NEPI

The National Energy Policy Institute (NEPI) is based in Tulsa, Oklahoma, at The University of Tulsa. NEPI was created in 2008 to provide policymakers with better research with which to design energy policy. NEPI provides expert energy economic analysis for national policies that reduce oil use and oil imports as well as carbon dioxide and other air emission pollutants.

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PROLOGUE

America’s economic prosperity is inextricably linked to its use of energy. While past energy practices have fueled this country’s unparalleled economic growth, it is time to acknowledge the challenges we face in the absence of national energy policy. Excessive dependence on foreign oil and continued massive emissions of carbon dioxide and other airborne pollutants threaten our national and economic security, our health, and our environment. To meet these threats, we need domestically produced energy that is affordable, efficient, less carbon-based, and more sustainable. Such goals demand change. That change is development of a comprehensive national energy policy.

Why do we need a policy to achieve these goals? In our economic system, the marketplace provides the most efficient allocation of goods and services. But some costs of the energy we use are not reflected in the market price of that energy, including the costs imposed by our vulnerable foreign oil supply on our economy and security, the illnesses and premature deaths caused by air pollution, and the unabated direction of climate change. It is the responsibility of our elected leaders to craft a national energy policy that addresses these social costs, primarily through comprehensive, market-driven policies, while preserving the vital link between energy and our economic prosperity.

To help our leaders address America’s energy future, NEPI has engaged some of the country’s leading energy economists to construct a comprehensive methodology, parameters, and components for a national energy policy.

Our study begins with quantifiable targets and timetables. Our goal is to reduce oil use and imported oil by 16% and carbon dioxide emissions by 15% from 2010 levels by 2035. This improvement would include achieving 80% of electric generation from clean energy.

Next, building upon a previous study, we used a common model and metrics to analyze the five most promising policies, all of which use existing technology. Finally, the combination of these potential complementary policies was analyzed for synergistic results.

This work told us how far we would advance toward the targeted goals with each policy, as well as with the combined portfolio, and helped determine the individual and portfolio costs. The five policies consisted of a clean energy standard, an oil security dividend, LNG for transportation, automotive fuel economy, and energy efficiencies. Each policy was tested for cost effectiveness and ability to address the scale of the problem in accomplishing the two targets as well as the societal welfare cost, effect on the national economy and federal budget, and out of pocket consumer costs.

The results are both surprising and encouraging. We learned we can achieve solutions that are viable, low-cost, and realistic without calling upon undiscovered technologies or political miracles. The work is not offered as a prescriptive presentation. Rather, it is an exemplary exercise showing the possibilities for a comprehensive change and offering a blueprint for its structure. Our purpose is to make a positive contribution in the urgently needed debate about building America’s energy future.

Tony Knowles
NEPI President
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Part 1: Need, context and challenges for America's energy policy

A coordinated energy policy that can meet major American objectives for reducing fossil fuel use and emissions is well within the financial means of society. That is the conclusion of this project. We studied a portfolio of five complementary policies that would substantially ease U.S. vulnerability to oil imports and cut carbon dioxide output. By focusing on off-the-shelf technology and existing policy tools, we held costs exceptionally low. By 2035, consumer out-of-pocket costs were flat or negative; federal outlays were insignificant, and impact on Gross Domestic Product was too small to model. Extending tax incentives reduced federal revenue $120 billion over 20 years. The combination policy isn’t free—costs are explained throughout the report, and summarized in the conclusion—but even our most pessimistic estimates compare favorably with the cost society already incurs for living without an energy policy. A smart, aggressive policy to reduce carbon emissions and oil imports is something we can easily afford.

We have examined the many interlocking parts of our energy system through a single lens capable of bringing a comprehensive policy into focus. The clarity of our lens relies upon quantifiable, achievable targets to state our goals; consistent metrics to look at costs; a common modeling system to forecast policy outcomes; and analysis of how policies and policy combinations can scale up to the magnitude needed to meet the targets. The result is a package of five policy initiatives, using reliable, familiar technology, that can significantly mitigate U.S. climate change impacts and reduce oil use and imports over the next 20 years at a reasonable cost.

The starting point for our analysis is the year 2010. The Energy Information Administration (EIA) reports a wealth of energy data to paint a picture of the energy economy at that time. Figures 1.1 and 1.2 show liquid fuels use and energy-related carbon dioxide emissions by sector for the year 2010.

The challenge of developing a credible energy
policy is to exercise imagination within the realm of the possible. Choices must be evaluated on an even footing, taking into account economic and social implications, not only technological promise. An appealing alternative without political viability cannot be included. A meaningful energy policy must be practical to adopt and implement in the near term, and able to achieve benefit in the long term for the nation and its people.

We have addressed this complex planning challenge through an approach that is conceptually simple. Beginning with our 2010 report, written in partnership with Resources for the Future, we considered the broad array of energy options. We selected specific oil consumption and carbon emission goals that were achievable and justifiably beneficial. We compared 35 policies and combinations of policies to work toward our goals using consistent metrics and a common modeling system. Finally, here, we have combined the most promising of those options in a clear, integrated package derived from the analytical process—the package that could take us toward our goal at a reasonable social and economic cost.

The five elements in our package of policies are:

- **NEPI Clean Energy Standard**: Establishes a 2035 goal for clean electrical generation and requires technology-neutral, market-driven decisions by utilities to use low-carbon and renewable fuels to achieve this target.
- **Oil security dividend**: Imposes a modest, graduated oil products tax that is fully rebated through the tax system to the public.
- **Automotive fuel economy**: Follows the Corporate Average Fuel Economy (CAFE) Standards as adopted in 2012, and considers an alternative ‘feebate’ mechanism with similar impact and potential advantages.
- **LNG trucks**: Provides a temporary fuel tax reduction to encourage the nascent shift in the heavy truck market from diesel to liquefied natural gas (LNG).
- **Energy efficiency**: Extends existing incentives for energy-saving appliances and building codes and home-based renewable energy.

Each strategy works by itself, but the comprehensive policy is more than a shopping cart of unrelated initiatives. Like a well-cooked dish whose flavors combine into a successful whole, these five individual policies are designed to complement one another for greater collective benefits. The whole is greater than the sum of its parts, with significantly increased impact, because of the way the integrated policies interact to boost their collective effectiveness. Through modeling and analysis, only policies with complementary impacts are included. The combination of policies is discussed in detail in Part 3.

Our intent is not to advocate for these particular choices. An adopted national energy policy will surely have other features, and some options we highlight may not be favored through the political process. We instead present this work as an aid for policy makers to move forward, asking them to use its analysis as a light showing the way to meaningful reductions in our use of fossil fuels, dependence on foreign oil, and emissions of greenhouse gases.

### 1.1 Purpose of the energy policy

Our country’s well-being depends on fulfilling national needs that are not currently valued in the energy market. Americans pay real costs for the effects of climate change, the health impacts of air pollution, and the economic and national security burden of dependence upon insecure oil supplies. The premise of this project is to reduce the total social and economic price of energy by embedding these costs in the energy market rather than continuing to allow energy users to impose them on others without

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paying. With initiatives in place to account for the real costs of energy use, the market itself can effectuate our policy goals. We need not pick winners among technologies or industries.

Implicit in the use of the market to achieve national goals is the recognition that affordable, readily available energy is essential to the American way of life. A subsidiary goal of any practical national energy policy must be to avoid interference in energy markets that would significantly diminish standards of living. Figure 1.3 shows the historical relationship between energy use and the growth of the economy. A market-based policy approach supports this subsidiary goal by blending national priorities with private needs. The alternate approach, of mandating technologies and programs, often costs more and works less effectively because it does not take advantage of the market’s ability to harmonize these conflicting interests.

Society’s cost for climate change cannot be calculated precisely, but ample evidence points to a developing threat to national security and the economy, as well as peril to the natural world. These tangible and intangible costs, already real, will increase over decades, if allowed, and eventually become catastrophic. Reducing emissions from burning fossil fuels is the most effective way to mitigate climate change. The human health gains from reduced emissions of air pollution are an additional and immediate benefit.

America’s excessive dependence on oil and imported oil (Figure 1.4) also threatens our national security, at the cost of lives and treasure, and exposes our economy to painful burdens and shocks. International agreements prevent us from limiting oil use by reducing imports through quotas or tariffs. Instead, we can adopt other policies that reduce our use, while allowing domestic production to grow. Reducing our use of oil also assists with the goal of lowering carbon dioxide emissions.

The clarity of these problems allows us to state our policy goals simply. We must reduce our emissions of carbon and other pollutants from fossil fuels. We must reduce our use of oil as long as politically unstable regions are an important source of global supplies. These two goals, meanwhile, must be achieved in the context of America’s continued prosperity, without diminishing the freedom and economic vitality empowered by affordable access to energy.
1.1.1 The goal of reducing carbon dioxide emissions and air pollution

The destruction caused by Superstorm Sandy in 2012 renewed the public’s sense of urgency about climate change by making manifest the consequences of ever-increasing carbon dioxide concentrations in the atmosphere. Although the storm’s existence cannot be attributed directly to climate change, some portion of its severity probably does relate to elevated sea surface temperatures caused in part, over a span of time, by atmospheric warming due to greenhouse gases. Likewise a historic drought across the United States in 2012 focused attention on the issue, regardless of its proximate cause.

These events illustrated the sudden, patchy and unpredictable nature of costly climate change impacts. More than a decade ago the scientific community disposed of doubt that human carbon dioxide emissions would drive atmospheric warming, but the focus of discussions centered on a seemingly gradual and distant increase in global mean temperature. Through 36 consecutive years of above-average global temperatures (Figure 1.5), the perception of an incremental threat led to a cautious accounting of incremental mitigation strategies, up to 2012, the warmest year ever in the U.S. (Figure 1.6) Now a different calculation is required by the recognition that the climate’s response could be violent and regionally disastrous even before atmospheric concentrations of CO₂ reach the milestone levels cited in international goals. With the prospect of unacceptable costs, mitigation efforts become insurance premiums against catastrophe.

1.1.1.1 New concern about extremes

Recent developments in climate science suggest modeling predictions have been too conservative. The decades-long shrinkage of the Arctic Ocean ice sheet, which came to a new record low ice extent

Fig. 1.7a Arctic Sea Ice Extent 09/18/2007

Fig. 1.7b Arctic Sea Ice Extent 08/26/2012

in 2012 (Figures 1.7a and 1.7b), is but one indicator that the mid-range estimates of climate sensitivity may have been too low—no model predicted ice retreating at this rate. While the quantity of carbon dioxide added to the atmosphere is known, the climate’s rate of response, or sensitivity, remains the most important unknown in predicting climate change.
The lower boundary of sensitivity is well established, but the upper boundary has been relatively difficult to pin down and may be theoretically unknowable with greater precision than already exists.\textsuperscript{2}

The worst-case-scenario of climate sensitivity becomes especially relevant if we think of carbon reductions as insurance against catastrophe. For example, with continued reliance on fossil fuels, the Intergovernmental Panel on Climate Change (IPCC) projects a 3 to 6 degree C increase in global mean temperature by 2100. Scientists predict that a 5 degree C increase, which has a one-third probability, would cause loss of major crop species and a decline in the human carrying capacity of equatorial regions. At a global mean increase of 7 degrees C, portions of the planet become physically uninhabitable due to heat stress, and at 11 to 12 degrees C the uninhabitable regions cover most of the current population of the Earth.\textsuperscript{3} The likelihood of such scenarios can be very low yet still justify significant current expenditures to make sure they do not occur.

### 1.1.1.2 Climate-related threats

The costs of climate change impacts will reach unacceptable levels far short of global catastrophe. Economic losses are already accumulating from extreme weather events, changes in water distribution and precipitation affecting industries ranging from agriculture to winter tourism, and forest destruction by fire and insect infestation in changing biomes, to name but a few impacts. In complex ecological systems gradual change can reach unknown thresholds that trigger rapid, unanticipated change. Likewise, complex human systems sometimes exhibit unexpected fragility, as when a minor fault in the electrical grid cascades into a major blackout for a broad swath of the country.

The national security threats due to climate change fall in this category of unpredictable change with the potential to cascade into catastrophe. The National Academy of Science, working with the U.S. intelligence community, has identified a long list of social stresses caused by climate trends or extreme weather events that could lead to violent internal or international conflict, including water, food and health security, epidemics, humanitarian crises and disruptive migration. Environmentally vulnerable and politically unstable countries would flare first in these scenarios. For example, drought and resulting hydropower outages in Pakistan in 2010 and 2011 led to demonstrations and riots and increased tension with India over the Indus River. Both nations are armed with nuclear weapons.\textsuperscript{4}

Climate change not only imposes costs that are difficult to know, it also threatens resources for which establishing a market price is impossible because their value is intangible or is of a kind that transcends materialism. IPCC estimates 20 to 30 percent of plant and animal species are at risk of extinction by the end of the century, a rate 10,000 times that found in the fossil record.\textsuperscript{5} Scientists studying the acidification of the oceans due to

\textsuperscript{3}Sherwood and Huber PNAS 2010.
\textsuperscript{4}Steinbruner, et al., Climate and Social Stress: Implications of Security Analysis; National Research Council, 2012.
\textsuperscript{5}http://www.epa.gov/climatechange/impacts-adaptation/ecosystems.html#Extinction
human carbon dioxide emissions say it is probably already too late for coral reefs to be expected to survive, and many other shell-bearing organisms are at risk if the increase in acidity does not cease.

