



C H A P T E R 6

TRANSITIONING TO A CLEAN ENERGY FUTURE

American prosperity depends on a continuous supply of safe and reliable energy. Energy heats, cools, and lights homes and businesses; transports workers to jobs, customers to stores, and families to relatives; and runs the factories that manufacture the goods Americans consume and export. It is increasingly clear, however, that existing energy supplies pose risks to national security, the environment, the climate, and the economy. To counter those risks, while recognizing the continued importance of safe, responsible oil and gas production to the economy, the Administration is committed to moving the Nation toward use of cleaner sources of energy with the potential to support new industries, exports, and high-quality jobs; to improve air quality and protect the climate; and to enhance America's energy security and international competitiveness.

A future with cleaner energy sources promises numerous benefits. Innovation in cleaner energy will reduce U.S. dependence on oil—over half of which is imported—decreasing the vulnerability of the U.S. economy to supply disruptions and price spikes (Box 6-1). Cleaner energy will improve the quality of the air American families breathe, because energy use accounts for the vast majority of air pollution such as nitrogen oxides, sulfur dioxide, and carbon monoxide. Cleaner energy is essential for the United States to make progress toward its pledge, as part of the United Nations Climate Change Conferences in Copenhagen and Cancun, to cut carbon dioxide (CO₂) and other human-induced greenhouse gases by roughly 17 percent below 2005 levels by 2020, and to meet its long-term goal of reducing emissions by more than 83 percent by 2050. Finally, supported by well-designed policies, clean energy can make an important contribution to America's ability to compete internationally using innovative new technologies, while also having ancillary economic benefits like lower risks from accidents at coal mines and oil wells.

Box 6-1: Energy Security Benefits of Reduced Oil Consumption

Combustion of all fossil fuels generates pollution to varying degrees. But because more than half of the petroleum consumed in the United States is imported, it creates an additional set of costs for the American economy.

First, although 20 percent of U.S. imports come from Canada, America's biggest supplier, many of the most accessible reserves are concentrated in unstable regions, leading to fears of supply-related world price fluctuations. The risk may have declined over time, because the U.S. economy has become less energy intensive and the Strategic Petroleum Reserve is now filled to capacity with 727 million barrels of crude oil—more than two months of net imports. Nevertheless, petroleum still plays a key role in the United States, accounting for 37 percent of energy use and over 7 percent of personal consumption expenditures.

The second cost relates to the missed opportunity for the United States to lower world oil prices by decreasing its own demand for oil. Because the United States is the world's largest consumer of crude oil, decreased U.S. demand results in lower world prices. Lower prices benefit petroleum purchasers and harm petroleum producers, with no overall global benefit. Because the United States is a net importer, the offsetting effects would on balance favor U.S. interests.

The third component of the energy security cost of oil involves policy expenses borne by U.S. taxpayers. Among such expenses are military costs associated with protecting oil supply routes and maintenance costs of the Strategic Petroleum Reserve.

The Environmental Protection Agency and the National Highway Traffic Safety Administration estimated that the fuel economy and greenhouse gas emissions standards for cars and light trucks, issued in May 2010, have energy security benefits of \$7 a barrel of oil in saved macroeconomic disruption costs in 2015 (in 2009 dollars), or about \$0.16 a gallon of gasoline. This estimate depends on predictions about future oil prices, supply disruptions, OPEC behavior, and the elasticities of global oil supply and demand. The estimate does not include the demand-side market power benefit, which represents a transfer from exporters to importers. Nor does it include the U.S. policy expenses, because it is difficult to know how much of them to allocate to an incremental change in oil consumption. By comparison, one U.S. government estimate of the global social cost of the CO₂ emissions associated with one barrel of oil is \$9.52 in 2010, going up to \$20 in 2050 (Box 6-4).

These same security, environmental, and economic risks confront all the countries of the world to varying degrees. And many, like the United States, have embarked on efforts to transition to cleaner sources of energy. As a consequence, the clean energy sector is likely to be a vibrant source of innovation, growth, and international trade worldwide. Innovation is an engine of the American economy and a key to long-term job creation and economic growth. Those nations that invest first, and whose transition efforts are most successful, are likely to lead the world in exporting equipment and expertise as the rest of the world's countries seek the same secure, clean, affordable energy. The number of clean energy patents worldwide grew about 20 percent per year from 1997 through 2007, and the United States was home to 18 percent of the clean energy patents issued between 1988 and 2007, behind Japan with 30 percent (UNEP, EPO, and ICTSD 2010). The Obama Administration's commitment to clean energy represents an effort to ensure that the United States does not slip behind but instead leads the world in this critical sector.

