave of fuel economy improvements for vehicles, including incremental improvements in traditional gasoline-powered cars, more efficient hybrid-electric cars (including plug-in hybrids that can travel for short distances on electric power alone), and vehicles that do not require fossil fuels at all, such as hydrogen and battery-electric vehicles.
- Finding the best ways to effectively use plant-based fuels and feedstocks while investigating and devising processes to mitigate any negative environmental impacts that may result.
- Conducting research to develop more energy-efficient consumer products, office equipment and industrial equipment, as well as to develop effective strategies to speed the deployment of energy efficiency technologies in the American economy.
- Investigating ways to cost-effectively store the energy created by renewable technologies like wind and solar power.
- Devising a plan for the intelligent transition of the nation's electric grid from one powered mainly by large fossil fuel and nuclear power plants to one powered primarily by renewable energy.

New Policies

America's current energy predicament is a by-product of public policies that have long subsidized fossil fuels at the expense of renewable energy sources and energy consumption at the expense of conservation. Achieving a New Energy Future will require a dramatically different set of policies based on creating stable, long-term energy supplies provided largely by clean, homegrown sources of energy.

A detailed run-down of the policies that can move us toward a New Energy Future is beyond the scope of this report. But the following strategies would be a good start:

- Policies to require improvements in the energy efficiency of household products, buildings, and business equipment. (See page 11 for a more detailed list of energy efficiency policies.)
- A federal renewable energy standard similar to those now in place in 20 states that would set a minimum threshold for the percentage of electricity coming from renewable sources.
- Stronger fuel economy standards for cars and trucks.
- Renewable fuels standards for transportation fuels, coupled with policies to ensure that a growing share of biofuels comes from energy crops and plant wastes.
- Policies to reduce the environmental impacts of fossil fuel use, such as mandatory, economy-wide limits on global warming pollution and preservation of key natural and offshore areas from oil and gas drilling.

New Investments

Achieving a New Energy Future will require the investment of money, and not just for research and development. Renewable energy sources such as wind and solar power require large capital investments up-front, but can pay for themselves over time in reduced fuel costs. The same is true for energy efficient technologies like hybrid-electric vehicles and advanced "zero energy" homes. And the massive investments we currently make in our transportation system will need to be reoriented to focus on the development of more transportation choices for Americans.

Those investments will need to come from all sectors of the American economy – from government, businesses and individuals. But well-crafted incentives to promote investments in energy-saving and renewable technologies, coupled perhaps with disincentives for energy waste and over-consumption of fossil fuels, can encourage various actors in society to make the investments needed to secure America's long-term energy security.

New Attitudes

Meeting the goals of a New Energy Future will require Americans to change long-held attitudes about the role of energy in our lives. Wisdom in our use of energy, stewardship of our nation's domestic energy resources, and openness toward new, sometimes novel technologies to tap renewable energy sources will need to become guiding values as America seeks to establish a solid energy foundation for the future. Government officials, business leaders and community leaders have a responsibility to speak honestly, openly and forthrightly about the nation's energy challenges and to invite the public to participate in the decisions that shape our energy future. And individual Americans have the responsibility both to use energy wisely and to educate themselves about the energy choices facing America.

Achieving a New Energy Future will not be an easy task. But as this paper demonstrates, it is a worthwhile and attainable target. By attaining the goals laid out here for energy and oil savings and the development of renewable energy sources, America can finally break our dependence on foreign oil, cut our use of fossil fuels and the environmental damage that results from it, and put the nation on a course toward a more economically and environmentally secure tomorrow.

Methodology and Technical Discussion

The purpose of this paper is to assess the benefits in terms of reduced fossil fuel use of achieving the following three goals (called the "New Energy Future goals" or "platform"):

- Reduce home, business and industry energy use by 10 percent below today's levels by 2025.
- Reduce oil consumption by one third of today's consumption by 2025.
- Obtain 25 percent of America's energy from clean, renewable sources by 2025.

To assess the benefits of achieving the goals, we undertook three steps:

1) We constructed a baseline (or "reference case") scenario to estimate America's future energy consumption under "business-as-usual" conditions and to calculate what the New Energy Future goals mean in terms of specific reductions in energy consumption.
2) We considered a range of technologies or public policies that could contribute to achieving the goals and assembled them into an alternative scenario, which we call the "New Energy Future scenario."
3) We then projected how adoption of those technologies would affect the use of energy in the United States, based on a series of assumptions, in order to estimate how much less of various types of fossil fuels America would use in 2025 under the New Energy Future scenario.