1.1.1.3 Toward a climate solution

Embedding the price of insurance against climate catastrophe in the cost of fossil fuels would tend to drive energy use toward fuels that emit less carbon and thereby reduce the probability of an unlivable future. The combined uncertainties of climate science, economics and geopolitics have foiled previous attempts to set a precise price on emissions. The error bar on IPCC’s 2007 carbon price estimate spans two orders of magnitude, from $10 to $350 per ton of carbon dioxide. But lack of precision is no reason to ignore a danger that is, in its general outline, very certain. Our plan’s target for emission reduction is covered in Section 1.5 of this part, along with a discussion of the current trajectory of emissions levels.

When it unanimously rejected the Kyoto Protocol in 1997, the U.S. Senate resolved that the U.S. should not commit to reduce greenhouse gas emissions without a similar commitment from developing countries. But energy users’ responsibility to pay the cost of their emissions does not depend on whether others also do so. Moreover, the benefit of reductions redounds to the United States as well as any other nation. As a major energy user and emitter of carbon dioxide, the United States may need to take a leadership role in stimulating action by other countries. As a practical matter, international negotiations on carbon reduction offer no real alternative. They have proved costly, ineffective and even potentially counter-productive, as the expectation of an international agreement diminishes political will for unilateral reductions. The vast majority of success to date has come through local, state and national efforts. This is likely to continue.

1.1.1.4 Reducing air pollution

To cut greenhouse gas emissions, Americans will, among other changes, burn less of the dirtiest fuels upon which we currently rely for power, the most important of which is coal. Burning coal and oil, using current technology, produces air pollution which injures human health (although oil is cleaner than coal). Pollutants such as fine particulates, ozone, nitrogen oxides, and sulfur dioxide can damage the respiratory system, and methylmercury from coal can impair children’s neurological development. Americans have already received enormous benefits relative to their costs by reducing these pollutants through the Clean Air Act. Additional reductions in use of dirty fuels will further improve human health and increase lifespans. See the sidebar on “Air pollution,” on page 7 for more on the health aspects of these pollutants.

1.1.2 The goal of reducing oil vulnerability

Oil vulnerability has played an outsized role in the economic and foreign policy history of the United States since the 1970s, when domestic supplies began to fall seriously short of demand. In the past few years U.S. imports have been lower due to technological advances boosting domestic production, and economic weakness and energy conservation restraining demand (Figure 1.8). America’s oil use declined 2.5 million barrels a day (mmbd) from 2007 to 2011, and our domestic production from land and waters yielded an increase of half a million barrels of crude oil a day during that period. Overall, we reduced imports from 61% to 50% of our consumption, which now totals 17.4 million barrels a day.

The relevant oil issue, however, does not concern petroleum imports but our vulnerability to overseas
Air Pollution

The air we breathe may be our most fundamental common resource. When it is polluted with smokestack and tailpipe emissions, we have no escape or recourse, yet the illnesses caused thereby harm and kill thousands of Americans. The value of clean air and the responsibility of industry and society to control emissions are beyond serious debate.

Combustion for energy production and transportation emit a dominant share of the pollutants harmful to human health, including sulfur oxides, nitrous oxides, methylmercury, and particulates. Here are some health effects of these pollutants:

- Sulfur oxides can aggravate respiratory illnesses, especially affecting people with asthma. In the atmosphere, sulfur oxides form small particles that cause or worsen diseases such as emphysema, bronchitis and heart disease. In the environment, sulfur oxides cause acid rain.
- Nitrous oxides have impacts similar to sulfur oxides, including respiratory effects and formation of harmful particles. In addition, nitrous oxides react with sunlight and heat to produce ground-level ozone, which produces smog and harms the lungs.
- Methylmercury is the organic form of the element mercury most often affecting humans, because emissions into the atmosphere accumulate in fish. Among the many ways mercury harms human health, the most severe are to children and fetuses, in whom it can damage brain development, causing lifelong mental deficits.
- Particulates are simply particles of chemicals or soot small enough to lodge deep in the lungs. Besides respiratory impacts, they can cause heart attacks, strokes, and a variety of other serious illnesses leading to death.

The health cost of these pollutants for Americans, overwhelmingly from coal and oil combustion in power plants and motor vehicles, totals $120 billion annually, according to a 2009 study by the National Academy of Sciences, mostly from the 20,000 premature deaths they cause. (Figures are in 2000 dollars.) The Academy calculated the uncompensated health cost of electricity produced by coal-fired power plants at 3.6 cents per kilowatt hour, almost a third of the retail price of power for all customers in the United States. The similar price for a gallon of gasoline or diesel came to 23 to 38 cents per gallon. The Academy study found total air pollution health costs attributable equally to coal and oil.

Huge improvements can be made to these costs through regulations that require state-of-the-art pollution controls. A modern coal power plant can reduce the health cost of its emissions by more than a factor of 10 over one not using the latest technology. EPA regulations that will phase in over the next four years will dramatically reduce this pollution. But improvements could continue to increase longer by switching to fuels that produce less pollution in the first place—first to natural gas, and then to clean energy such as nuclear and renewables. A program to make that kind of progressive improvement requires a market-based strategy that includes the cost of pollution in the price of the power and fuel we use.

This report proposes such market-based policies to address carbon dioxide emissions and oil consumption, adding to and extending the benefits of the new EPA pollution regulations on power plants (see Section 2.1.4.6). Carbon dioxide in fact does not directly harm human health. Its constituent elements, carbon and oxygen, are the fundamental material of life. But efforts to reduce carbon dioxide emissions to mitigate the global warming will simultaneously curtail air pollution that damages our health. Likewise, reducing the use of oil, while addressing American dependency on foreign sources, will save lives at home by cleaning the air.

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a large oil consumer. Coordinated policies that reduce oil consumption within large economies often reduce the world oil price, particularly if the governments use domestic energy policies rather than international trade policies like tariffs or quotas.

The simplest method to reduce oil imports would be an import tax or quota, options lacking political viability either domestically or in keeping with free trade agreements. Instead, we propose to reduce oil imports by reducing oil use while allowing domestic production to increase. This approach also supports our goal of reducing greenhouse gas emissions from burning fossil fuels. Our targets for this goal are covered in Section 1.5.

1.2 Current status of achieving an energy policy

Something like the weather, national energy policy is a topic everyone talks about but no one does anything about. Eight presidents have declared the necessity of reducing oil use, yet no comprehensive national energy policy has ever passed Congress. Instead, states and the federal government have enacted piecemeal legislation for particular issues in different parts of the energy economy. While these policies have accomplished important individual goals, the overall need to reduce oil vulnerability, greenhouse gas emissions and air pollution remain to be addressed in a broad and coordinated way. Never has the federal government considered all the interlocking parts of these issues, the available technology, and the social and economic costs and benefits. That is our goal.

In part, events have intervened where policy makers have been unable to act. The last several years have seen encouraging trends of increased energy efficiency (Figure 1.10), reduced oil use, increases in domestic oil production, and a flattening of carbon dioxide emission levels from developed nations, including the U.S. But some of these changes were unpredictable and did not all come from welcome causes. The world economic crisis and years of slow recovery depressed use of petroleum and other fossil fuels worldwide. The lack of economic activity was the primary reason why carbon dioxide emissions did not rise at their previous rate.

Domestic oil exploration and development rejuvenated, thanks to new fields and technological advances for recovering oil from tight shale deposits and with horizontal drilling. The new availability of abundant natural gas from shale also benefited the national carbon footprint, as a sharp decline in gas prices put coal at a competitive disadvantage for power production. Gas-fired plants emit half as much carbon, less than a third the nitrous oxides, less than 1 percent of the sulfur oxides and particulates, and no methylmercury.

Natural gas mainly improves carbon emissions by displacing coal for electrical generation. Coal produces 80% of carbon emissions caused by power production (Figure 1.11), with power plants

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Fig. 1.10  U.S. Primary Energy Use and Energy Intensity 1949–2011 (quadrillion Btus; thousand Btus/2005 $ GDP)

Fig. 1.11  Power Sector CO2 Emissions by Fuel - 2,271 million metric tons 2010

Data source: EIA

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accounting for 40% of U.S. energy-related emissions. In the longer run the lower natural gas price may work against renewable sources other than traditional hydropower, such as wind and solar. Currently, these renewable sources provide less than 5% of electrical generation (Figure 1.12)

Americans allocate more than 90% of our oil to transportation and industry (Figure 1.1, page 1), sectors which together are responsible for half our carbon emissions.

1.2.1 Past energy policy initiatives

Despite the lack of a comprehensive national energy policy, Americans have taken action on various individual issues affecting our energy economy. Some efforts have been small but worthwhile, such as decisions by individual families to drive hybrid vehicles or install efficient lighting, while others have been large but inefficient, such as the federal government’s investment in ethanol as an alternative fuel. America is an experiment and our willingness to try new ideas is a strength. While only a few broad-scale initiatives have measurably affected outcomes on the national level, we can draw useful lessons from these individual pieces of energy policy attempted by the states and the federal government.

1.2.1.1 Sulfur dioxide and nitrous oxide cap-and-trade

Congress established the federal government’s first cap-and-trade emission reduction program in 1990, under the leadership of President George H.W. Bush. The Acid Rain Program (ARP) aimed to reduce emissions of sulfur dioxide that damage lakes, forests and soils through acidic precipitation. Instead of mandating new technology on power plants that emit sulfur dioxide, the program created a cap on emissions, but allocated permits to individual emitters that they could buy and sell to meet the cap. The market in permits allowed those who could reduce their emissions at the lowest cost

Table 1.1 Emissions, Heat Input, and Emission Rates from Acid Rain Program Sources 1990 - 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>SO2 (million tons)</th>
<th>NOx (million tons)</th>
<th>Heat Input (billion mmBtus)</th>
<th>SO2 Rate (lbs/mmBtus)</th>
<th>NOx Rate (lbs/mmBtus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>15.7</td>
<td>6.7</td>
<td>19.68</td>
<td>15.73</td>
<td>6.66</td>
</tr>
<tr>
<td>2000</td>
<td>11.2</td>
<td>5.1</td>
<td>25.62</td>
<td>11.20</td>
<td>5.10</td>
</tr>
<tr>
<td>2005</td>
<td>10.2</td>
<td>3.6</td>
<td>27.14</td>
<td>10.22</td>
<td>3.63</td>
</tr>
<tr>
<td>2010</td>
<td>5.2</td>
<td>2.1</td>
<td>27.00</td>
<td>5.17</td>
<td>2.10</td>
</tr>
<tr>
<td>2012</td>
<td>3.3</td>
<td>1.7</td>
<td>25.28</td>
<td>3.32</td>
<td>1.71</td>
</tr>
</tbody>
</table>

*2012 are preliminary as of February 19, 2013

Data source: EPA

7http://www.eia.gov/electricity/monthly/xls/table_1_01.xlsx
to profit by their improvements while imposing relatively manageable costs on those who did not have cost-effective options to reduce emissions. Later, the Environmental Protection Agency (EPA), which administers the Acid Rain Program, added a similar cap and trade program for nitrous oxide emissions that create smog-producing ozone pollution and also contribute to acid rain, broadening the concept to reduce unhealthy pollution that drifts from state to state.

The EPA’s cap-and-trade programs have gone through various changes and court challenges, but their record of success is accepted by academia, business and regulators (Table 1.1). EPA’s analysis claims the programs have reduced tens of thousands of premature mortalities and saved up to $100 billion in health costs. Sulfur dioxide and nitrous oxide emissions from U.S. power plants both went down by about 60% from 2000 to 2011. The General Accounting Office estimated the cost of these reductions may have been halved by using cap and trade rather than a command-and-control regulatory approach.

1.2.1.2 CAFE Standards

Corporate Average Fuel Economy Standards, first enacted by Congress after the Arab oil embargo of the 1970s, require vehicle manufacturers to improve the fuel efficiency of their products. Vehicle fuel efficiencies improved for cars but (until 2005) not trucks as a result of these programs (Figure 1.13). By 2001, fuel use was one-third less than it would have been without CAFE Standards, according to the National Research Council, although higher gas prices also played a role. The federal government further tightened CAFE Standards during the George W. Bush and Barack Obama administrations.

CAFE Standards represent the nation’s singular success story and most powerful policy tool for reducing oil use for transportation, but the policy’s unintended consequences were significant as well. By exempting larger passenger vehicles, euphemistically categorized as light trucks, Congress created a perverse incentive for the explosion in market share of gas-hungry sport utility vehicles and minivans. By 2005, those categories constituted more than half of vehicles sold.

Changes in recent years have addressed some of the program’s flaws and introduced a market-based element, allowing manufacturers to trade credits for meeting the standard. However, the resulting CAFE Standard rules are complex. While incorporating the existing program in our policies, we have also studied a simpler, more flexible market mechanism that could produce the same result.

1.2.1.3 Energy efficiency standards for appliances and buildings

To reduce the waste of energy is among the most obvious and familiar ways of reducing fossil fuel use, and one that is within the capability of every homeowner. Since 1987, the federal government

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*http://www.epa.gov/airmarkets/progress/ARPCAIR11_downloads/emissions.xls

has set efficiency standards for 55 products, and energy-saving efforts have accelerated in recent years. Building codes can also save energy by influencing design and materials, but they are not as easily managed at the national level, since codes are locally enacted by state and local governments. The International Code Council promulgates model codes that are widely adopted with local revisions, and the U.S. Department of Energy seeks to guide this process by publishing analyses and recommendations.