The benefits of transitioning to clean energy—energy security, cleaner air, fewer risks from climate change, and enhanced economic competitiveness—are enjoyed by everybody, not just the producers or consumers of the clean energy. As a consequence, the benefits are not fully represented in market prices. Examples of these benefit spillovers abound. Clean energy innovators reap only part of the overall rewards for their efforts—the rest spill over to others who build on their work. The payments that solar and wind power generators receive for the electricity they supply do not reflect the benefits that spill over to the rest of the economy. Energy users reap only part of the benefits from weatherizing their homes and driving electric vehicles. These spillover benefits are substantial. A peer-reviewed report prepared by the EPA estimates that for the year 2010 alone, the Clean Air Act Amendments of 1990 yielded net benefits of \$1.2 trillion—everything from lives saved to healthier kids to a more productive workforce (EPA 2010). These spillovers mean that market rewards for switching to clean energy production are lower than the societywide benefits, market costs of switching to clean energy consumption are higher than the societywide costs, and markets alone provide less clean energy than is optimal.

Because there are many types of clean energy benefit spillovers, the path to a clean energy future includes many possible policies. Existing fossil fuel consumption can be made cleaner by increasing the efficiency of combustion, by capturing and sequestering CO₂ emissions, or by switching within the fossil fuel sector to lower-emitting natural gas. Cleaner fossil fuel technologies and nonfossil sources of energy, such as wind, solar, geothermal, natural gas, and nuclear power, can supply a larger share of

the Nation's energy consumption with the help of a Federal Clean Energy Standard. Energy use by homes and vehicles can become more efficient. And more energy-efficient technologies, some of which may have yet to be discovered, can be supported as they are developed and brought to market. Transitioning to a clean energy future and progressing toward America's carbon pollution reduction goals will be best accomplished by pursuing cost-effective, well-coordinated public policies.

This chapter highlights some of the important steps the Administration has already taken or is proposing to take to ensure that the economy makes the important transition to clean energy. The list of policies discussed here is not exhaustive but rather serves to demonstrate the economic rationale that motivates ongoing work on these programs. The policies include assisting with residential and commercial energy efficiency; increasing vehicle efficiency; increasing the share of electricity generated by clean sources; recording, reporting, and accounting for the cost of greenhouse gas emissions; funding transportation infrastructure including expanded transit and high-speed rail; assisting with manufacturing and adoption of electric vehicles; and providing incentives for clean energy research and development (R&D).

INITIAL STEPS TOWARD A CLEAN ENERGY ECONOMY

The Administration's first task in January 2009 was to end the deepest recession since the 1930s, and while doing so, it made major initial investments to help turn the economy in a new, cleaner direction. Many of those initiatives were integral to the recovery effort; others were distinct but concurrent.

Energy Investments in the Recovery Act

The American Recovery and Reinvestment Act (Recovery Act) directed about \$800 billion in Federal expenditures and tax relief to investments and job creation, with a primary objective of reversing the collapsing economic conditions of early 2009. As part of that effort, the law contained over \$90 billion in public investment and tax incentives targeted at increasing sources of clean energy and reducing America's dependence on fossil fuels (Box 6-2).

These clean energy investments directly targeted the beneficial spillovers that provide an economic rationale for promoting clean energy. One example is the Recovery Act funds directed to the Weatherization Assistance Program. The funds helped retrofit more than 300,000 low-income homes by the end of November. A recent study by the Oak Ridge National

Laboratory estimated that the annual average savings for homes weatherized by the program include \$437 in heating and cooling costs and 2.65 tons of reduced CO₂ emissions (Eisenberg 2010). Another example of Recovery Act spending targeted at home energy efficiency is the Smart Grid funds that electric companies are using to test various types of electricity metering, enabling customers to monitor and adjust their electricity use to save power and money. Still other Recovery Act investments in transit, electric vehicles, and high-speed rail create construction jobs and will provide energy savings and other benefits to Americans for generations.