The New Energy Future scenario presented here is intended to be illustrative of the types of the types of technological and policy changes that can achieve the goals of the New Energy Future platform. It is not intended to be a definitive roadmap for how America should achieve those goals. Other paths to achieving the goals might produce somewhat different results in terms of the reductions in fossil fuel consumption that would ensue.

STEP 1: CONSTRUCTING A BUSINESS-AS-USUAL SCENARIO AND CALCULATING THE GOALS

Our business-as-usual scenario is based on energy consumption estimates and projections from U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2006 (AEO 2006)*, February 2006.

The New Energy Future goals were calculated as follows:

1) Reduce home, business and industry energy use by 10 percent below today's levels by 2025.
We assumed this goal would require a 10 percent reduction in delivered (site) energy consumption (including the consumption of fossil fuels for non-energy purposes in the industrial sector) versus 2006 levels by 2025, with data based on 2006 projected energy use from *AEO 2006*.

2) Reduce oil consumption by one third below today's levels by 2025.
We assumed that achieving this goal would require a reduction in petroleum consumption by all sectors of the U.S. economy of 7 million barrels per day versus 2025 projected levels under the business-as-usual scenario in *AEO 2006*.

3) Obtain 25 percent of America's energy from clean, renewable sources by 2025.
We calculated the 25 percent renewable energy goal by first assuming that the other two goals of the New Energy Future platform are met (or, in the case of the oil savings goal, exceeded). We then assumed that, to meet the goal, the United States would need to obtain 25 percent of its delivered (site) energy from renewable sources by 2025, using the EIA's definition of "renewable" energy sources. An alternative approach would have been to assume that America would receive 25 percent of its total (primary) energy – including energy inputs for electricity generation – from renewable sources. Such an approach would have made it easier to achieve the 25 percent renewable energy goal using conventional methods (such as those used by EIA) for assessing the total energy consumed by renewable sources of power. However, such methods artificially assign values for total energy consumption to renewable energy sources (like wind and solar power) based on the average energy use of fossil fuel-fired power plants, and were judged to be a

less reliable indicator of energy use for calculating the goal than delivered energy consumption.

STEP 2: IDENTIFYING TECHNOLOGIES AND POLICIES TO MEET THE GOALS

Our approach to constructing the New Energy Future scenario is described below:

1) Reduce home, business and industry energy use by 10 percent below today's levels by 2025.
We assumed that the United States could achieve reductions of 10 percent below today's levels in delivered energy consumption in the residential, commercial and industrial sectors. As described in the text of the report, this assumption is based on the large amount of cost-effective energy efficiency potential in each of the three sectors, with the additional assumption that advances in technology or conservation efforts could achieve the additional savings needed to achieve the goal.

Unlike the oil savings and renewable energy goals described below, we did not construct a technological or policy pathway for achieving the 10 percent energy savings goal. That is, we did not identify energy savings from specific policy or technological approaches and then add those savings together to assess compliance with the goal. Rather, we assumed that policy initiatives to support energy efficiency improvements would drive energy savings over a range of technologies employed in the residential, commercial and industrial sectors.

2) Reduce oil consumption by one third below today's levels by 2025.
The New Energy Future scenario for achieving the oil savings goal is based on a mix of technological, policy-based and goal-driven assumptions. For example, we used technological assessments of the potential future role of biofuels as substitutes for petroleum; policy-based assessments of the potential savings that could result from increased fuel economy standards for cars; and goal-driven assumptions to estimate the impact of reducing growth in vehicle travel. Description of the specific targets and goals for each of these changes can be found in the report text or in the section that follows.

3) Obtain 25 percent of America's energy from clean, renewable sources by 2025.
The mix of renewable technologies used to achieve the 25 percent renewable energy goal is based on assessments of the short- to medium-term technical or economic potential of a variety of technologies. Specific targets and goals for each of the technologies included in the scenario are described in the text of the report.

STEP 3: ESTIMATING THE IMPACT OF THE SCENARIO ON AMERICA'S ENERGY SUPPLY

The methods for calculating the energy savings or fossil fuel savings that would result from the New Energy Future scenario are described below:

1) Reduce home, business and industry energy use by 10 percent below today's levels by 2025.