1.2.1.4 Federal Air Quality Act and EPA requirements

The Air Quality Act, passed in 1967, began the federal government’s regulation of air pollution, followed by the Clean Air Act, passed in 1970, and creation of the EPA the same year. Including amendments that significantly strengthened it in 1990, the Clean Air Act gives the EPA broad power to create programs managing sources of air pollution. In 2007, the U.S. Supreme Court ruled that the act also obliged the EPA to regulate greenhouse gas emissions unless the EPA determined the gases clearly do not contribute to climate change.\(^\text{11}\) Political and legal challenges to that additional authority have failed and EPA has indeed issued rules to limit carbon dioxide emissions from vehicles and stationary sources.

The Clean Air Act stands as one of the nation’s greatest environmental achievements. The EPA estimates that by 2010 more than 160,000 deaths had been averted by the 1990 amendments to the act, as well as 130,000 heart attacks, 1.7 million asthma exacerbations, and 13 million lost work days. It calculated that by 2020 benefits of $2 trillion would come at a cost of just $65 billion.\(^\text{12}\)

But the linkage of these efforts to national energy policy remains haphazard, like the EPA’s court-mandated authority for climate change measures. Although the Supreme Court and EPA classified carbon dioxide emissions as harmful, those decisions came only after a lawsuit brought by 12 states, not through a rational policy-making process. Consequently, the legal framework is a misfit for the problem. A rational policy to address climate change would look at the sources, uses, and conservation of energy, not only the contents of the tailpipe or smokestack.

1.2.1.5 State renewable energy portfolio standards

States have responded to the vacuum in national energy policy with their own initiatives (Figure 1.14). The mix of standards, incentives, rebates and other energy policies pursued at all levels of government and by utilities themselves cannot be summarized; they fill a database.\(^\text{13}\) These policies represent progress on energy conservation and carbon mitigation, and for that we can thank the U.S. system’s exceptional ability to respond to problems regionally and at various governmental levels. Indeed, some components of an energy policy can only be accomplished with state and local involvement, such as improving local building codes for energy efficiency. But the most important tools for accomplishing our major goals—of reducing oil use and greenhouse gas emissions and air pollution—lie beyond the reach of the states.

1.2.1.6 Regional carbon reduction schemes

In the absence of federal action on climate change, a group of 10 northeast and mid-Atlantic states created the Regional Greenhouse Gas Initiative, which seeks to reduce carbon dioxide emissions from power generation by 10% by 2018. The cap-and-trade program began in 2009 and has held a number of auctions for allowances, with states spending the proceeds on projects benefiting the public and carbon reduction goals.\(^\text{14}\) The initiative raised less money than expected because a surge in utilities’ use of natural gas caused carbon dioxide emissions to abate on their own (the states are considering a lower carbon cap to respond).\(^\text{15}\) Calling the program a failure, New Jersey

\(^{12}\) EPA CCA Second Prospective Study 1990-2020.  
\(^{13}\) Such a database can be found at http://dsireusa.org/  
\(^{14}\) http://www.rggi.org/  
\(^{15}\) http://www.ctmirror.org/story/18431/overhaul-ner-regional-greenhouse-gas-initiative
Governor Chris Christie withdrew his state in 2011. The remaining nine states continue to participate, but New Jersey’s action highlights the vulnerability of state coalitions when trying to do the work of the federal government.

California faces similar and additional challenges as it begins a more ambitious carbon cap-and-trade program in 2013, which is intended to cover many sources in addition to electric generation. Other western states that planned to participate did not follow through, and California will go it alone. By itself, the state loses the advantages of a larger market for carbon allowances, and is vulnerable to industry leaving the state to avoid the new costs. Utilities using the power transmission grid may simply send lower-carbon power to California and keep their overall generation profile unchanged. Finally, California’s program has been challenged on the grounds that it interferes with interstate commerce, in violation of the U.S. Constitution.

Only the federal government can overcome the difficulties facing states addressing these issues on their own.

17 http://www.washingtonpost.com/opinions/californias-climate-change-experiment/2012/12/30/423b44204f411d03f6d3c4a4fcb4d11_story.html

1.2.1.7 Federal ethanol and renewable energy policy

U.S. policy on biofuels and other renewable energy has suffered from decision making influenced by parochial political factors and with a short-term outlook. America’s main biofuel is corn-based ethanol, which does reduce the need to import oil, but does so at a high cost and without reduction of carbon emissions, since the carbon footprint of corn production offsets the benefits of lowered fossil fuel use. In 2005, Pimentel and Patzek found that corn ethanol costs 29% more in fossil fuel energy than is gained from the resulting ethanol. In addition, the diversion of agricultural resources from producing human food to making fuel is unsustainable and can exacerbate poverty by increasing world food prices. As Oliveira finds, “The direct and indirect environmental impacts of growing, harvesting, and converting biomass to ethanol far exceed any value in developing this alternative energy resource on a large scale.”

While Congress has tailored biofuel policy to fit the needs of corn producers, it has encouraged wind and solar energy in only a short-term, piecemeal fashion, with mixed results. Rapid growth of the renewable energy industry encouraged by...
federal policy over the last decade led to retrenchment when incentives ran out and competition stiffened from subsidized overseas producers and low natural gas prices. Also, solar and wind installations produce power only when the sun shines or the wind blows, not necessarily when customers want electricity. Without technology to economically store this intermittent power production, the usefulness of solar and wind remain fundamentally limited. Like biofuels, these energy sources have the potential to contribute to our national energy goals, but achieving that potential requires a consistent, comprehensive policy to make them part of a predictable, rational market for clean energy.

1.2.2 Results of current policy

America’s energy policies have been uncoordinated, inefficient and sometimes irrational, but, as we have seen, they have not been entirely ineffective. The Clean Air Act saved thousands of lives and CAFE Standards slowed the growth of oil use, to name but two examples. But these improvements did not fully internalize all of the excluded social costs.

From 1990 to 2011, the world’s carbon dioxide emissions increased more than 50%. (See Figure 1.5 on p. 4) During that period, the atmospheric concentration of carbon dioxide rose from 354 parts per million to 392 (Figure 1.15). The United States’ increase in carbon dioxide emissions was more modest, and some European countries managed significant reductions in emissions after signing the Kyoto Protocol in 1997. But much of this improvement came about when industrial production moved to east Asia, especially China, which in 2007 surpassed the U.S. as the world’s largest greenhouse gas emitter. For example, the U.K. reduced its carbon emissions by 15% from 1990 to 2005, but its carbon footprint—the carbon emitted to make the products its citizens’ use—rose by 19% when imported goods are taken into account.

The bottom line for climate change is not good. Carbon intensity of energy production worldwide has increased due to the low price of coal. Scientists now agree the international goal of limiting warming to 2 degrees C is out of reach. Leaders in various nations have resigned to inevitable climate warming and are emphasizing adaptation rather than avoidance of change. Two decades have been lost without significant progress.

America has made progress on reducing oil imports in the last few years, but, as discussed earlier, credit for this improvement belongs to improved petroleum industry technology, high energy prices that reduce energy consumption, and a prolonged economic slump rather than any intentional policy moves by our government. Projections based on a business-as-usual approach to the energy market show that world oil prices will trend higher over the next few decades. Perhaps more worrisome, much of the world’s oil supply will remain in politically volatile regions where supply interruptions can disrupt the flow of petroleum.

At least two lessons may be drawn from these mixed results. On one hand, we have the lesson that policy does work to positively influence our energy use and health when we take action as a nation. On the other hand, we have the lesson that to work well, policy must take into account the economic drivers of human behavior and be integrated into our daily decision-making, allowing technology and the marketplace to operate within the context of our goals, rather than be controlled by them. Command-and-control policies, often beset by unintended consequences, produce results far inferior to flexible, market-based solutions like the sulfur dioxide market in the United States.

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20 NOAA Earth Systems Research Laboratory
http://www.esrl.noaa.gov/gmd/ccgg/trends/

21 This and other numbers in this subsection: Nature special section “After Kyoto,” Vol 491 p 653-667 (11/29/12)
22 Ibid
Finally, the evidence of these decades shows that our actions really do matter for the health and prosperity of our future, and for the integrity of natural systems on Earth. In 2011, the United States consumed the energy equivalent of 2.3 billion metric tonnes of oil, far more than double any other nation except China, which consumed just 15% more than the U.S. (much of it to produce products for our use). (Figure 1.16) Yet we have only 5% of the world population. U.S. per capita energy use remains four times that of China (Figure 1.17). Our actions, even in the absence of cooperation from other nations, will make an important difference, for bad or for good.

1.3 The purpose of this report

This report presents practical solutions to meet the goals of reducing use of imported oil and of reducing carbon dioxide emissions and air pollution. Simply stated, we can achieve these goals by burning less fossil fuel for transportation and electrical generation and by using a cleaner mix of the fossil fuels we do burn. Our analysis in this report and the related 2010 report points to the best policies to achieve these ends, taking into account technology, economics, legal mechanisms and, to the extent needed for real-world impact, the political viability of the solutions we have studied.

1.3.1 Pricing policy: benefits and lack of political viability

The most efficient, simplest and least expensive tool to achieve our energy policy goals would be a tax on carbon emissions. Such a tax, designed to increase the price of high-carbon fuels, would reconnect the social cost of energy paid by everyone to the users who benefit from its use. Higher prices would encourage conservation and substitution of cleaner fuels, lowering carbon emissions, reducing air pollution, and cutting the need to import oil. The allocation of funds raised by the tax would be less important than the incentive it would create for energy users. When the price of
fuel reflects its true cost to society—including the cost for national security, economic security, climate change and health—those externalities are addressed by the change in user behavior, regardless of how the tax money is spent.

A cap-and-trade system for carbon reduction is, in effect, a type of carbon tax. The need for fossil fuel users to obtain carbon emission credits or allocations imposes increased cost on high-carbon fuels, discouraging their use, and thereby mitigating the externalized price previously borne by society as a whole. Making allocations tradable allows those who can reduce their emissions relatively easily to profit by selling unneeded allocations to more intensive emitters. Trading should add efficiency to the system by allowing the market to choose the lowest-cost solutions.

Our research in the 2010 report confirmed that a pricing policy such as a carbon tax or cap-and-trade program would be the most cost-effective way to meet our goals. Unfortunately, the political climate in the United States does not support such a tax. The Waxman-Markey American Clean Energy and Security Act of 2009, which would have established a cap-and-trade system, died in the U.S. Senate in 2010 without coming up for a vote. With gasoline prices already a potent political issue, Congress appears unlikely to pass legislation that would increase the cost of fossil fuels for consumers.

1.3.2 Finding alternatives to pricing policy

The task of designing a national energy policy without a carbon tax begins with analyzing technology. Do we have technology available to meet our goals of reducing use of imported oil and reducing greenhouse gas emissions and air pollution? To be included for consideration, any technology we screen must meet several criteria. It must be capable of conserving energy or delivering cleaner energy. It must be affordable and ready to use. And it must be scalable, and thus able to make a significant, national contribution to the problem.

Our previous report established that the technological tools are at hand to meet national energy goals. However, since the nation’s energy problems have not solved themselves, the existence of technology alone is not enough. We also need policies to mobilize technology for the benefit of society. While a carbon tax might be the most efficient way to do so, policies targeted at workable technological solutions can have much the same impact. The key unknown would be whether they can accomplish these goals at little additional cost. This objective is most likely to be reached when the users of energy pay the full costs of their energy use.

To find an optimal, comprehensive policy, we analyzed suites of selected policies by cost and scale to determine their ability to meet our goals. In practice, more than one potential mix of policy options could be combined for a successful recipe. We completed this analysis in the 2010 report, offering a set of policies that, in combination, are nearly as effective as a broad-based carbon tax. In this report, we highlight our preferred mix of five options, refine and deepen the analysis, and update our prescription for the changing energy landscape.

1.4 Previous work and key updates

NEPI and RFF gathered top energy experts to study 35 different policies and their ability to reduce oil consumption and carbon dioxide emissions, leading to our November 2010 report, “Toward a New National Energy Policy: Assessing the Options.” The work covered in that report laid the foundation of this document, with targets, metrics, modeling, cost analysis and identification of the five most promising policies.

Key changes are in targets for the changes we hope to achieve through policy. Our target for reduction in oil use has been adjusted to address changes in the oil market, the extension of our study outlook from 2030 to 2035, and more refined thinking in our work about the cost of oil vulnerability. The emission reduction target takes into account recent changes and an extended outlook, and also recognizes that, with the failure of international efforts, working toward a particular stabilization number for atmospheric CO₂ is probably not meaningful. In addition, we have added new metrics in this report and we have made certain modeling adjustments.

The general approach to the problem remains the same. The details of our methods are covered in the following section.

1.5 Targets

Targets are desired outcomes expressed numerically. They allow comparison of policy options. Targets must be low enough to be realistically attainable but high enough to significantly affect the energy problems we want to solve. They should be aggressive but fact-based. The targets selected here meet these criteria. However, their purpose here is exemplary, not prescriptive.

1.5.1 Oil use reduction target

A surge in domestic oil production using enhanced technology, combined with continuing weakness in demand due to the sluggish economy, have facilitated a reduction in oil imports. The principal concern about oil markets, however, is the trend in the nation’s vulnerability to surprise geopolitical events overseas. The work of Brown and Kennelly, summarized in Section 1.1.1.2 and covered in more detail in the sidebar “The Costs of U.S. Dependence on Oil Imports” below, quantifies the cost of oil vulnerability on America’s economy and national security. Those costs include the expected loss in economic output attributable to oil price shocks to our economy. It is much more difficult to incorporate the national security expenses of defending our oil supplies because our military forces are present in the Middle East for reasons other than oil. We have excluded costs that are much harder to quantify, such as the restriction that oil dependence places on the prerogatives of U.S. foreign policy. This

The Costs of U.S. Dependence on Oil Imports

Leaders have recognized the need to reduce U.S. dependency on imported oil for decades, but just how much of a reduction is needed remains controversial. To inform our target for reducing oil consumption—which is our primary means of reducing imports—we commissioned an analysis of the social cost of U.S. dependence on imported oil by Stephen P. A. Brown, director of the Center for Business and Economic Research at the University of Nevada, Las Vegas, and Ryan T. Kennelly, an economic analyst at the center. Their paper is posted at the NEPI website http://nepinstitute.org/wp-content/uploads/2013/04/Brown-Costs-of-Oil-Dependence-Apr-20131.pdf.