Box 6-2: Clean Energy Investments in the Recovery Act

The more than \$90 billion in Recovery Act expenditures aimed at reducing American fossil fuel use fell into eight categories:

- \$30 billion for energy efficiency, including retrofits for low-income homes
- \$23 billion for renewable generation, such as wind turbines and solar panels
- \$18 billion for transportation and high-speed rail
- \$10 billion for Smart Grid technologies to improve the efficiency of electricity use and distribution
- \$6 billion for domestic production of advanced batteries, vehicles, and fuels
- \$4 billion for green innovation and job training
- \$3 billion for carbon capture and sequestration
- \$2 billion in clean energy equipment manufacturing tax credits

As an example of the programs that make up these categories, the top category, energy efficiency, includes the following:

- \$5 billion for the Weatherization Assistance Program
- \$3.1 billion for the State Energy Program
- \$2.7 billion for Energy Efficiency and Conservation Block Grants
- \$454 million for retrofit ramp-ups in energy efficiency
- \$346 million for energy-efficient building technologies
- \$300 million for energy-efficient appliance rebates / Energy Star®
- \$256 million for the Industrial Technologies Program
- \$104 million for national laboratory facilities
- \$18 million for small business clean energy innovation projects

Another part of the Recovery Act addressed the positive spillovers that R&D generates for others by subsidizing a wide variety of investments in clean energy R&D. These investments included several billion dollars for

R&D directly related to clean energy. Roughly \$3.4 billion has been awarded for research, development, and deployment of carbon capture and storage technologies. Another portion has funded R&D on potentially transformative, next-generation clean energy and efficiency-enhancing technologies, including advanced materials and building systems, vehicle efficiency, solar power, biofuels, and wind turbines. Recovery Act funds have also been awarded to finance clean energy research at universities as part of a larger \$2 billion effort, managed by the Department of Energy, to support basic scientific research.

Funding for the Advanced Research Projects Agency-Energy (ARPA-E) within the Department of Energy represents an especially innovative R&D component of the Recovery Act. ARPA-E is modeled after the 50-year-old Defense Advanced Research Projects Agency (DARPA), which is credited with the initial innovations underlying the Internet, navigation satellites, and stealth technology for aircraft. ARPA-E aims to attract America's best scientists to focus on creative, transformational energy research that the private sector by itself cannot support but that could provide dramatic benefits for the nation (Box 6-3).

Full details of the Recovery Act and its economic effects, including the law's clean energy components, can be found in the CEA's quarterly reports to Congress.

Further Steps Toward a Cleaner Economy

In addition to the clean energy investments in the Recovery Act, the Administration has taken several other steps to lay the groundwork for cleaner energy. Among the most significant of these are new vehicle standards; increased electricity generation from renewable sources; and programs to record, report, and account for the cost of greenhouse gas emissions.

Vehicle Standards. In May 2010, the Environmental Protection Agency and the National Highway Traffic Safety Administration issued standards that will raise the combined car and light truck fuel economy from 30.1 miles per gallon in 2012 to 35.5 miles per gallon in 2016 and that are projected to reduce combined car and light truck tailpipe CO₂ emissions from 295 grams a mile in 2012 to 250 grams a mile in 2016. As a result of these rules, vehicles to be sold during model years 2012 to 2016 are projected to use 1.8 billion fewer barrels of oil over their lifetimes, and by 2030 the entire light-duty vehicle fleet will emit 21 percent less carbon pollution. The reduced fuel costs will save consumers \$66 billion per year by 2030, in 2009 dollars, after taking into account the increase in the purchase price of vehicles.

Box 6-3: The Recovery Act and ARPA-E: Spurring Innovation to Transform the Energy Economy

The Advanced Research Projects Agency-Energy (ARPA-E) was developed to support innovations with the potential to create new clean energy jobs, businesses, and industries. It attracted thousands of proposals and has funded over 100 projects that have the potential to radically transform the energy sector.