Based on data from *AEO 2006*, we assumed that achieving the 10 percent energy saving target would result in a 15 quad reduction in delivered energy use versus business-as-usual levels in 2025. To allocate energy reductions to the various fuels used in the residential, commercial and industrial sectors, we first assumed that consumption of each fuel would be reduced to 10 percent below 2006 consumption levels, except where this would result in an increase in consumption of that fuel versus projected consumption in 2025 (as would happen if consumption of a fuel were projected to decline between 2006 and 2025). In those cases, we assumed that the 2025 projected consumption of the fuel would be reduced by 31 percent, with 31 percent representing the reduction in overall fossil fuel and electricity consumption required to achieve the 10 percent energy savings target. Remaining reductions in energy consumption were allocated to each fuel based on its share of fossil and electric energy use in the residential, commercial and industrial sectors.

2) Reduce oil consumption by one third below today's levels by 2025.
Oil savings from each of the steps used to achieve the goal were calculated using separate methodologies.

Fuel Economy Standards

We assumed that fuel economy standards for cars and light trucks of 40 miles per gallon in 2018 and 45 miles per gallon in 2023 would be phased in linearly beginning in 2009. To estimate the benefits of increased fuel economy standards for light-duty vehicles, we first assumed that vehicle fuel economy would increase commensurate with projections in *AEO 2006*. Fuel economy estimates in *AEO 2006* were adjusted downward by approximately 20 percent to approximate "real world" conditions, based on on-road fuel economy degradation factors for 2020 from EIA, *Assumptions to AEO 2006*. For example, the on-road fuel economy for new vehicles under a 40 MPG fuel economy scenario was assumed to be 32 MPG for both cars and light trucks, taking into account the 20 percent difference between laboratory and on-road values.

To estimate how increasing fuel economy standards would affect vehicle emissions in 2025 among all vehicles (not just new vehicles), we made assumptions about the proportion of miles that will be driven by vehicles of various ages and about the split in vehicle-miles traveled between passenger cars and light trucks, such as SUVs. To make the former estimate, we relied on data on VMT accumulation by vehicle age from the U.S. Department of Transportation's 2001 National Household Transportation Survey (NHTS, downloaded from nhts.ornl.gov/2001/index.shtml, 21 June 2006). We used the estimates of the number of miles driven per vehicle by vehicles of various ages from NHTS to estimate the percentage of total VMT in 2025 that could be allocated to vehicles of various model years. (To eliminate year-to-year anomalies in the NHTS data, we smoothed the VMT accumulation curves for cars and light trucks using several sixth-degree polynomial curve fits.)

These percentages were then applied to the on-road fuel economy standard for new vehicles of each model year to create a weighted average fleetwide fuel economy estimate for both cars and light trucks in 2025, which we then compared with the baseline estimate of what fleetwide fuel economy would be without stronger fuel economy standards. Finally, we assumed that 40 percent of light-duty VMT in 2025 would take place in cars and 60 percent in light trucks. The weighted average fleetwide fuel economy for cars and light trucks was then multiplied by their share of total light-duty VMT to arrive at a percentage reduction in fuel consumption that would result from the higher fuel economy standards in 2025. The percentage reduction in per-mile fuel consumption was then applied to the estimated gasoline consumption of light-duty vehicles in 2025, including the reduction in gasoline use resulting from the reduced VMT growth scenario below, to estimate the amount of gasoline that would be saved.

For heavy-duty truck fuel economy standards, we used 2004 fuel economy estimates for heavy-duty diesel and gasoline-powered trucks from *AEO 2006* to establish a baseline. We then assumed that fuel economy standards equivalent to a 50 percent increase in miles-per-gallon fuel economy would be phased in linearly beginning in 2009 and ending in 2020. Fuel economy improvements were assumed to penetrate the vehicle fleet according to VMT accumulation by vehicle age estimates from U.S. Census Bureau, *2002 Economic Census: Vehicle Inventory and Use Survey*, December 2004. Fuel consumption per mile for vehicles of each model year was then multiplied by the percentage of VMT traveled in vehicles of each model year, and then summed across model years to arrive at an estimate of fleetwide fuel economy after imposition of fuel economy standards. The fleet fuel economy estimate for heavy-duty trucks was then divided by current average fleet fuel economy to arrive at a percentage reduction in fuel consumption per mile driven. This percentage reduction was then applied to estimates of diesel and gasoline use by heavy-duty trucks in *AEO 2006* to arrive at an estimate of total fuel savings.