The market price of oil paid by its consumers does not reflect the full cost of oil use that is borne by society, and its price also can be distorted by OPEC’s exercise of monopoly power. These market failures justify the use of public policy to correctly assign the costs of oil use. One type of market failure occurs when a cost is not included in the price, such as oil’s environmental impact. This kind of cost is known as an externality, because it is external to the monetary transaction between oil buyer and seller. Another type of market failure occurs when the structure of the market affects prices, such as in the case of OPEC’s monopolization of the oil market. To address market failures through policy requires economic analysis because market prices themselves do not inform us about the cost of externalities or monopolies.

Brown and Kennelly begin by reviewing various theories proposed by a wide range of scholars about oil market failures, and determine which should be included in our calculation of the cost of U.S. dependence on imported oil. For example, they do not consider the cost of environmental damage from oil, because it affects domestic as well as international production. They also exclude the cost of U.S. foreign policy being inhibited by oil supply concerns, because such concerns cannot be precisely defined or quantified, and many of these concerns derive from fears of the economics losses associated with supply disruptions. Brown and Kennelly prefer to measure the economic costs of the disruptions instead.

In generating its broadest measure of the costs of U.S. dependence on imported oil, the paper evaluates five costs to find a total oil dependence premium. Brown and Kennelly show the size of each cost in a chart. Here we summarize the meaning of several key items on the chart.

- The monopsony premium. The large role of U.S. oil purchases in the international market confers power to hold down prices that is analogous to the power of monopoly sellers to support prices. Because U.S. oil buyers do not act in concert, however, this purchasing power is not exercised. We pay more for oil as a consequence, an increment called the monopsony premium. One way to exercise U.S. purchasing power would be to set a quota that artificially limits oil imports; although that would be illegal under international agreements, domestic policies that reduce total oil consumption can have the same impact when they lessen imports. A reduction of U.S. imports would depress the world price of oil. Multiplying that price reduction over all the oil used in the U.S., domestic or imported, yields large dollar-value savings.

- Price shock. International supply disruptions can cause large, sudden increases in oil prices that drain wealth from Americans’ pockets and send it to oil producers.

- Change in GDP due to price shocks. A rapid increase in oil prices usually causes a drop in economic activity. Scholars have suggested various possible mechanisms for this out-sized effect, but do not question its importance.

- Defense spending. The question of how much U.S. defense spending relates to protecting oil importation is difficult and debatable. Brown and Kennelly tackle it by looking at defense spending increases following oil shocks, then price these expenditures on a per-barrel basis.

Brown and Kennelly combine these five elements to reach a figure of $27.96 per barrel as the cost of dependence on imported oil. They also find a comparable figure of $2.65 per barrel as the cost of dependence on domestic oil. Combining these estimates yields a figure of $25.31 per barrel for displacing oil imports with domestic oil production. Brown and Kennelly translate the latter estimate into a target for reduction of oil imports that we could use to measure policies in our study. To do so, they calculate the effect on imports if the premiums they calculate were to be imposed as taxes on imported oil. The consequent reduction in imports caused by this hypothetical tax becomes our target for reducing oil consumption.
perspective has allowed us to take a clear measure of the value of reducing oil imports.

Converting the dollar cost of the oil dependence premium into an import quota, Brown and Kennelly find that a reduction of 1.9 mmbd from its level in the reference case by 2035 would remove the U.S. exposure to oil vulnerability cost effectively. Subtracting that figure from the EIA’s Reference Case prediction of oil use in 2035, we find that U.S. oil use in that year should be no more than 15.2 mmbd, compared to actual oil use of 18.2 mmbd in our base year of 2010 (Figure 1.18).

### 1.5.2 Carbon dioxide emission target

U.S. carbon dioxide emissions from fossil fuel use have slightly declined during the slow economic recovery and recent period of low natural gas prices. Our Reference Case takes this change into account. We have targeted a cumulative carbon dioxide reduction of 21.7 gigatons by 2035 compared to our Reference Case (Figure 1.19). The target is consistent with reductions called for by the IPCC 2007 report, the Waxman-Markey Clean Energy Bill, and the goals called for by President Obama—all of which would reduce emissions in 2050 by 83% compared to 2005.

The passage of time has helped illustrate that even this aggressive carbon dioxide target will not resolve climate change. The adoption of the Waxman-Markey bill, which did not occur, would have been consistent with stabilization of atmospheric carbon dioxide at 450 parts per million, a level estimated by IPCC’s 2007 report as necessary to limit climate warming to 2 to 2.4 degrees C. But that stabilization would have occurred only with immediate participation of all emitters, including China and India. In the intervening years, international negotiations have foundered and Asian emissions have accelerated (see Sections 1.1.1.1 and 1.2.2). In these uncertain conditions, we cannot make a firm prediction of the atmospheric CO₂ level. We can expect, if our target is achieved, a smaller increase in the amount of warming. Achieving these reductions may also make it easier to convince other countries that they should also take action.

We have chosen a target of a cumulative reduction of 21.7 gigatons by 2035. This brings the cumulative emissions to a level of 123.3 gigatons which is a 15% reduction from the reference case level of 145 gigatons. Serving primarily as a landmark in a shifting landscape, this target is an ambitious objective for achieving important improvement at an affordable cost.

**Fig. 1.18** Oil Use Reference Case and Target 2010 - 2035 (million barrels per day)

**Fig. 1.19** Cumulative Total Energy-related CO₂-e Emissions Reference Case and Target 2010 - 2035 (gigatons of CO₂-equivalents)

**Fig. 1.20a** Sources of SO₂ Emissions 2008

Data source: EPA
1.5.3 Air pollution reduction targets

We have not established a numeric target for reduction of air pollution, such as sulfur dioxide, nitrogen oxide or methylmercury. The EPA’s existing programs have substantially reduced sulfur dioxide, with improvements expected to level off in 2015, and have made significant impact on nitrogen oxide. New rules will go into effect in 2015 to reduce methylmercury emissions. These pollutants come from fossil fuels, primarily coal. (Figures 1.20a, 1.20b and 1.20c) The policies we recommend for reducing coal and oil consumption will yield health benefits by further cutting these other pollutants. Due to the complexity of the task we have not established separate targets for these pollutants, but we do report the impact of our policies on their emissions.

1.6 Metrics

Metrics are standards of measurement for evaluating actions and policies. They are essential to this project. Besides choosing a yardstick, we must also select which dimensions to consider when measuring a problem, a solution or a benefit, including whose interests are important to consider and which impacts are worth weighing. Since we seek a national energy policy that includes social and environmental goals as well as material goods, we need multi-dimensional metrics.

For the two targets cited earlier—for reduced oil consumption and carbon dioxide emissions—success can be measured simply, in barrels of oil saved and tons of carbon dioxide emission avoided. But the primary effort of our work is finding the least costly way to make these changes. We look for bang-for-the-buck in policy options, justifying the benefits of our goals holistically, in the terms stated earlier in the discussion of goals and targets. In measuring the cost effectiveness of a policy we divide the costs of the policy by the physical measure of effectiveness—the cost per barrel of oil or ton of CO₂ reduced. This measure is included for each policy.

We have not performed strict cost-benefit analysis, which would monetize the positive effects of each policy. Putting dollars to the benefits of reducing oil use and carbon dioxide emissions is difficult and subjective, and we believe the benefit of our overall targets is clearly established.

Our focus for policy comparisons has been on a common metric of costs. We have evaluated which costs to include and what kind of impacts to count. In the free market of classical economics, each actor determines value on his or her own, based on private wants and needs, and fair prices are set through exchanges among willing buyers and sellers. As we have seen, however, fossil fuel use...
imposes costs on others who are not party to their monetary purchase. The good of the nation and the planet depend on managing such externalities, returning that burden to the energy user responsible.

1.6.1 Welfare costs

How shall we measure the cost of the externalities? In our 2010 report, we focused primarily on welfare cost. A simple definition of welfare cost is the sum of all costs to the economy of a chosen action. A costly government action diverts economic resources that would otherwise be used to produce and consume goods and services of value for citizens. Welfare cost calculations take into account these lost opportunities. Although welfare costs are more complicated to calculate than other impacts, they provide a valuable metric if one wishes to focus on the size of the pie rather than on how it is divided among the various groups.

For example, if a policy would produce electricity with cleaner but more expensive fuels, the total private cost of that action would be part of the welfare cost, regardless of who would pay or benefit from that action. A policy that discourages driving would impose a private cost on a family that thereby drives less than it would like; the sum of that cost across everyone’s altered driving preferences would be part of the welfare cost. As explained below, these private costs may be partially offset by reduced damages from pollution and other social costs that are not priced in the market system.

Welfare cost can be more effective than Gross Domestic Product at measuring some of the costs and benefits that concern us. GDP is the monetary value of all the goods and services produced in the country annually. Negative events such as an increase in chronic disease can boost GDP, and environmental damage caused by economic activity is not considered in its calculation unless it affects other economic activity. Welfare cost, on the other hand, takes into account a more meaningful span of costs. For example, if air pollution induced asthma in a child, welfare cost could account to some degree for that affliction as a cost, while GDP might count it positively for the increased economic activity in the health care industry.

While welfare cost is a powerful metric in concept, it also has serious weaknesses in practice. Important costs that are taken into account, including the examples above, can be difficult to quantify. Calculations become complex and often require assumptions about costs that cannot be directly measured. Different economists use different methods that can lead to different results. These issues can combine to produce substantial uncertainty in the outcome of welfare cost calculations, or results that vary greatly among researchers.

Welfare cost, while subject to wide variations of assigned costs, is an important metric. Federal agencies, including Congressional offices, include welfare costs in mandatory cost-benefit analyses of planned regulations and proposed legislation to consider society’s point of view in aggregate.

1.6.1.1 Welfare costs and market efficiency

A major puzzle confounds cost estimates for economists studying energy policy. Economic theory indicates that consumers and businesses, given adequate information, should invest as readily in energy efficiency as in any other investment that yields the same financial return. But they do not. Research shows that businesses and consumers undervalue energy efficiency improvements, demanding quick pay-back for long-lasting benefits. Typical decision-makers require a return on investment much higher for energy improvements than for other investments—as high as 40 percent.

Estimating welfare costs is complex enough if we can assume that everyone behaves as would be expected in an efficient market, but an additional complication enters the picture if actors are misinformed, irrational, or make bad decisions for any other reason, a condition called market failure. For example, suppose a building owner would forgo the financial benefit of installing energy-saving equipment, but is forced to accept that benefit by a government policy. Such a policy could produce a negative welfare cost—more than a free lunch.

But before we can be sure of such a policy benefit, we need to know for certain that these investment decisions really are market failures. If purchasers know of hidden costs that offset the benefits of energy improvements, then they may have good reason for avoiding these investments. In that case, with an efficient market, or no market failure, the welfare cost of a policy would not be offset, and there would be no free lunch.
Some researchers use an adjusted discount rate to simulate the partial market failure they see in energy improvement investment decisions. Discount rates relate present dollars to future dollars, reflecting the fact that money we have now is worth more than money we will get later. In this study, adjusting the discount rate downward to reflect partial market failure would yield dramatically lower welfare costs, producing essentially a free lunch for our entire comprehensive policy, before even considering the benefits of reduced oil imports and carbon dioxide emissions.

We have not chosen that approach. While the likelihood is high of at least some market failure in the undervaluing of energy investments, our study was not designed to quantify that factor or to look for hidden costs. Without such a factual basis, choosing a discount rate to simulate market failure would be arbitrary. Instead, our welfare costs represent an efficient market, with no market failure. As such, they represent a highly conservative and defensible policy cost, which can be thought of as a maximum. Any consideration of market failure would make the welfare cost lower.

### 1.6.2 Additional measures of policy impacts

The uncertainties in welfare cost calculations are compounded by the concept’s significant limitations for policy makers in a political environment. Welfare cost looks only at the total, so it does not take into account whether one group within society gains or loses from an action or how it might create transfers from one part of society to another. Income transferred between groups by a tax or government subsidy would not affect welfare cost, but may have great significance for the affected groups. Likewise, a policy that leads to job losses in a particular industry might not represent large welfare costs for the total economy if the same policy were to expand jobs in another sector. Yet real-world decision-making, especially for democratically elected leaders, often ignores what is best for society and instead focuses upon what is best for particular groups. Complexity also undercuts the measure’s usefulness in non-technical discussions. Variables can be difficult to quantify and results difficult to explain.

For these reasons, we have expanded beyond looking only at welfare costs. In this report we have updated welfare costs for the package of five preferred policies we feature, which were selected from 35 policies we screened for the 2010 report. But we have also added additional impact metrics to understand the varied consequences of the policies for specific groups within society. These new metrics simply reflect impacts that many people would want to know before adopting a policy.

Our new metrics cover the impacts of policy options for consumers and government. For consumers, we look at out-of-pocket expenses, primarily for fuel and taxes. For government, we consider the impact of policies on the federal budget.