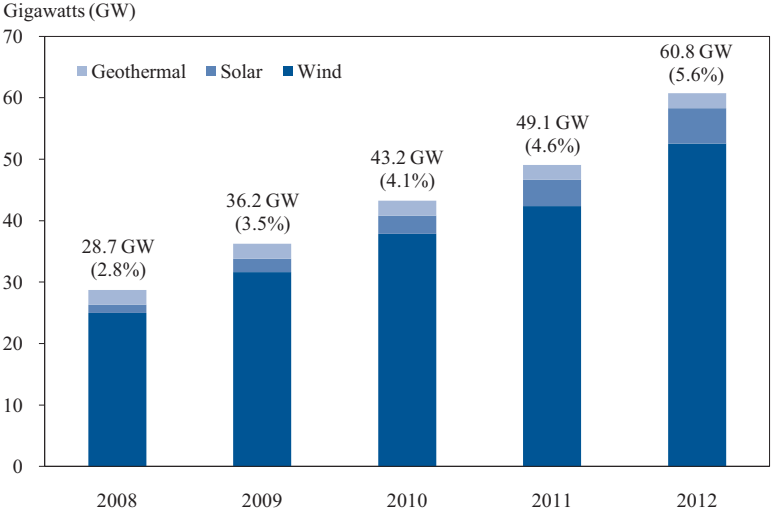
One small startup company is developing a new way to manufacture the key part in solar panels—silicon wafers—for less than 20 percent of current costs. If successful, the technology could be used to increase domestic clean energy production and add many new jobs in the solar photovoltaic industry. A second startup is developing an inexpensive and versatile means of storing energy, using a new type of catalyst to separate pure hydrogen and oxygen from ordinary water. That technology could allow renewable energy to be used even at times or places where wind or sun is not available. Another company has partnered with Argonne National Laboratory to create lithium-ion batteries with the highest energy density in the world. The technology has the prospect of increasing U.S. leadership in advanced batteries and boosting the performance of hybrid/electric vehicles. Yet another small company is developing a new type of wind turbine that generates more energy than existing models and is cheaper to produce and operate. The turbine is compact enough to use in urban locations and could hasten the growth of wind power in the United States.

ARPA-E funds have enabled companies to pursue their innovative research, to attract additional financing from private investors, and to increase the odds of a dramatic breakthrough that would accelerate the development of American clean energy.

Doubling Renewable Electricity Generation. Early in his Administration, the President announced a goal of doubling the amount of electricity generated in the United States by wind, solar, and geothermal energy. Toward this goal, tax credits have assisted both the production of electricity from renewable sources and the manufacture of equipment (such as solar panels and wind turbines) used in that generation. As Figure 6-1 shows, the United States is on track to achieve that goal, adding more wind, solar, and geothermal capacity in 4 years than in the previous 30. Yet as the figure also shows, those particular sources of energy still account for only a small fraction of the Nation's overall electricity generating capacity. To build

on the progress made to date, the President has proposed a Federal Clean Energy Standard to obtain 80 percent of electricity from these and other clean sources of electricity by 2035, expanding the range of sources from which clean energy is generated. The standard will double the share of electricity generated by this broader group of clean sources in 25 years, and will provide utilities with incentives to generate clean energy, along with the associated spillover benefits, at the lowest possible cost (see “Next Steps,” below).

Figure 6-1
U.S. Wind, Solar, and Geothermal Energy Generating Capacity



Notes: Net summer generating capacity of wind, solar, and geothermal energy. Percentages are shares of total net summer electricity generating capacity.
Sources: Energy Information Administration, Annual Energy Outlook 2011; CEA calculations.

Information Provision and Disclosure. In addition to these concrete, tangible steps that increase the efficiency of vehicles and the share of renewable sources used for electricity generation, the Administration has taken two significant steps that involve collecting and analyzing information. These two disclosure and information-gathering endeavors will inform and guide future Federal climate and energy policy.

The first of these was an interagency study to estimate the “social cost of carbon” (SCC), a set of values for the climate-related damages from incremental changes in carbon pollution. These estimates enable Federal agencies to consistently quantify the benefits of reduced CO₂ emissions when analyzing the costs and benefits of their regulatory actions, similar to the way all Federal agencies use consistent discount rates for trading off current and future costs and benefits. Based on the SCC described in Box

6-4, the CO₂ reductions in 2030 resulting from the new car and light truck standards described above are expected to save an estimated \$3.1 billion to \$31.8 billion, in 2009 dollars, in the form of reduced damages from climate change. The ability to quantify benefits consistently across agencies in this manner is critical for assessing the cost-effectiveness of rules and regulations.