Increases in fuel economy may have other impacts on consumers' driving and vehicle purchasing habits. Many studies have identified a "rebound effect" in which purchasers of more efficient vehicles increase their vehicle travel. In addition, changes in fuel economy standards can cause consumers to shift from one class of vehicles to another (for example, from cars to SUVs). We do not include the rebound effect in these calculations, on the assumption that strategies to eliminate growth in per-capita vehicle travel will achieve their goal. We also do not include "mix shifting" among vehicle types.

Stabilization in Per-Capita Vehicle-Miles Traveled

The impact of stabilizing per-capita VMT at 2006 levels was estimated by first calculating per-capita light-duty vehicle VMT using projections of light-duty VMT and U.S. population from supplementary tables to *AEO 2006*. We then calculated the ratio of per-capita VMT in 2006 versus projected per-capita VMT in 2025. This ratio was then applied to the estimate of light-duty vehicle gasoline consumption in *AEO 2006* to estimate gasoline savings from VMT stabilization in 2025.

Biofuels

Estimated oil savings from the transportation use of ethanol and biodiesel were based on achieving a target of 2.7 quads of oil savings from biofuels, with two thirds coming from ethanol and one third from biodiesel. Estimated quantities of ethanol and biodiesel required to meet that target were calculated by dividing the energy requirement in quads by the energy content per gallon of ethanol and biodiesel. The per-gallon energy content of ethanol was obtained from Oak Ridge National Laboratory, *Bioenergy Conversion Factors*, downloaded from bioenergy.ornl.gov/papers/misc/energy_conv.html, 25 May 2006. The per-gallon energy content of biodiesel was obtained from National Biodiesel Board, *Energy Content*, downloaded from www.biodiesel.org/pdf_files/fuelfactsheets/BTU_Content_Final_Oct2005.pdf, 25 May 2006.

Throughout this report, we assumed that 1 BTU of plant-based fuel or material consumed would replace 1 BTU of fossil fuel, with no energy penalty resulting from the use of fossil fuels to produce biofuels. The amount of fossil fuel inputs required to produce biofuels depends on the technology used and the type of biofuel being produced. As a result, this scenario may overstate somewhat the fossil fuel savings that would result from adoption of biofuels and other plant-based products.

Other Savings

In counting the number of barrels of oil saved to assess attainment of the oil savings goal, we also included savings attributable to attainment of the 10 percent reduction in energy use goal described above. However, these savings are only counted once in the cumulative savings scenario presented at the end of the report.

3) Obtain 25 percent of America's energy from clean, renewable sources by 2025.

To assess attainment of this goal, we first factored in reductions in energy consumption resulting from attainment of the 10 percent energy savings and oil savings goals.

We estimated the total amount of renewable energy produced under the New Energy Future scenario in two steps. First, we calculated the amount of direct (non-electric) renewable energy consumption that would result from the technologies included in New Energy Future scenario. In calculating this figure, we assumed that direct consumption of renewable energy would continue to grow as projected in *AEO 2006*. We then added renewable energy consumption from transportation use of biofuels and from the other sources of direct renewable energy listed in the text of the report.

The resulting sum represented the total direct consumption of renewable energy from the technologies in the New Energy Future scenario. We subtracted this figure from the amount of delivered energy needed to achieve the 25 percent renewable energy goal, and assumed that the remainder of the goal would be filled by renewable generation of electricity. We converted this figure to kilowatt-hours of delivered (site) electricity using the standard conversion factor of 3413 BTU/kWh, and then to the amount of net generation of renewable power that would be required by dividing the site electricity figure by 90 percent to account for transmission losses. (We did not assume transmission losses for solar photovoltaic power, which is typically produced at or near the place of consumption).

The resulting figure represented the amount of net generation of renewable electricity that would be required to attain the 25 percent goal. To estimate the amount of new renewable generation that would be required, we subtracted 2025 projected renewable net generation from *AEO 2006* from this total.

The total amount of generating capacity assumed for each renewable electricity generation technology is described in the text of the report. We assumed that the following renewable generation technologies had the following capacity factors:

- Solar photovoltaic: 18 percent
- Concentrating solar power: 37.5 percent
- Wind power: 33 percent
- Geothermal: 90 percent

We then multiplied the capacity targets for each of the renewable electricity technologies by 8,760 and then by the relevant capacity factor, to estimate the net generation of renewable power that would result from meeting the target for each source. We also placed a limiting condition that prevented new and existing wind power from accounting for more than 30 percent of the nation's electricity mix.