We studied policy impacts on GDP, but ultimately found they were too small to be meaningfully quantified by the model that was the core of our project.

### 1.6.3 Allocating costs to combined goals

Our project has two goals, to reduce oil use and imports and to reduce carbon dioxide emissions. Three of our five promising policies contribute to both goals, and the combination of all policies described in Part 3 is designed to mix these benefits in a complementary way. This blending of policies and goals is a strength of the comprehensive policy. In determining the cost effectiveness of polices on a per unit basis—per barrel of oil or per ton of carbon dioxide reduced—a challenge arises as to determining the allocation of costs between the two goals. Economists refer to this as the joint allocation of cost problem.

In Part 2, we present individual policies. For policies that contribute to both our goals, we assign the total welfare cost in full to each, the barrels of oil reduced and the tons of carbon dioxide emissions reduced. While this, in effect, double-counts the cost, showing oil barrels and carbon dioxide tons as more expensive to reduce, it avoids an arbitrary and unhelpful allocation of costs among the goals. For the combination of policies reported in Part 3, we simply present the present discounted value of the welfare cost (rather than cost-effectiveness) with other policy measurements, as there is no rational basis for allocating costs per policy.

### 1.7 Modeling

This project brings value to the energy policy debate in part through the rigor of our process of evaluating many alternatives using the same economy-wide computer model. An energy-
economic model is a computer program using mathematical formulae to represent the relationships of the many parts of the energy economy. Modelers can change inputs representing economic conditions or change assumptions about economic behavior to see how those changes cascade through the system and ultimately impact oil use, carbon emissions, and other energy-related outputs.

Since our work has sought to analyze many policies covering a wide variety of fuels, technologies and sectors, we chose to use an important national model with sufficient detail and the ability to disaggregate these factors, the National Energy Modeling System (NEMS), maintained by the Energy Information Agency (Figure 1.21). This is a detailed energy-system model that incorporates facets of numerous technologies while balancing supply and demand throughout the economy’s energy system. Assumptions inform the model about how prices and availability of products influence human behavior—for example, concerning the fuel prices at which consumers switch to more efficient vehicles or hybrids—as well as factors such as future fossil fuel discoveries or improved oil recovery technologies. Like other researchers in the field, we have started with the EIA’s data and its Reference Case for projections that incorporate existing laws and regulations. Model runs conducted for NEPI by OnLocation, Inc. used data and Reference Case assumptions found in the EIA’s Annual Energy Outlook 2012 (“AEO 2012”). This is the basis for creating a Reference Case for our analysis. (A single exception is explained in Part 2, Section 2.4.3.) We refer to this version of the model as NEMS-NEPI. The model does not estimate welfare costs: instead, model output was used to inform calculations of welfare costs, which were done off-line.

1.8 Refining the five most promising policies

After analyzing 35 policy alternatives, our 2010 report gathered the most promising into groups of crosscutting policy combinations in search of the most powerful and least expensive politically viable package for a national energy policy. The NEMS-RFF model allowed us to test various combinations with differently interlocking pieces to find a suite with the strongest complementary features. In this report, we focus on the five most promising policies, studying them more deeply, refining their qualities for greatest benefit, and updating the data used to analyze them to take into account recent changes in the energy outlook, as laid out in the EIA AEO 2012 report (see the previous paragraph).

The results of that work are presented in Parts 2 and 3 of this report.
Part 2: Five Promising Policies: Explanation and impact of the components

Five policies have emerged from our analysis as the most promising to address, at low cost, the national energy goals of reducing oil use and importation and cutting emissions of carbon dioxide and air pollution. In this chapter we explore the function and impact of each policy individually. The policies are:

• **NEPI Clean Energy Standard:** Establishes a 2035 goal for clean electrical generation and requires technology-neutral, market-driven decisions by utilities to use low-carbon and renewable fuels to achieve this target.

• **Oil security dividend:** Imposes a modest, graduated oil products tax that is fully rebated through the tax system to the public.

• **Automotive fuel economy:** Follows the Corporate Average Fuel Economy (CAFE) Standards as adopted in 2012, and considers an alternative ‘fee-bate’ mechanism with similar impact and potential advantages.

• **LNG trucks:** Provides a temporary fuel tax reduction to encourage the nascent shift in the heavy truck market from diesel to liquefied natural gas (LNG).

• **Energy efficiency:** Extends existing incentives for energy-saving appliances and building codes and home-based renewable energy.

2.1 The NEPI Clean Energy Standard (NCES)

Americans have a multitude of opportunities to reduce carbon emissions and air pollution from electrical generation, but making reductions requires decision-making by many actors addressing conditions in individual localities. Policy makers have tried setting state-by-state Renewable Portfolio Standards (RPSs), requiring or recommending a percentage of electricity in each state to come from renewable sources by a certain date, but the national impact of these efforts is limited by regional jurisdictions and the problem of scale. Current renewable energy technology simply cannot produce enough reliable power to replace fossil fuels. The NEPI Clean Energy Standard establishes a 2035 clean energy goal that will be accomplished by a national, market-based approach to identify the lowest-cost options for a transition to cleaner fuels, which may or may not be renewable, thereby yielding greater and less expensive emission reductions.

A number of CES policies have been proposed to reduce the carbon emissions of the electric power industry. Electric generation produces over 40% of energy-related greenhouse gas emissions in the U.S. (as seen in Figure 1.2.) However, the particular design of a CES policy significantly affects its cost and effectiveness. Here we have refined the concept by modeling various program designs to find the best option, which we present and compare to other similar concepts under discussion. The resulting policy achieves 64% of our target for carbon dioxide reductions.

After presenting the policy, we describe modeling results that show impacts on fuel sources, carbon dioxide emissions, energy prices, air pollution, and other parameters. Next we consider policy costs. In addition, we analyze the electricity rate impact of the program on a sample of states and regions of the country, which differ depending on their current fuel mix and their energy resources. Finally, we look at the feasibility of converting to renewable and nuclear sources of energy at the scale the policy would require.

In Figure 2.1, we see our Reference Case total energy-related emissions compared to power sector emissions, and our target total emissions.

![Fig. 2.1 CO₂-e Emissions Reference Case Total and Power Sector, and Target Total Emissions 2010-2035](image)
2.1.1 How the NCES works

The NEPI Clean Energy Standard sets a specific goal for clean electrical generation through 2035, to be accomplished with market-driven, least-cost decision making. NEPI and RFF designed a somewhat similar standard as part of our 2010 report, in pursuit of the overall Intergovernmental Panel on Climate Change carbon reduction target recommended in 2007. We also aligned our concept with the share of carbon reduction that would have been accomplished by the Waxman Markey Clean Air legislation proposed in Congress in 2009. Finally, the standard would actuate the vision that President Obama articulated in his 2011 State of the Union Address when he said, “I challenge you to join me in setting a new goal: By 2035, 80% of America’s electricity will come from clean energy sources. Some folks want wind and solar. Others want nuclear, clean coal and natural gas. To meet this goal, we will need them all.”

Our analysis confirms that meeting the 80% goal cannot be accomplished at an acceptable cost without a blended strategy that uses more natural gas, renewables, and nuclear energy and less conventional combustion coal. (The meaning of the phrase “clean coal” is ambiguous; coal-burning technology cannot currently produce economically priced electricity without high carbon and other pollution emissions, but it may have that capability in the future with carbon capture and sequestration.) The path from our present energy mix to the President’s clean energy goal must take us through intermediate technology that is currently available on the scale necessary before we can reach low-carbon solutions not yet ready in adequate abundance. A policy to navigate this path requires a market mechanism to mobilize electric utilities to make a myriad of individual decisions pointing in the right direction.

The NCES would phase in clean energy, beginning with a 45% standard in 2015 and then increasing by increments to reach 80% by 2035. Clean energy in 2010 reached 44% of U.S. generation thanks to low natural gas prices and the increasing use of wind power, and was estimated at 47% in 2012. But the standard would drive additional clean energy immediately because every electricity retailer, regardless of size, location or ownership, would be responsible to meet the standard or acquire credits to compensate for excessive carbon emissions.

The NCES sets the cost of moving to clean energy through the trading of credits. Those generation utilities that surpass the standard would earn credits to sell or to bank for use in future years. Existing renewable and nuclear energy producers would get full credit for the clean electricity they generate, as would owners of distributed generation, such as rooftop solar panels or on-site wind generators. The credits they earn and sell effectively lower the cost of the power they produce; the necessity to buy those credits conversely increases the cost of power produced with coal.

A conventional coal-fired power plant represents the baseline definition of dirty energy. The NCES allocates credits to generators depending on their carbon dioxide emissions in comparison to coal. A carbon-free renewable or nuclear plant receives a full credit per kilowatt hour of electricity produced, a conventional coal plant receives no credits, and technologies in between receive partial credits: a combined-cycle natural gas plant, which emits about half the carbon dioxide of a coal plant, receives half a credit for each kilowatt hour of energy produced. Figure 2.2 shows the relative emissions and credits earned by various technologies.

As the emission standard phases in through the years, high emitters would be increasingly dependent on buying credits from low emitters.

![Fig. 2.2 CO2 Emissions and Credits Earned as % of New Conventional Coal Plant Emissions](image)

1. IGCC: Integrated Gasification Combined Cycle;
2. NGCC: Natural Gas Combine Cycle;
3. CCS: Carbon Capture and Sequestration.
creating high prices for emission credits and stronger incentives for low-emission generation. The NCES offers no alternative compliance payment system, such as a fine for failing to meet the standard, which would allow generators to avoid participation in the emission credit market; such a system of fines fails to assure that emissions are ever reduced.

The system of credits encourages movement toward cleaner fuel sources without dictating the technology selected, thereby allowing individual producers to choose the least costly path to lowering carbon emissions in their own locale. Like a Renewable Portfolio Standard, which sets a percentage goal for how much electricity must be generated by renewable sources, the NCES establishes a goal for the percentage of power production that must be carbon-free. Unlike an RPS, however, the NCES does not pick the technology to meet the goal, instead giving credit in proportion to an electrical generator’s contribution to meeting the national standard. Under the NCES, carbon emissions avoided by moving from coal to natural gas are equal in value to equivalent emissions avoided by moving from natural gas to wind.

For example, in 2015 the proposed standard calls for 45% of electric generation to be clean. The most carbon-intensive energy technology, the conventional pulverized coal plant, is defined as 100% dirty. In 2015, it would need credits to compensate for falling 45 percentage points short of the standard. A wind installation, zero percent dirty, would receive credits for the 55 percentage points by which it surpassed the standard. The wind plant’s owners could then sell those credits to the coal plant’s owners to meet their carbon reduction obligation. A conventional combined-cycle natural gas plant, which produces half the carbon dioxide of a conventional coal plant per kilowatt hour, would be rated as 50% clean. In 2015, it would exceed the 45% standard by 5 percentage points, receiving credits that its owners could sell, or could bank for later use. In 2025, when the standard rises to 60%, and the gas plant would need credits (as it would now fall short of the standard) it could use previously banked credits to make up the difference, or buy credits on the open market (figure 2.3).

2.1.2 Alternative designs of a CES

Many versions of a clean energy standard are possible. A recent version was embodied in the Clean Energy Standard Act, a bill sponsored in February 2012 by Senator Jeff Bingaman (D-N.M.), then chair of the Senate Energy and Natural Resources Committee. In our study and modeling, we have chosen several features different from the Bingaman bill. Some of our changes are not important to the overall analysis but make modeling easier. Others reflect real differences.

Bingaman’s bill exempted small utilities. Depending on the definition of “small,” this kind of provision can leave out up to 25% of electricity generation. We include all utilities to avoid that problem, and to avoid the complexity of selecting a proper size definition and quantifying its impact. We realize that some very small utilities that lack practical fuel alternatives should and probably will be excluded, but those adjustments would not significantly affect our analysis.

The 2012 bill also excluded existing nuclear and hydropower plants from receiving tradable credits for carbon-free generation. Proponents of this provision argue that providing credits to existing generators does not advance the purpose of the program, which is to increase clean energy. In addition, the inclusion of existing facilities may disproportionately benefit regions of the country where nuclear or hydroelectric projects already provide much of the electricity used. We have studied that issue and address it in Section 2.1.6.
We have chosen to include existing generation in the NCES. This decision produces the most comprehensive policy, against which other alternatives can be measured, with the market able to function in the most pure form. It also would create a constituency with a vested interest from year one: utilities that receive credits would be able to profit from them only with continuation of the policy. Finally, the greater availability of credits broadens the market, reducing the probability of sudden increases in credit prices.

Two other elements of our NCES that differ from some other proposals underline the decision to make this policy a market-driven solution. We do not allow high-carbon generators to avoid the market for credits by paying a government fine for excessive emissions. Such a work-around opportunity can keep the market price of credits from going too high, but it also threatens to undermine the entire purpose of the program, which is to meet the standard.

The NCES also allows producers to bank credits earned in the early years, which they could use later when the standard becomes harder to meet. By allowing banking of credits, we allow utilities greater discretion to hold down their costs, which should tend to reduce the cost of compliance. Moreover, the bankability of credits increases the intrinsic value of credits, adding to the incentive to cut emissions in the early years. But the bankability feature also tends to moderate increases in the cost of credits, since it increases the supply.

Some proposed CES systems would provide credits for energy efficiency improvements. While it is true that efficiency measures can be a cheap way to reduce carbon emissions, usually on a small scale, quantifying the contribution of any particular project is difficult and complicated. An appealing feature of the NCES is the simplicity of awarding credits. Consequently, we do not allow energy efficiency projects to earn credits, but we do encourage efficiency through another component of our comprehensive national energy policy.