Box 6-4: The Social Cost of Carbon: A Tool for Cost-Effective Policy

In 2010, an interagency task force that included the Council of Economic Advisers produced an important white paper called “Social Cost of Carbon for Regulatory Impact Analysis” (Interagency Working Group 2010). The goal was to measure the present value of benefits from reducing CO₂ emissions by an extra ton. The report suggests four values for this social cost of carbon (SCC): \$5, \$22, \$36, and \$67 a ton, in 2009 dollars. The first three average SCC estimates across various models and scenarios and differ based on the rate at which future costs and benefits are discounted (5, 3, and 2.5 percent, respectively). The fourth value, \$67, comes from evaluating the worst 5 percent of modeled outcomes, discounted at 3 percent. All four values rise over time as more carbon in the atmosphere exacerbates the damages from each additional ton. For example, the central value of \$22 rises to \$46 in 2050. These estimates provide guidance for assessing the costs and benefits of agencies’ rule-makings that reduce incremental carbon pollution.

Why is it important for agencies to agree on a common range for the SCC? A key advantage of market-based regulations such as pollution fees or tradable permit schemes is that they are cost-effective. By putting a common price on emissions, these types of policies give each source of pollution equal private incentives to avoid paying that price by abating. The incremental cost of abating pollution will thus be equal across sources, meaning that it will not be possible to reduce collective compliance costs by abating less from some sources and more from others.

While most regulations do not involve a price on carbon, and the SCC is not itself a price, setting a common SCC range allows policymakers to explicitly compare the benefits and costs of emissions reductions across a wide range of regulations, and to mimic the cost-effectiveness of a true market-based policy. The Administration will periodically reassess whether the four SCC values are appropriate for evaluating U.S. policies; meanwhile, the SCC helps guide Federal agencies in the direction of consistent and cost-effective policymaking.

The second information-gathering step the Administration has taken has been to require major sources of carbon pollution to publicly report their annual emissions. The Mandatory Reporting of Greenhouse Gases Rule, published in October 2009, covers 85–90 percent of U.S. emissions from roughly 10,000 facilities. Data collection began in January 2010 for stationary sources, including electricity generators, large industrial facilities, and suppliers of fossil fuels. For cars and light trucks, engine manufacturers are required to report emissions beginning with model year 2011. This important step will be instrumental in helping identify cost-effective opportunities to reduce carbon pollution as well as ways to target regulations efficiently.

NEXT STEPS TOWARD A CLEAN ENERGY ECONOMY

In his 2011 State of the Union address and in his 2012 Budget, the President outlined a series of proposals that build on current efforts to transition to an economy based on cleaner sources of energy. Among these are a Federal Clean Energy Standard for electricity; further investments in energy efficiency; a substantial commitment to transportation infrastructure, including a major investment in high-speed rail and steps to achieve the Administration’s goal of 1 million electric and hybrid vehicles on the streets by 2015; and increased investments in clean energy R&D.

A Federal Clean Energy Standard

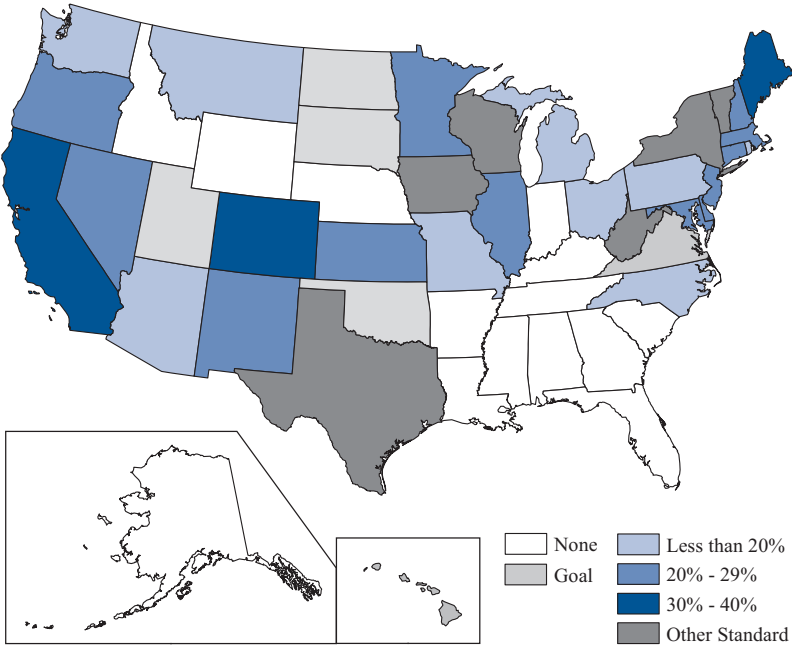
The President has proposed a goal of generating 80 percent of the Nation’s electricity from clean energy sources, defined broadly to include renewables and nuclear power as well as partial credit for fossil fuels with carbon capture and sequestration and efficient natural gas. To meet this goal, the Administration is proposing a Clean Energy Standard (CES) that would require electric utilities to obtain an increasing share of delivered electricity from clean sources—starting at the current level of 40 percent and doubling over the next 25 years. Electricity generators would receive credits for each megawatt-hour of clean energy generated; utilities with more credits than needed to meet the standard could sell the credits to other utilities or bank them for future use. By ensuring flexibility through a broad definition of clean energy and by allowing trading among utilities, the program is designed to meet the overall target cost-effectively. The Administration’s proposal emphasizes the importance of protecting consumers and accounting for regional differences.