CALCULATING TOTAL FOSSIL FUEL SAVINGS

For the 10 percent energy savings goal and the oil consumption reduction goal, savings of the various fossil fuels were a direct output of the calculation methodology described above and were summed by fuel to produce the estimates of fossil fuel savings from the achievement of each goal. With regard to technologies used to achieve the 25 percent renewable energy goal, we did not assume any fossil fuel savings for technologies used to reduce direct fossil fuel use in homes, business or industry. Many of these technologies – ranging from biomass use in industry to solar hot water heating – can be used to replace consumption of a variety of fossil fuels, as well as of electricity. Time and resource constraints prevented us from producing a detailed analysis of fossil fuel savings from these technologies, but their omission means that the total fossil fuel savings from the New Energy Future scenario are likely conservative compared to what ultimately would be achieved.

With regard to renewable technologies used to generate electricity, we assumed that these technologies would offset or replace fossil fuel and nuclear powered generation according to following assumptions:

1) First, we projected the total amount of net generation of electricity that would be required in 2025 after achievement of the 10 percent home, business and industry energy savings goal.
2) We then assumed that there is no projected growth in net generation from any fossil fuel or from nuclear power generation between 2006 and 2025. This assumption has the rough effect of assuming that no new fossil or nuclear power plants are built between now and 2025.
3) We then calculated the amount of net generation of renewable power in 2025 by adding projected net renewable generation in 2025 under business-as-usual with net generation from new renewable sources calculated as described above.
4) We subtracted net renewable generation as calculated in step 3 from total net generation in step 1 to produce an estimate of the amount of fossil and nuclear power generation that would be required in 2025. We then compared this total with the amount of fossil/nuclear net generation calculated in step 2 (assuming no growth for any fuel after 2006) to estimate the percentage reduction in fossil/nuclear net generation that would result from the New Energy Future scenario.
5) Finally, we multiplied the estimate of net generation for each fossil fuel and nuclear power from step 2 by the percentage reduction arrived at in step 4 to estimate the amount of fossil fuel and nuclear power consumption that would be averted by achievement of the 25 percent renewable energy goal.

The New Energy Future scenario described in this report results in America achieving 22 percent of its delivered energy use from renewable energy by 2025 using the technologies described in this report. Should America achieve the full 25 percent renewable energy goal, savings in fossil fuels would likely be greater.

GENERAL SOURCE NOTES

Conversions between BTUs and native units (e.g. short tons of coal, cubic feet of natural gas) were based on two sources. For coal, natural gas, total petroleum, and renewable energy technologies, heat rates were based on U.S. Department of Energy, Energy Information Administration, *State Energy Data System: Consumption, Technical Notes for Updated Data*, Appendix B, downloaded from www.eia.doe.gov/emeu/states/_seds_updates_tech_notes.html, 18 September 2006. For specific petroleum products, heat rates were based on U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review August 2006*, Appendix A, 28 August 2006.