2.1.3 How the NCES differs from an RPS

The majority of U.S. states and territories have adopted Renewable Portfolio Standards, which are policies setting objectives for increasing renewable sources in a state’s mix of power generation. (See Figure 1.14) Considering the popularity of this approach, we have devoted modeling efforts to comparing the RPS to the NCES. Modeling shows the NCES yields superior results at lower cost, as we show in the next section. Here we focus on the functional differences between the two approaches that produce these differences.

The meaning of the term Renewable Portfolio Standard varies from state to state, depending on how “renewable” is defined, whether the standard is mandatory or aspirational, how projects are counted, and whether a system of tradable credits exists. This diversity makes precise predictions impossible as to the impact of these measures, but the Energy Information Agency (EIA) notes that, to the extent the policies could be modeled, and if they all work as hoped, renewables would consequently account for 10% of power production by 2025, with their share thereafter rising more slowly than total energy demand.26

For the purposes of our study, we have modeled a national RPS with ideal features. This approach allows a fair comparison of the two approaches based on their fundamental differences rather than on real-world compromises that occur when any policy is implemented.

The RPS seeks to reach 25% renewable energy by 2028. Improvements come only from certain renewable energy sources. Electricity generated

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from nuclear energy or natural gas doesn’t count, nor do existing hydroelectric generation or municipal solid waste generation facilities. The RPS does allow generators to earn credits by surpassing the renewable standard, and requires them to buy credits if falling short, but the credits cannot be banked for later use. A utility unable to meet the mandate or obtain credits can continue operating by making an Alternative Compliance Payment, similar to a fine, which we modeled as being set at 10 cents per kilowatt hour. This provision limits the cost of the policy to that ceiling, but creates the potential that the national standard will not be met.

As has been explained elsewhere in this report, a clean energy standard does not dictate the technology to be used, such as wind or solar, but instead encourages progress toward a national goal of 80% clean energy by whatever means and in whatever area of the country improvements can be accomplished at the least expense to society and energy users. If switching a Midwest power plant from coal to natural gas avoids a ton of atmospheric carbon more cheaply than building a west coast windmill, that would be the option we choose for the benefit of the environment and our national wellbeing. The market mechanism in the NCES allows these trade-offs to be valued and exchanged or saved for future use.

2.1.4 NCES benefits and modeling results

The NCES guides U.S. electricity generation toward lower carbon emissions on whatever path accomplishes the goal at the least cost. Modeling shows this path uses natural gas as a bridge to carbon-free energy (Figure 2.4).

The exchange of clean energy credits creates a flow of funds from dirtier to cleaner producers of electricity. Initially, this flow increases the price of electricity generated from conventional coal and reduces the price of power from natural gas, renewables and nuclear energy. Natural gas has the greatest potential for rapidly increased generation, so it would gain market share in the earlier years of the program. But as the standard increases in the later years of the program, natural gas burning utilities would begin needing to buy credits, which would encourage them to phase out fossil fuel use in favor of nuclear and renewable production.

The Renewable Portfolio Standard does not achieve the same level of carbon reductions (Figure 2.5.) It puts more renewable generation into service, but also leaves much more coal generation operating.

These scenario results emerge from runs of the National Energy Modeling System, as modified for our purposes by OnLocation, Inc., which we call the NEMS-NEPI model. The Reference Case represents a no-action alternative, continuing current policies and taking into account anticipated fuel costs from the EIA’s Annual Energy Outlook 2012 (AEO2012). Details from the modeling follow.

2.1.4.1 Electricity generation by fuel source

The Reference Case shows electricity being produced by much the same mix of fuels in 2035 as we currently use, but with coal accounting for 38% of generation and non-hydro renewables 9%.
All scenarios continue roughly the current share of hydropower through the study period, of around 6%. The RPS reduces coal to 32% while increasing non-hydro renewables to 20%. The NCES reduces coal to 16%, increasing non-hydro renewables to 13%.

The NCES achieves this much greater reduction in coal use by shifting more power generation to natural gas and nuclear (Figures 2.7a and 2.7b). Including hydropower and nuclear, the NCES achieves more carbon-free electricity generation than the RPS, despite using less renewable energy.

Since the RPS targets only renewables such as wind, solar, and biomass, those sources alone receive credits and a competitive boost in the market. Natural gas receives no credits, and thus little market advantage compared to coal; consequently, construction of new natural gas plants is more limited than in the NCES and Reference Cases. The market in renewable energy credits makes scant impact on the more carbon-intensive coal because renewables are not an effective substitute for coal in baseload power applications. The reduction of coal that does occur comes mostly through substituting biomass in co-fired plants. Figure 2.7a shows the impact of the RPS compared to the Reference Case.

The NCES issues credits to all generation cleaner than the standard requires. At the beginning of the policy, natural gas generation earns partial credit for being cleaner than coal, creating a market advantage that leads to gas displacing coal from the first year of the program. As time passes and the standard rises toward 80% clean, natural gas no longer earns credits and itself begins to be displaced by zero-carbon generation, including biomass, nuclear and wind. Renewables also displace additional coal. Figure 2.7b shows the impact of the NCES compared to the Reference Case.

### 2.1.4.2 Carbon dioxide emissions

The Reference Case shows modest changes in carbon dioxide emissions through the study period to 2035 (Figure 2.8). The RPS achieves a reduction in emissions to 2030, but then emissions begin to rise again to 2035. This increase in emissions occurs because the 25% renewable goal is reached in 2028 and because the policy includes a price cap on the cost of adding renewables, in the form of the Alternative Compliance Payment. The NCES achieves much larger improvements. The rapid transition from coal to natural gas in the early years
of the policy gives the NCES a large immediate advantage in reducing carbon dioxide emissions. The advantage continues to broaden through the later years of the study as the standard continues to rise to 80% in 2035.

The NCES produces the best results in cumulative carbon dioxide reduction by the 2035 target year. Compared to the Reference Case, the NCES reduces energy-related carbon dioxide emissions by 13.8 gigatons, which is 64% of the 21.7 gigaton target that NEPI has set as our overall target for a national energy policy. The RPS produces only a 5.1 gigaton reduction, or 24% of the 21.7 gigaton target. The NCES, on the other hand, continues to incentivize changes in the fuel mix until reaching the 80% clean energy standard in 2035.

2.1.4.3 Electricity sales

The NEMS-NEPI model shows electricity use increasing throughout the study period for the Reference Case, the RPS and the NCES (Figure 2.9). Differences among the three are not large, but the NCES shows the smallest increase in power sales. The RPS depresses power sales by 2025, but they rise faster and exceed the Reference Case in 2035. The reason is the same as identified in the previous section: once the RPS standard is met in 2028, the policy produces no further pressure on prices.

2.1.4.4 Electricity prices

None of the scenarios drive substantial increases in the price of electricity (Figure 2.10). The Reference Case shows a rise from 9.8 cents per kilowatt hour to 10.2 cents in 2035, an increase of only 4 percent over 25 years (these numbers are in real dollars and include all sectors of power use). Under the RPS the price of electricity increases until peaking at 10.7 cents in 2028, when the 25% renewable standard is met. Alternative Compliance Payment (ACP) of 10 cents per kilowatt hour helps keep the price increase modest but limits the amount of carbon dioxide reduced. After achieving the standard, power prices fall under the RPS to 10.2 cents in 2035, the same as the Reference Case.

The price of electricity rises faster under the NCES and continues to rise through the study period. The price rises in 2015, to 10.2 cents per kilowatt hour, when the policy kicks in, and continues to rise in response to the steady phase-in of the standard, reaching 11.8 cents in 2035. The total increase over the 25-year period is 21%, or less than 1% per year, which is hardly enough to be noticeable in an electricity bill, and could easily be offset in individual households that conserve power.
2.1.4.5 Natural gas prices

The NCES and RPS have opposite impacts on the price of natural gas, although both scenarios and the Reference Case end at close to the same price in 2035 (Figure 2.11). Since the NCES gives partial credit to natural gas for its lower carbon emissions than coal, it encourages a shift from coal to natural gas for electricity generation in the early years of the policy, creating an upward pressure on the prices, with a spike when the policy first bites, in 2015. Later in the study period, as the increasingly stringent clean energy standard phases in, natural gas no longer can earn credits and utilities move to carbon-free energy instead. That shift moderates gas price increases and brings the price close to the Reference Case. The RPS gives no credit to natural gas and drives its use and price below the Reference Case.

2.1.4.6 Emissions of other pollutants

Reducing air pollution is an important goal of a national energy policy. Sulfur dioxide, nitrogen oxides and methylmercury all contribute to illness, premature death, lost work time and health care costs; all are products of fossil fuel combustion, especially coal. The rapid transition from coal to natural gas in the NCES attacks these pollutants, and the improvements increase in the later years when natural gas generation is displaced by technologies with no air emissions. Part 1 further explains the goal of reducing air pollution.

EPA policies based on the authority of the Clean Air Act have already saved thousands of lives, and new limits on the books and still taking effect will save many more. These improvements are included in the Reference Case modeled by the EIA in AEO 2012. Our modeling demonstrates an additional improvement for the NCES above what the EPA is expected to achieve (Figures 2.12a, b, and c).

The EPA rules drive down emissions of sulfur dioxide and methylmercury dramatically in this

Fig. 2.11 Natural Gas Spot Prices Reference Case, RPS and NCES 2010 - 2035 (2010 $ per million Btu)

Fig. 2.12a SO₂ Emissions Reference Case, RPS and NCES 2010 - 2035 (million tons per year)

Fig. 2.12b NOₓ Emissions Reference Case, RPS and NCES 2010 - 2035 (million tons per year)

Fig. 2.12c Mercury Emissions Reference Case, RPS and NCES 2010 - 2035 (tons per year)
decade, with reductions of around 80%. Emissions of nitrogen oxides are significantly improved as well, down by about 20%. These changes are the same for the Reference Case, the RPS or the NCES until 2017, when EPA rules are fully in effect and emissions of all three pollutants begin creeping up slowly under the Reference Case.

By reducing use of fossil fuels, the RPS and NCES both continue to hold down emissions beyond 2017; however, the NCES is significantly more effective. The RPS essentially holds emissions flat, but the NCES contributes further gradual reductions in the pollutants over the entire study period, finishing in 2035 68% below the EPA requirements for sulfur dioxide, 58% lower for mercury, and 24% better for nitrogen oxides.

The superior performance of the NCES derives from the policy’s tendency to replace coal generation with much cleaner natural gas early in the study period, followed by continued improvement as plants with zero emissions of air pollution replace natural gas generation. The RPS eliminates less air pollution because its incentives favor renewable energy primarily at the expense of natural gas, leaving much more coal generation in the mix to the end of the study period.

2.1.5 Policy costs

The cost for implementing the NCES can be measured several ways. The results of our cost analysis are shown in Table 2.1. The welfare cost for the policy in 2010 dollars is $307 billion. This is a cumulative cost through the year 2035 and represents the total policy costs across society. It does not include the environmental or public health benefits of the policy, which are expected to far outweigh the costs. The cost effectiveness of the policy is determined by calculating the price per ton of carbon dioxide emissions reduced. For the NCES this figure is $22 per ton. We provide no comparable figure for barrels of oil. Because so little oil is used in power production in the United States, this policy has insignificant impact on oil use, and a per-barrel figure would not be meaningful.

The increased cost of electricity under the NCES would likely be too small for residential consumers to notice. Modeling shows the residential out-of-pocket electricity cost of the NCES to consumers (on a per household basis) is a $122 increase by the year 2035 or an average increase of $4.88 per year. The residential out-of-pocket natural gas cost shows a slight decline by 2035 under the NCES policy. Modeling shows a $6 decrease in per household natural gas cost by 2035, essentially a zero cost effect.

The federal government would not have significant costs for the program. Other than the small increases in the cost of its purchases of electricity and natural gas, federal expenses would be limited to administration, including setting standards and monitoring compliance, which is already performed within the EPA budget.

2.1.6 Regional and state price impacts of the NCES

Nationally, we have projected reasonable costs for electric utilities to reduce carbon dioxide emissions through the NCES, but differences in the

<table>
<thead>
<tr>
<th>Table 2.1 NEPI Clean Energy Standard Policy Key Metrics</th>
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<tr>
<td><strong>Progress on Oil Target by 2035</strong></td>
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<tr>
<td>Reduction from 2010 (mmbd)</td>
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<td>2010 - 2035 [mmt CO2]</td>
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<td>(2010 $/ton CO2)</td>
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<td>(2010 $/barrel)</td>
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<tr>
<td>(2010 $/ton CO2)</td>
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<tr>
<td>Cost Effectiveness CO2</td>
</tr>
<tr>
<td>Impact on Consumer Households in 2035</td>
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<tr>
<td>Natural Gas Cost (2010 $/household)</td>
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<td>Total 2010-2035Tax Revenue Impact (2010 $ billion)</td>
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<td>Impact on Federal Budget</td>
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<tr>
<td>(6)</td>
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<tr>
<td>b.</td>
</tr>
<tr>
<td>a. oil reductions are insignificant - this policy is directed at CO2 emissions reductions</td>
</tr>
<tr>
<td>b. administrative cost only</td>
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mix of energy resources in electricity markets around the country create significant variations in individual regions and states. Future prices depend on an area’s current use of coal, availability of natural gas and renewable options, the state regulatory system, and the ability to move gas or electricity from other regions. Looking at six states that are significant users of coal, we found that the cost to reach the 80% clean energy standard in those states ranged from 10 to 40 percent above the Reference Case (for all sectors, not only residential users).