The proposed Federal CES will provide a critical complement to the Administration's investment in clean energy R&D, by creating a stable market for new technologies. Funding for R&D provides a "push" to technological innovation by helping to promote basic and applied research and addressing the market spillovers associated with private research efforts. A CES would create economic incentives for deployment of clean energy that can help "pull" new technologies coming out of R&D into the market. Importantly, a CES would not pick particular clean technologies, but instead let markets and businesses determine the most cost-effective technologies to achieve the target share of clean energy.

The Administration's proposed CES will build on the national progress depicted in Figure 6-1, as well as on a range of existing efforts at the state level. By the end of 2010, 31 states plus the District of Columbia had enacted renewable energy standards (RES), which specify the minimum amount of electricity that utilities are required to generate or purchase from renewable sources—typically solar, wind, geothermal, and biomass (Figure 6-2). Five additional states have also recognized specific renewable energy goals. The laws range from modest departures from the overall business-as-usual forecast to requirements that 33 percent of power come from renewable sources in California by 2020 and 40 percent in Hawaii by 2030. Together, the states that have binding RES policies currently account for nearly two-thirds of all national retail electricity sales.

Most RES laws incorporate market-based regulatory flexibility by allowing some utilities to meet the minimum renewable shares by purchasing renewable energy credits (RECs) from other utilities that exceed the standard. Because utilities can sometimes purchase energy and RECs across state borders, the patchwork of state standards depicted in Figure 6-2 can achieve some, but not all, of the cost-effectiveness benefits of a national standard. Although states have led the way, making significant advances in the use of renewable energy sources, a coordinated Federal action could achieve even greater benefits with lower costs. A Federal standard with nationally tradable credits would ensure that renewable power and other clean energy sources are deployed in those locations where they can be most cost-effective. By covering the whole country and including a wider array of sources, a Federal CES has the potential to accelerate the transition to clean energy at significantly lower cost.

Figure 6-2
State Renewable Energy Standards in 2025



Notes: Percentages are renewable energy standards that are binding on utilities. In some states, the standards are binding only on investor-owned and/or large utilities.

Sources: North Carolina Solar Center, Database of State Incentives for Renewable Energy; various state sources.

Energy Efficiency

One certain approach to reducing energy-related pollution and America's reliance on fossil fuels would be to consume less energy. Americans have many opportunities to make energy efficiency-enhancing investments—in their homes, their vehicles, and their businesses. Examples include weatherizing buildings, replacing old appliances with new energy-efficient models, and switching to compact fluorescent light bulbs. For a variety of reasons, however, people tend to under-invest in these types of simple energy-saving measures where up-front costs would be paid back in the form of reduced energy bills.

There are numerous explanations for this energy paradox. People may simply not have the information necessary to evaluate the tradeoffs between current costs and future savings. Some energy efficiency decisions are made by landlords who have diminished incentives to invest in energy efficiency because their tenants pay the electricity bills. In other cases, people may plan to sell their homes before they would have enough time to reap the

energy savings and might not expect those energy-saving investments to be reflected in resale prices. And some individuals simply do not have access to the funds to invest in energy efficiency, even if they know they would earn that investment back many times over. Existing Federal programs designed to address this energy paradox include the Energy Star program, which labels appliances, consumer electronics, and building products, providing the information consumers need to make cost-effective choices, and the Weatherization Assistance Program, which helps cash-strapped low-income families conserve energy and reduce their energy bills.