Notes

[1] U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2005*, 27 July 2006.
[2] Ibid.
[3] U.S. Department of Energy, Energy Information Administration, *International Total Primary Energy Consumption and Energy Intensity*, downloaded from www.eia.doe.gov/emeu/international/energyconsumption.html, 18 September 2006.
[4] U.S. Department of Energy, Energy Information Administration, *International Energy Annual 2002*, March-June 2004.
[5] See note 1.
[6] Ibid.
[7] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2006*, February 2006.
[8] Ibid.
[9] Ibid.
[10] The United States was responsible for nearly one-quarter of the world's emissions of carbon dioxide, the leading global warming pollutant, in 2003. To prevent concentrations of carbon dioxide and other global warming pollutants in the atmosphere from exceeding the levels scientists believe could trigger catastrophic global warming, the world will need to halt the growth of global warming emissions in this decade, begin reducing emissions soon, and slash emissions by more than half by 2025. Should U.S. global warming emissions increase by 27 percent over today's levels by 2025 as projected, it will be difficult or impossible for the rest of the world to achieve the emission reductions necessary to forestall the worst impacts of global warming. For further, detailed discussion of this topic and references to further data on global warming, please see U.S. PIRG Education Fund, *Rising to the Challenge: Six Steps to Cut Global Warming Pollution in the United States*, Summer 2006.
[11] See note 7.
[12] Steven Nadel, Anna Shipley and R. Neal Elliott, American Council for an Energy-Efficient Economy, *The Technical, Economic and Achievable Potential for Energy-Efficiency in the United States – A Meta-Analysis of Recent Studies*, 2004.
[13] R. Neal Elliott, Therese Langer, Steven Nadel, American Council for an Energy-Efficient Economy, *Reducing Oil Use Through Energy Efficiency: Opportunities Beyond Cars and Light Trucks*, January 2006.
[14] U.S. Department of Energy, Office of Conservation and Renewable Energy, *Energy Conservation Trends: Understanding the Factors that Affect Conservation Gains in the U.S. Economy*, September 1989.
[15] Devra Bachrach, NRDC and Matt Ardema and Alex Leupp, Silicon Valley Manufacturing Group, *Energy Efficiency Leadership in California: Preventing the Next Crisis*, April 2003.
[16] Comparison based on oil imports information from U.S. Department of Energy, Energy Information Administration, *Petroleum Navigator: U.S. Imports by Country of Origin*, annual data for 2005, downloaded from tonto.eia.doe.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbblpd_a.htm, 8 September 2006.
[17] Comparison based on residential natural gas use in 2005 from U.S. Department of Energy, Energy Information Administration, *Natural Gas Navigator: Natural Gas Consumption by End Use*, downloaded from tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm, 8 September 2006.
[18] Assuming a capacity of 120 tons of coal per rail car, with each car 53 feet, 1 inch in length.
[19] Comparison based on residential electricity consumption for 2004 from U.S. Department of Energy, Energy Information Administration, *Electric Power Annual with Data for 2004*, November 2005.
[20] U.S. Environmental Protection Agency and U.S. Department of Energy, *Energy Star Qualified Homes*, downloaded from www.energystar.gov/index.cfm?c=bldrs_lenders_raters.pt_bldr, 8 September 2006.

[21] "Less efficient that those produced two decades ago" based on average EPA-adjusted light-duty vehicle fuel economy for 1985 and 2005 model year vehicles from U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2006*, July 2006.
[22] See, for example, Don MacKenzie and David Friedman, Union of Concerned Scientists, *UCS Analysis of Fuel Economy Potential*, memorandum to Julie Abraham and Peter Feather, NHTSA, 29 April 2005. Note: all proposed fuel-economy standards discussed in this report are based on current methodologies for calculating compliance with the standards. These methods produce estimates that overstate fuel economy by 20 percent or more.
[23] See, for example, David Friedman, Union of Concerned Scientists, *A New Road: The Technology and Potential of Hybrid Vehicles*, January 2003; Mark Cooper, Consumer Federation of America, *50 by 2030: Why $3.00 Gasoline Makes the 50 Mile per Gallon Car Feasible, Affordable and Economic*, May 2006.
[24] Note: Oil savings from higher fuel economy savings are based on the assumption that per-capita vehicle travel will be stabilized at current levels. Oil savings from fuel economy savings would be greater if vehicle travel continues to rise as projected by the U.S. Department of Energy and others.
[25] Stacy C. Davis, Susan W. Diegel, Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 25*, 2006.
[26] Therese Langer, American Council for an Energy-Efficient Economy, *Energy Savings Through Increased Fuel Economy for Heavy-Duty Trucks*, prepared for the National Commission on Energy Policy, 11 February 2004.
[27] Vehicle-miles traveled data from U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Summary to 1995 and 2004 editions. Total light-duty vehicle-miles traveled based on adding VMT of passenger cars with those of other 2-axle, 4-wheel vehicles in the *Highway Statistics* reports. U.S. population for computation of per-capita VMT obtained from U.S. Census Bureau, *National Population Estimates: Annual Estimates of the Population by Sex and Five-Year Age Groups for the United States: April 1, 2000 to July 1, 2005*, downloaded from www.census.gov/popest/national/asrh/NC-EST2005-sa.html, 8 September 2006 (for 2004) and U.S. Census Bureau, Population and Housing Unit Counts: United States Summary, downloaded from www.census.gov/population/censusdata/table-16.pdf, 8 September 2006.
[28] Based on comparison of projected light-duty vehicle miles traveled and U.S. population from U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2006*, February 2006.
[29] We assume annual production of about 13.8 billion gallons of cellulosic ethanol in 2025, based on a growth path for cellulosic biofuels from Nathanael Greene, et al., *Growing Energy: How Biofuels Can Help End America's Oil Dependence*, December 2004. We assume production of conventional (e.g. corn-based) ethanol of approximately 13.4 billion gallons per year in 2025. The Energy Policy Act of 2005 requires that 7.5 billion gallons of ethanol be blended into U.S. gasoline by 2012. Given the timeline for meeting this requirement, the vast majority of that ethanol will likely be produced from corn or other conventional crops. Further incremental growth in conventional ethanol production beyond 2012 or expedited development of cellulosic ethanol, is assumed to fill the remaining 5.9 billion gallon per year gap.
[30] The U.S. Department of Energy has identified the potential for 10 billion gallons per year of biodiesel production by 2030. See K. Shaine Tyson, et al., National Renewable Energy Laboratory, *Biomass Oil Analysis: Research Needs and Recommendations*, June 2004.
[31] Several recent analyses suggest that the potential for biofuels development can go well beyond the estimates used in constructing the New Energy Future scenario. In 2002, the Biomass Technical Advisory Committee set a 4.0 quad goal for consumption of biofuels for transportation by 2020. A 2005 analysis published by Rocky Mountain Institute estimated the potential to develop 3.7 million barrels per day of crude oil equivalent biofuels by 2025, more than twice the amount of biofuels included in the New Energy Future scenario. Sources: Biomass Technical Advisory Committee, *Vision for Bioenergy & Biobased Products in the United States*, October 2002; Amory B. Lovins, E. Kyle Datta, et al., *Winning the Oil Endgame: Innovation for Profits, Jobs and Security*, Rocky Mountain Institute, 2005.
[32] National Renewable Energy Laboratory, *How Much Land Will PV Need to Supply Our Electricity?*, downloaded from www.nrel.gov/ncpv/land_faq.html, 8 September 2006.
[33] California Solar Center, *Solar Evolution: The History of Solar Energy*, downloaded from www.solarschoolhouse.org/history_passive.html, 8 September 2006.