These numbers come from a paper by utility consultant Mark A. Foster, whom NEPI asked in 2011 to analyze the state and regional cost impacts of a clean energy standard similar to the NCES (we had not yet fully designed and modeled the NCES). The All Clean standard that Foster looked at had been developed by the EIA during its work on Senator Bingaman’s clean energy standard legislation. (For purposes of Foster’s analysis, the Reference Case is the AEO2011) Although Foster’s results are not precisely aligned with the NCES, they are close, and more than adequate to shed light on the issue of regional differences.

2.1.6.1 Regional and state-by-state results

The EIA modeled power cost impacts of the All Clean standard on regions of the country, finding that some areas could see significantly reduced electricity costs by 2035, while others, including Texas, would experience equally large percentage increases. Foster found that the cost of meeting the standard depended not only on the ability of a region to inexpensively transition to a cleaner fuel source, but also on the interconnection of electrical markets and degree to which an area is constrained by transmission bottlenecks within or across its boundaries. The state regulatory system played a part, too, as regulated utilities are generally more capable of obtaining financing for nuclear power investments (as we will explain in Section 2.1.8.1).

Foster further focused his analysis on six states that represented a wide range of circumstances and probable cost outcomes, and grouped them into pairs: Texas and Florida, Pennsylvania and Ohio, and Colorado and New Mexico.

In Texas, where coal is currently an important fuel, a shift to natural gas, nuclear and renewables, combined with a continued need to buy credits, drives a price increase in 2035 of more than 40% above the Reference Case. In Florida, coal is replaced primarily with nuclear, and somewhat less with renewables, and credits are still needed in 2035. Florida pays 30% more for electricity than the Reference Case in 2035, but its cost per kilowatt hour remains higher than Texas because Texas rates are lower to begin with. Both states see a decline in power generation due to the increased price and changes in household income and population.

Power cost increases in Ohio and Pennsylvania are 32 and 37 percent above the Reference Case in 2035, respectively; both are required to buy credits to meet the standard in 2035. Ohio, which in the Reference Case produces 80% of its energy from coal, reduces its power production by 30% under the clean energy standard, a change achieved through efficiency and conservation and with imports through the regional grid. Power load is also assumed by natural gas and existing nuclear generation, while a third of electricity still comes from coal-burning plants. In 2035, coal can remain in the mix of a clean energy standard through biomass co-firing and carbon capture and sequestration, or through purchasing credits. Pennsylvania increases natural gas use to replace coal.

Colorado and New Mexico are heavy coal users in the 2035 Reference Case as well—81% and 60% respectively—but modeling shows they can make dramatic gains in use of renewables and in efficiency and conservation. New Mexico meets the standard in 2035 at a cost only 9% over the Reference Case, in part by decreasing power use and with in-state and imported clean energy. Colorado switches by 2035 from coal to nuclear, renewables, and natural gas, and reduces total generation. Its power cost rises 32% over the Reference Case in 2035.

2.1.6.2 Solutions to price differences

Some price differences in electricity cost between regions of the country are to be expected. The
2009 cost of power in the six states we studied ranged from 6.9 cents per kilowatt hour in Texas to 11.6 cents in Florida, a 68% difference. Federal policymakers need not intervene to reduce such disparities, relying on the market to act, and normally they do not.

Our approach to preventing onerous electricity price differences under the NCES also relies on market forces. While it is true that states are endowed unequally with clean energy resources, the study showed that importing energy, through electric or gas transmission lines, could reduce these inequalities. Transmission bottlenecks caused higher prices, but these bottlenecks can theoretically be overcome. Decisions about building power lines will continue to be made by regional governments balancing power costs against other considerations. Likewise, states whose regulatory systems prevent financing of nuclear power plants are free to make that choice in exchange for the potential impact on electricity prices. Finally, states with only higher-cost options to produce clean power can work toward meeting the standard by reducing power consumption, through conservation and energy efficiency.

The market mechanism of tradable credits also can prevent price differences from becoming extreme. When clean power cannot be economically produced or imported to a state, the exchange of credits can assure an equivalent environmental benefit while holding down the price of power at the same time. Tradable, bankable credits effectively free the economic worth of clean energy electrons from the limitations of space and time, allowing the value of these perishable resources to cross geographic barriers and flow into future periods of greater need.

A key to realizing this solution is to create a credit market that is broad and liquid, so that prices for credits rise only gradually, without disruptive spikes. Permitting existing low-carbon generation to receive credits helps in this goal, as does the provision allowing credits to be saved for future use. For these reasons, a policy which might seem inequitable, of granting credits to resource-rich regions with existing generating capacity, in fact also benefits states where the clean energy challenge is greater.

**2.1.7 Technology limits and renewable energy**

The NCES can only achieve its aims if the costs it demands of society are within the range of the public’s willingness to pay. Credit trading can mobilize the lowest-cost energy alternatives, but success ultimately depends on the options themselves: will they be ready in time, can they achieve the scale necessary, are they socially acceptable, and will they be affordable? In this section we examine the ability of renewable energy to fulfill the role projected for it in the clean energy standard and in the next section the challenges facing our projected increase in nuclear energy, along with ideas to meet these challenges.

The NCES does not drive a revolutionary increase in renewable energy. The increase foreseen by the model appears well within the likely capacity of technology development over the time span of the policy. The NEMS-NEPI model shows the NCES would, by 2035, increase renewable energy in the American power generation mix to 20%, including 7% from hydropower and 13% from all other renewables (Figure 2.13).

The Reference Case, which assumes minimal policy intervention, shows non-hydro renewables generating 456 billion kilowatt hours (9% of the total generation market share) by 2035. The NCES, with 626 billion kilowatt hours of non-hydro renewables generation in 2035, brings about a reasonable 37% increase in non-hydro renewables above the Reference Case level (Figure 2.14).

Fig. 2.13 Non-hydro Renewable Electricity Generation by Source
(As a percent of total non-hydro renewables generation)
Reference Case, RPS and NCES - 2010 and 2035
Renewable energy made a dramatic surge in output in recent years, while federal incentives were in place, increasing by 68 billion kilowatt hours, or 66%, in just three years from 2007 to 2010. The increase anticipated for the NCES over the Reference case is 170 billion kilowatt hours, a difference to be made in 25 years—a pace less than a third as fast. Quicker mobilization of renewable power is probably possible, but we have chosen a market mechanism to govern selection of clean energy sources in order to help society find the least expensive path to reduce carbon dioxide emissions. Under this policy, without direct incentives, the model shows renewable energy growing at a healthy pace, but not booming as in the last few years.

In light of this projected slower growth of renewables, it appears safe to assume that the technology will be able to meet the need when the market is ready.

### 2.1.8 Nuclear power challenges and opportunities

Nuclear energy is an essential part of the mix that allows the United States to reach the NEPI Clean Energy Standard of 80% by 2035. It comprises 29% of electric generation at that time, compared to 18% in the Reference Case and 20% today. Nuclear-generated electricity is important because of its stable price, predictable production, ability to scale up to large output, and lack of carbon dioxide, sulfur dioxide, nitrogen oxide and methylmercury emissions. No other energy source can match these qualities. Without nuclear power, the 80% standard probably is not achievable.

However, nuclear energy is beset by financial, safety and environmental concerns that must be addressed before it can assume a much-increased role. NEPI asked Geoffrey Rothwell of the Stanford Institute for Economic Policy Research to examine these issues and suggest possible solutions that would make nuclear a financially viable and socially acceptable option for rapid increases in U.S. power generation. His resulting paper outlines technical innovations and policies—well within the reach of current technology—that could accomplish the task.28

#### 2.1.8.1 Financial issues for nuclear power

Nuclear power plants can produce relatively inexpensive energy predictably over a long period of time, but the up-front cost of a plant is high and the predictability is low of permitting and building one on budget and on time. Most countries that emphasize nuclear power do so with government policies that spread the financial risk to society as a whole. In the U.S., where relatively small utilities must go to Wall Street to raise money to build plants, the premium imposed for perceived risk can be unaffordable, making nuclear energy uneconomic.

Several factors drive the high cost of capital for nuclear power, but the sheer expense of a nuclear power plant is fundamental to all of them. The EIA estimates the cost of a two-unit advanced nuclear plant at $12 billion, excluding the cost of borrowing funds (in other words, if the plant could be built overnight). For many utilities, Wall Street financing is not available because the plant, when built, would constitute too large a portion of the total assets of the entire utility company. Even for larger utilities such an enormous capital investment, if vulnerable to large regulatory or technological uncertainty, makes investors nervous and commands a high cost of capital.

The ability of utilities to charge ratepayers for plant construction also affects the cost of capital. In 26 states, representing 40% of the U.S. population, traditional rate-of-return utility regulation permits the

operator to charge ratepayers for the cost of financing during construction, reducing the risk and the cost of borrowing. Another 20% of the population lives in states with less generous rules, and 40% lives in states with unregulated utilities, where investors shoulder all of the risk. This latter 60% of the population cannot avail itself of traditional nuclear power plant construction because the market considers the risk too high. In its modeling projections, the EIA expects the use of nuclear power will decline, in part because the NEMS model assumes all utilities operate in unregulated markets with costly capital.

One solution to these barriers is for the federal government to provide loan guarantees to utilities that build nuclear power plants. As exponents of market solutions in the balance of our policy recommendations, NEPI has not included loan guarantees for nuclear power in our package of solutions. We do believe utility regulation and the spreading of cost burdens to ratepayers is a reasonable solution to enable communities to obtain costly but beneficial energy facilities, but in our federal system of government a national policy has no role in deciding how individual states regulate utilities.

A technical solution could save the day for nuclear power. Nuclear power plants do not have to be so large and expensive. Huge plants enjoy economies of scale that potentially lower the cost of electricity, but much smaller plants could have advantages in safety, simplicity and mass production, with total prices low enough to make capital affordable for utilities that want to build them. Such a unit, called a Small Modular Reactor (SMR), would produce about a sixth as much power as a unit at a traditional plant.

The cost of a civilian SMR has not yet been quantified through a prototype engineering process funded by the Department of Energy, but Rothwell estimates that, once in routine production, units could cost about $2 billion each. SMRs save money two ways. By being more common and using standardized designs, components could be mass-produced in factories rather than being built one at a time on-site. Also, the smaller investment would entail less risk for utilities, allowing them to borrow at lower cost. The economies of scale lost by building smaller plants might be offset by these savings; however, a mix of small and traditional large plants probably makes sense.

Small Modular Reactors are not a new idea—they have a long, illustrious history in the U.S. Navy’s 60-year record of operating them on ships and submarines without a significant accident. Bringing this technology ashore, to civilian plants, promises broader use of nuclear power, and extension of the safety benefits already developed through their extensive use.

2.1.8.2 Safety issues for nuclear power

Three iconic accidents—Three Mile Island, Chernobyl and Fukushima—have instilled understandable skepticism in the American public about the safety of nuclear power. Rothwell examines the causes of these accidents in his paper. In each case, human errors either caused the accident or contributed to making it worse. Error threatens to infect every human endeavor. Nuclear energy cannot be quarantined from this threat, but technology can strengthen its immunities so that major accidents are extremely rare and, more importantly, have far lesser consequences when they do occur. National safety regulators need to be active.

On the other hand, passive safety systems reduce the need for human intervention in an accident, ideally allowing nuclear material to cool even if systems fail or are not activated. All U.S. SMRs being considered for development incorporate passive safety measures. For example, the 180-megawatt Babcock & Wilcox mPower reactor would be installed underground, allowing the reactor’s heat to dissipate into the earth after a shut-down. In November 2012, The Department of Energy selected this reactor for engineering and design certification, with plans to install six units near Oak Ridge, Tennessee.

New large reactors also will rely on the passive safety concept, but SMRs have additional safety benefits. Their designs can be based on U.S. naval reactors, with their exceptional safety record. And they would be built in larger numbers, allowing the replication of reliability found in the aviation industry when airliners are produced on an assembly line.
2.1.8.3 Environmental issues for nuclear power

Long-term disposal of used nuclear fuel remains unresolved. With the cancellation of the Yucca Mountain Nuclear Waste Repository by the Obama Administration, the radioactive waste of U.S. power plants remains stored on-site, near where it was used. By the time of its cancellation, the design capacity of the Yucca Mountain facility already had been exceeded by the volume of waste stored on plant sites.

Secretary of Energy Steven Chu noted that on-site storage is considered safe for many decades, allowing time for a Blue Ribbon Commission on America’s Nuclear Future to study a new solution. Among its findings, the commission recommended creation of Monitored Retrievable Storage facilities that could consolidate material for several decades while waiting for a permanent disposal solution.29 Rothwell finds that these facilities could hold waste from new plants for a couple of centuries at reasonable cost to utilities.

While decades of national procrastination over permanent disposal of nuclear waste is hardly a virtue, it does not by itself constitute an environmental threat. The waste is currently secure and no special intervention is required to keep it so for many years. But action by Congress is required. Under current law, without a permanent disposal facility coming on line, temporary consolidated storage cannot be licensed, and without consolidated storage, licensing and relicensing of plants is on hold, as they must demonstrate they can ultimately be decommissioned and their sites reclaimed—not possible without a place to send waste.

Is permanent disposal of nuclear waste impossible? The answer appears to be no: several technical solutions exist, including reprocessing to recover energy and reduce waste volume and use of underground salt domes that are stable for many millions of years. The energy content of nuclear fuel is very high relative to its waste volume. Compared to the billions of tons of fossil fuel carbon already disposed of in the atmosphere, the mass of spent nuclear fuel is miniscule and the environmental challenge of containment relatively manageable.