To build on existing efforts to address the energy paradox and the beneficial spillovers from energy efficiency, and to help boost job creation in the construction and manufacturing industries, the Obama Administration has proposed two new programs to help retrofit buildings: Homestar for residences, and the Better Buildings Initiative for commercial properties.

Homestar. The Homestar Energy Efficiency Retrofit Program would provide point-of-sale rebates to homeowners who make efficiency-enhancing improvements to their homes. Rebates of \$1,000 to \$1,500 would be paid for 50 percent of the costs of straightforward retrofits, including insulation, water heaters, windows and doors, and air conditioners. Other rebates of \$3,000 would help pay for home energy audits and follow-up retrofits that reduce energy costs by 20 percent. Included in the proposal is an oversight program to ensure that contractors are qualified and that efficiency-improving work is done properly. The program aims to create tens of thousands of jobs and save homeowners hundreds of dollars a year in energy costs.

Better Buildings. For the commercial real estate that is currently responsible for roughly 20 percent of U.S. energy consumption, the President has proposed a Better Buildings Initiative. The initiative encourages retrofits of commercial buildings so that they become 20 percent more energy efficient over the next 10 years and save an estimated \$40 billion a year in energy costs. The program calls for replacing the current tax deduction for commercial building upgrades with a more generous tax credit; promotes energy efficiency loans to small business, hospitals, and schools; and provides competitive “Race to Green” grants to state and local governments for programs that encourage energy-efficient commercial upgrades.

Together, Homestar and Better Buildings would complement the energy efficiency progress already made under the Recovery Act, help homeowners and businesses save energy costs, and help the Nation capitalize on the beneficial spillovers from energy efficiency investments.

Transportation

Transportation accounts for more than one-fourth of energy consumption in the United States, so the transition to a clean energy future must enable Americans to choose more energy-efficient vehicles, such as electric and hybrid cars, and to use less energy-intensive modes of transportation, including public transit and high-speed trains.

Vehicles. The President has challenged the Nation to become the first country in the world to have 1 million electric vehicles on its roads, and to do so by 2015. To achieve that goal, several obstacles must be overcome. One obstacle is what the industry calls its “chicken and egg” problem: many drivers will not purchase fully electric vehicles unless an infrastructure of charging stations is ready to support them, and businesses will not invest in charging stations without a sufficiently large base of electric vehicle owners as customers. A second obstacle involves the standard R&D innovation spillover—some of the gains from efforts to develop the first generation of electric vehicles will be earned by producers of subsequent generations of cars.

To help achieve the million-car goal, over \$2.4 billion in Advanced Technology Vehicle Manufacturing loans are already supporting three of the world’s first electric car factories, located in Delaware, Tennessee, and California. To make further progress, the 2012 Budget proposes to provide a \$7,500 point-of-sale rebate to customers who buy electric vehicles; to invest \$580 million toward research, development, and deployment of electric vehicles; and to fund a new \$200 million competitive grant program to reward communities that invest in infrastructure to support electric vehicles.

Americans who continue to choose gasoline-powered vehicles can still make progress toward a clean energy future when those vehicles become more fuel-efficient. The new fuel economy and greenhouse gas emissions standards for cars and light trucks for model years 2012 to 2016 is a step in that direction. To make further progress, the National Highway Traffic Safety Administration and the Environmental Protection Agency have announced plans to develop standards for new cars and light trucks for model years 2017 and beyond, along with the first proposed requirements to increase fuel economy and reduce greenhouse gas emissions from medium- and heavy-duty trucks and buses.

Alternatives to Automobiles. Another way to reduce transportation-related energy use is to provide more Americans with the opportunity to choose alternative, cleaner forms of mobility such as railways for intercity travel and commuting, and bicycles and walking for short local trips. However, all transportation systems require infrastructure investment: automobiles require roads, trains need tracks, and airplanes need airports and air traffic control systems. Throughout U.S. history, public investment

in transportation infrastructure has led to long-term benefits, from the Erie Canal to the transcontinental railroad to the interstate highway system. As Chapter 3 notes, these types of infrastructure investments have been shown to have broad economic spillovers, including increased economic growth, productivity, and land values. Some transportation infrastructure investments, such as public transit, high-speed rail, and improved air traffic control, can also have significant energy efficiency benefits.