[34] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Building Technologies Program: Passive Solar Design*, downloaded from www.eere.energy.gov/buildings/info/design/integratedbuilding/passive.html, 8 September 2006.
[35] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Solar Hot Water and Space Heating & Cooling*, downloaded from www.eere.energy.gov/RE/solar_hotwater.html, 8 September 2005.
[36] Potential for 40 percent market penetration from U.S. Climate Change Technology Program, *Technology Options for the Near and Long Term*, August 2005; savings per unit based on U.S. Department of Energy, Energy Efficiency and Renewable Energy Clearinghouse, *Solar Water Heating*, March 1996.
[37] Geothermal Heat Pump Consortium, *GeoExchange Heating and Cooling Systems: Fascinating Facts*, downloaded from www.geoexchange.org/documents/GB-003.pdf, 8 September 2006.
[38] Assumes that geothermal heat pumps can achieve 10 percent market penetration in the residential and commercial sectors, and that replacing conventional space heating, water heating and air conditioning equipment can provide average efficiency savings of 56 percent versus conventional equipment. Target of 10 percent market penetration from Jessica Commins, Geothermal Heat Pump Consortium, personal communication, 28 August 2006. Impact of 10 percent market penetration on energy use from conventional equipment based on energy consumption data and projections from U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2006*, February 2006. 56 percent energy savings based on weighted average of energy savings for various types of residential and commercial heating, space heating and air conditioning equipment from U.S. Environmental Protection Agency, Space Conditioning: *The Next Frontier – The Potential of Advanced Residential Space Conditioning Technologies for Reducing Pollution and Saving Consumers Money*, 1993. We assume the same proportional savings are possible in the commercial sector as are assumed for the residential sector based on the EPA analysis.
[39] Landfill methane potential: Brian Guzzone, U.S. Environmental Protection Agency, Landfill Methane Outreach Project, personal communication, August 2006. Anaerobic digester potential: U.S. Environmental Protection Agency, *Market Opportunities for Biogas Recovery Systems*, 2004.
[40] Based on data contained in U.S. Department of Energy, Energy Information Administration, *State Energy Consumption, Price and Expenditure Estimates Database*, downloaded from www.eia.doe.gov, 15 June 2006.
[41] Target from Biomass Technical Advisory Committee, *Vision for Bioenergy & Biobased Products in the United States*, October 2002. Feasibility based on U.S. Department of Energy, U.S. Department of Agriculture, *Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, April 2005.
[42] National Renewable Energy Laboratory, *What Is a Biorefinery?*, downloaded from www.nrel.gov/biomass/biorefinery.html?print, 8 September 2006.
[43] Biomass Technical Advisory Committee, *Vision for Bioenergy & Biobased Products in the United States*, October 2002.
[44] American Wind Energy Association, *U.S. Wind Energy Installations Reach New Milestone* (press release), 14 August 2006.
[45] BP, *BP Statistical Review of World Energy 2006*, June 2006.
[46] M. Milligan, National Renewable Energy Laboratory, *Tackling Climate Change in the United States: The Potential Contribution from Wind Power* (preprint copy), July 2006.
[47] See, for example, Randall S. Swisher, "Bringing Wind Energy Up to 'Code,'" *Public Utilities Fortnightly*, June 2004. Swisher, executive director of the American Wind Energy Association, a wind industry trade group, contends that the technical limits to the integration of wind into electricity grids is approximately 40 percent of annual energy use.
[48] Note: the figures for electricity production for all renewable technologies in this section are expressed in terms of site electricity consumption. Estimates of net generation from the various technologies have been adjusted downward by 10 percent to account for transmission losses. The exception to this is solar photovoltaics, for which no transmission losses were assumed.
[49] See note 45.
[50] Solarbuzz, *Fast Solar Energy Facts*, downloaded from www.solarbuzz.com/FastFactsIndustry.htm, 8 September 2006.

[51] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *California Approves Legislation for Million Solar Roofs Plan*, 23 August 2006.
[52] Based on interpolation between 2020 and 2030 target figures from Solar Energy Industry Association, *Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond*, September 2004.
[53] Based on three recently announced concentrating solar projects: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *California Utility to Buy 500 Megawatts of Solar Thermal Power*, 16 August 2006; U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Solargenix Breaks Ground on Large Solar Power Plant in Nevada*, 15 February 2006; U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *California Approves Contract for 500-Megawatt Solar Facility*, 9 November 2005.
[54] Mark Mehos, Program Manager, Concentrating Solar Power, National Renewable Energy Laboratory, personal communication, 30 August 2006. Another study, produced by Greenpeace International and others, suggests that North America could generate 15 gigawatts of concentrating solar power, with about half of that capacity in California. Source: Greenpeace International, European Solar Thermal Industry Association, IEA SolarPACES, *Concentrated Solar Power – Now!*, September 2005.
[55] See note 7.
[56] Jeff Tester, Massachusetts Institute of Technology, personal communication, September 2006.
[57] Comparison based on coal consumption data for 2005 from U.S. Department of Energy, Energy Information Administration, *Quarterly Coal Report, January-March 2006*, 23 June 2006.
[58] Comparison based on commercial natural gas consumption for 2005 from U.S. Department of Energy, Energy Information Administration, *Natural Gas Navigator: Natural Gas Consumption by End Use*, downloaded from tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm, 8 September 2006.
[59] Comparison based on oil imports information from U.S. Department of Energy, Energy Information Administration, *Petroleum Navigator: U.S. Imports by Country of Origin*, annual data for 2005, downloaded from tonto.eia.doe.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbblpd_a.htm, 8 September 2006.
[60] Comparison based on residential natural gas use in 2005 from U.S. Department of Energy, Energy Information Administration, *Natural Gas Navigator: Natural Gas Consumption by End Use*, downloaded from tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm, 8 September 2006.
[61] Comparison based on coal consumption data for 2005 from U.S. Department of Energy, Energy Information Administration, *Quarterly Coal Report, January-March 2006*, 23 June 2006.
[62] Comparison based on residential electricity consumption for 2004 from U.S. Department of Energy, Energy Information Administration, *Electric Power Annual with Data for 2004*, November 2005.
[63] For information on the job creation potential of renewable energy, see Union of Concerned Scientists, *Renewing America's Economy*, September 2004. For information on the job creation potential of energy efficiency investments, see Howard Geller, John DeCicco and Skip Laitner, American Council for an Energy-Efficient Economy, *Energy Efficiency and Job Creation* (summary), 1992.