For intercity travel, the 2012 Budget proposes enhancements to train and air travel that will reduce energy demands. The United States already has the world's most extensive freight rail network. To extend that expertise to passenger trains, the Administration is proposing to invest \$53 billion over six years to fund the development of a national passenger rail network, including high-speed trains, accessible to 80 percent of Americans by 2035. And for air travel, the budget includes continued investment in the NextGen satellite-based air traffic control system that will reduce delays, improve air safety, and yield significant energy savings.

For short local trips, the Administration is undertaking a number of measures to promote alternative modes of mobility, such as public transit, bicycles, and walking. The 2012 Budget allocates \$119 billion for transit programs over six years, more than doubling the commitment to transit in previous budgets. As part of that, the Administration is proposing \$28 billion in new grants over six years for projects supporting interconnections between various transportation modes and improving streets to make room for pedestrians, bicycles, and mass-transit alternatives.

Research and Development

Finally, a crucial, forward-looking part of clean energy policy involves R&D. As already described, market incentives produce less R&D than would be optimal because innovators create social benefits in excess of their private market returns. These positive spillovers affect every level of R&D, from basic science all the way through demonstration and deployment of existing technologies.

In the past, industries that have invested heavily in R&D have led the United States in creating high-quality jobs and exports. As Chapter 3 notes, R&D-intensive industries are characterized by higher sales per employee and more exports than comparable industries selling internationally tradable goods and services. For the future, the energy sector is a large potential source of R&D-intensive industries—along with the associated high-quality jobs and exports they produce. Other countries around the world face the same energy-related threats to their prosperity as those confronting the United States, and global demand for new clean energy technologies is

increasing. But given the spillovers associated with all R&D, those countries that make public investments in clean energy R&D are likely to be the first to develop those new industries. To address those spillovers, and help ensure that the United States leads the world in this important growth industry, the President has called for more than \$8 billion for clean energy research, development, and deployment incentives.

Research and development funding is often most productive when scientists collaborate across disciplines and institutions. To facilitate that cooperative work, the Department of Energy has launched three Energy Innovation Hubs. Each brings together top researchers from academia, industry, and government to work on a particular energy-related technology. The first three hubs focus on deriving fuel from sunlight, increasing energy efficiency in buildings, and improving nuclear reactors. The 2012 Budget proposes three additional hubs targeted at rare earths and other critical materials, vehicle batteries, and Smart Grid technology for energy transmission. Such funding for research and development will help make future innovations possible, yielding novel ways to produce clean energy and to store and use energy more efficiently.

CONCLUSION

To guide the United States toward a clean energy future, the Administration has enacted and proposed a wide variety of programs, including manufacturing loan guarantees, tax credits and rebates, R&D subsidies, weatherization assistance, new vehicle standards, information reporting requirements, significant investment in transit infrastructure, and a new Clean Energy Standard for electric utilities. The programs are connected in important ways. They are all motivated by the same fundamental economic rationale: the problem that the full social benefits of clean energy R&D, production, and consumption—including energy security, cleaner air and reduced carbon pollution, and enhanced international competitiveness and economic growth—are not reflected in private markets.

Moreover, the programs focusing on different parts of the clean energy supply chain—innovation, manufacturing, generation, and use—are complementary. The benefits from putting 1 million electric vehicles on the road will be fully realized only if the electricity used to charge those vehicles can be generated by clean sources. R&D creates technologies that will be valuable only if they are manufactured and deployed, which is why the Administration has proposed a Clean Energy Standard to create incentives for utilities to use new clean sources of energy. The Clean Energy Standard in turn is complemented by the Administration's programs to enhance energy efficiency.

In the end, all of the Administration’s clean energy programs are united by the overriding goal that in the decades to come American families will prosper in a cleaner, safer world. Today’s investments in clean energy R&D will lead to innovations and new industries with high-quality jobs. Clean sources of energy will mean that Americans breathe cleaner air, enjoy better health, face reduced risks from climate change, and work and do business in an economy facing lower risks from energy-related disruptions—a clean energy future.