2.2 Oil Security Dividend: A fully rebated oil tax

A broad-based tax is the most efficient means to reduce both oil use (and imports) and carbon dioxide emissions, but recent history has shown that proposals for a cap-and-trade program or straight carbon tax are not politically viable (as discussed in Section 1.3.1). For elected officials whose constituents are constantly aware of the price of gasoline, the very purpose of these policies—to increase the cost of carbon-intensive energy to the end user—smells of political poison.

NEPI’s Oil Security Dividend policy overcomes this difficulty by delivering the benefits of a broad-based oil tax without financial cost to the public. A tax would slowly increase the cost of fuel, with proceeds from the levy rebated in full to taxpayers. These refunds would completely offset the cost of the levy for the average taxpayer. Those who use more than an average amount of fuel would pay more in total, and those who use less fuel than average would receive a net financial benefit.

The dividend concept simplifies oil pricing strategy by removing it from the arena of federal revenue collection and wealth distribution. This policy is revenue neutral and also neutral in its impact on income equality. Its purpose and impact are focused not on taxation but on the goal of energy policy, to shift the true costs of oil use to the users of oil, including the cost of importing oil on national security and on America’s economic strength, and the environmental costs for climate change and air pollution.

NEPI engaged Roberton C. Williams of the University of Maryland, to evaluate three oil tax recycling concepts. We focus on one that imposes no net cost on the economy or the average household, and may slightly increase wealth—even before considering the positive impacts of the oil tax itself. As we’ve seen elsewhere in this report, reducing oil imports can bring economic and environmental benefits to Americans well in excess of the cost of a carbon tax, even when the revenues are not recycled. Under this policy, those benefits accrue without any cost to taxpayers. While no policy provides something for nothing, the Oil Security Dividend is as close to a free lunch as policymakers commonly encounter.

2.2.1 How the Oil Security Dividend works

This policy imposes a tax on oil to account for the costs that importation and combustion impose on the environment and economy, but which are not included in the market price paid by users. The tax affects all oil products. It is levied on a Btu basis at an amount that is equivalent to a certain level of taxation on gasoline. The tax escalates over time to avoid price shock, beginning at 8 cents per gasoline gallon-equivalent in 2013 and increasing annually by 8 cents until 2035, when the tax reaches $1.84 cents per gallon. In consumer perception, this gradual rise would disappear amidst the routine volatility of gasoline prices, which commonly change by 8 cents or more in a single week (since 2008, the average retail price of a gallon of gasoline has ranged from $1.61 to $4.12). The purpose of the tax is to influence oil users to conserve fuel, a well-established result based on modeling and past experience.

The Oil Security Dividend policy differs from a traditional fuel tax because the revenues are recycled to the taxpaying public. The total cost of the policy is very low—and may even be negative—because of the efficiency of an oil tax and the way the recycling mechanism encourages macroeconomic activity. The money paid at the pump, or paid in slightly higher costs of goods and services, comes back in reductions to payroll or income tax rates. Although these annual tax rate changes are small, they accumulate over time as the oil tax increases. By 2035, the average middle-income earner would pay $3,353 in oil taxes (in 2010 dollars), but would receive a 3.4% tax cut that would fully offset that cost. By using less oil-based fuel, the taxpayer could even profit from the system.

The offset to taxes could be applied to payroll or income taxes with reductions or credits (in our economic analysis it made little difference which tax was credited, so for simplicity we will reference income tax only). Tax rate adjustments would differ by income level to make the policy neutral with respect to income distribution. These adjustments are necessary because low-income Americans spend a larger percentage of their income on fuel than wealthier Americans; consequently, fuels taxes are regressive, hitting the poor harder than the rich. Under our policy, by 2035, a taxpayer whose income was in the lowest fifth of all Americans’ incomes would receive a tax break of 4.27%, compared to a break of 3.12% for a taxpayer in the highest fifth. For each, this would represent a net benefit of .1% of income. (Figure 2.15)

Why would recycling the oil tax produce a negative cost—or net benefit—for the policy? Lower income taxes create an incentive to work and save, boosting the economy. Also, the fuel tax is an economically efficient way of raising revenue. As it offsets taxes that are burdened with the inefficiencies of our complex income tax code, those inefficiencies are reduced. The overall economic efficiency of the nation’s tax system increases somewhat, yielding the net benefit shown in the modeling.

Fig. 2.15 Components of Net Burden by Income Quintile
Oil Tax with Distribution—Neutralizing Tax Change, 2035
The implementation of the policy would require a more detailed review of the tax code than was possible in this report. As noted, our modeling showed that the income tax or payroll tax would perform similarly for rebating the oil tax, but in actual practice, some lower-income Americans don’t owe income taxes and don’t have to file returns. A refundable tax credit could provide cash fuel tax rebates to these low-income workers.

### 2.2.2 Alternative designs of the Oil Security Dividend

Williams modeled three options for recycling oil tax revenue to the public (Figure 2.16).

The three recycling options are all revenue-neutral for the government, because all pay out 100% of the proceeds from the oil tax. The scenario we selected also maintained neutrality with respect to income distribution: it reduces income tax in variable amounts necessary to correct for the regressive nature of a flat cents-per-gallon fuel tax. The other two options included an across-the-board income tax rate reduction of the same percentage for everyone, or a lump sum cash payment of the same dollar amount for everyone.

![Graph of Net Cost per Household Under Three Recycling Options](image)

Economic factors unrelated to energy dominated the analysis of the recycling portion of the program. Using his custom-built model, Williams found the across-the-board income tax cut to be the lowest-cost option by a slight margin, but also found that it would hit low-income earners hardest, making it regressive. These results came about because lower-income earners spend a larger proportion of their income on fuel; if they receive a tax rebate at the same proportion as the wealthy, their net cost will consume more of their income. The modeling indicated the bottom 40% of earners would pay more in fuel tax than they would receive in income tax reductions, while the highest 60% would get a net benefit from the program.

This regressive aspect of the proportional reduction option contributed to its total cost being the lowest of the three options we examined, although the savings compared to the option we selected were quite small. The proportional tax option yielded a net benefit (or negative cost) of 0.15% compared to the 0.1% benefit for our preferred income-distribution-neutral option. This result came about because tax cuts for higher earners create greater economic efficiency: since their tax rates are higher, reducing them does more to lessen tax-caused distortions to their economic behavior.

The third option Williams modeled provides a fuel tax refund to everyone of the same dollar amount. The payment could be made as a tax credit, or it could be paid out in mass distributions of checks or direct deposits. This approach has a couple of appealing aspects. Sending out payments would render the benefit obvious to taxpayers, building support for the program, similar to the way the popular Alaska Permanent Fund Dividend program has made that state’s savings fund politically inviolate. Also, the lump sum payments would be highly progressive, enhancing income equality, as the Alaska program is noted for doing.

But this option has disadvantages, as well. In Williams’s modeling, its costs were significantly higher than the other two approaches. The reasons are complex, and are treated in Williams’s paper. In essence, the lump-sum dividend affects the economy more negatively because it creates a disincentive to work, and because it provokes tax increases to compensate for the lost economic activity and the inflation caused by the increased oil price.

### 2.2.3 Oil Security Dividend benefits and modeling results

Analysis of the Oil Security Dividend involved two models: the custom-made model Williams used
to look at recycling tax revenues, and the NEMS-NEPI model that informed our understanding of the energy and emissions savings of all the policies in the report. This section reports results from the energy model.

The essential working part of the dividend policy is an oil tax introduced at a slowly graduated pace, adding the Btu equivalent of 8 cents a gallon on gasoline to all oil products every year for 23 years, until reaching $1.84 per gallon. The reason for the slow increase in the tax is to prevent the economic or political shock of a sudden oil price rise. Despite its gentle rise, however, the policy does bite, increasing the price of oil and thereby reducing demand.

The model shows that the cost of the tax is essentially passed on in total to consumers, in the price of gasoline and in refined products, as we would expect. Similarly, the increased cost of higher fuel prices imposed on businesses flows through to higher prices for goods and services. Since individual consumers and not businesses will receive recycled revenues from the tax, it makes sense that consumers should pay these costs.

Higher fuel prices drive consumer decisions that save fuel, thereby cutting oil imports and reducing carbon dioxide emissions. The model shows that vehicle miles traveled decline by 4% compared to the Reference Case in 2035, and total gasoline use goes down by 9%. Oil use declines by 500,000 barrels a day, with 300,000 barrels a day being reduced from oil imports. The reduction in cumulative carbon dioxide emissions is 1.7 gigatons, or 1% compared to the Reference Case.

### 2.2.4 Policy costs

For the most part, policy costs for the Oil Security Dividend are addressed in the sections above that explain the revenue recycling concept. They are summarized in Table 2.2.

The welfare cost of a policy is the sum of its costs across society. Since the Oil Security Dividend returns tax proceeds to the public, the direct impact on consumers is a wash, or essentially zero. However, as discussed in Section 2.2.1 above, there is a net benefit to the economy from shifting some taxes from less efficient (income tax) collection methods to more efficient (oil tax) methods. That benefit shows up in the table as a negative cost of $117.1 billion (in 2010 dollars).

The problem of how to allocate the welfare costs to our two goals of oil use and carbon emissions is unimportant in evaluating the oil security dividend policy, because its total costs are negative—in aggregate, it provides more benefit than cost, even before looking at how it accomplishes the goals. The figures in the key metrics table show the total cost applied to each goal. In reality, these negative costs, or savings, can apply to only one goal or the other. For an explanation of this issue, see Section 1.6.3.

Since the policy refunds all fuel taxes paid, it has no out-of-pocket cost for taxpayers in the aggregate. While those who use an above-average amount of oil-based fuel would pay more, others who use a below-average amount would pay less.

The federal government’s cost for the program would be in administration only. Since the federal government already imposes taxes on fuel and

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<td><strong>Progress on Oil Target by 2035</strong></td>
</tr>
<tr>
<td><strong>Cumulative CO2 Reductions v Reference Case</strong></td>
</tr>
<tr>
<td><strong>PDV Welfare Cost</strong></td>
</tr>
<tr>
<td><strong>Cost Effectiveness Oil</strong></td>
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<tr>
<td><strong>Cost Effectiveness CO2</strong></td>
</tr>
<tr>
<td><strong>Impact on Consumer Households in 2035</strong></td>
</tr>
<tr>
<td><strong>PDV of Cumulative change in Total Gasoline Cost v Reference Case</strong></td>
</tr>
<tr>
<td><strong>Impact on Federal Budget</strong></td>
</tr>
<tr>
<td><strong>Total 2010-2035 Tax Revenue Impact (2010 $ billion)</strong></td>
</tr>
<tr>
<td><strong>Target</strong></td>
</tr>
<tr>
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</tr>
<tr>
<td>21,678</td>
</tr>
<tr>
<td><strong>Reference Case</strong></td>
</tr>
<tr>
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</tr>
<tr>
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<tr>
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<td><strong>Oil Security Dividend</strong></td>
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<td>(186)</td>
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1 Motor gasoline cost is for all light duty vehicles; declines in cost are due to reduced VMT and/or reduced gasoline price (excluding the phased oil tax component)

a. impact on residential electricity and natural gas costs are insignificant - these policies target oil consumption
b. administrative cost only
income, the incremental cost of changing these taxes would presumably be insignificant.

2.3 Automotive fuel economy

After the 1970s energy crisis, Congress mandated manufacturers to produce more fuel-efficient cars through a seemingly simple mechanism called the Corporate Average Fuel Economy (CAFE) Standards. The system has proved effective, but far from simple. Average fuel economy has risen to 26 miles per gallon, and under new rules adopted in 2012, will double to 54.5 MPG by 2025, a level of efficiency that will stretch the bounds of technological innovation. In light of that success, and the established regulatory system surrounding CAFE Standards, we recommend no more than continuing the already-existing regulations. However, we have also studied a simpler, market-driven, way of meeting the same objective with a more flexible policy, as we describe in this section.

The original CAFE Standards required each automaker to sell vehicles whose average mile-per-gallon efficiency met a government target, but the program created unintended consequences on a massive scale. By exempting light trucks, the rules brought whole new classes of gas-guzzling SUVs and minivans into the market, which grew in popularity until they comprised half of Americans’ auto purchases.

New law and new EPA rules have addressed problems in the CAFE Standards, introducing more sophisticated ways of addressing vehicle size, and allowing car companies to trade credits, so builders of less efficient cars can pay for that right to manufacturers of more efficient cars. With these updates, the CAFE Standards are a significant force in saving fuel and reducing our dependence on foreign oil and our carbon dioxide emissions from transportation. We should retain those benefits, and no additional policy action is required to do so.

However, the CAFE Standards are far from ideal, so NEPI also studied a market-based policy called feebates. A market-based policy, unlike a mandate, can do more than it was originally intended to do, and can respond to the day-to-day changes that inevitably affect real-world decisions. It is also less susceptible to the unintended consequences that beset the much more complex CAFE program.

A feebate is a fee connected to the sale of low-efficiency vehicles which is used to provide rebates to buyers of high-efficiency vehicles. Research by our consultant, Ken Gillingham, of the Yale School of
Forestry and Environmental Studies, shows that a simple feebate policy can exactly mimic the impact of CAFE Standards as they are presently configured, but do so without complex rules or mandate rigidity. As with any mandate, the CAFE Standards cannot achieve results better than the target set out in the rules. As a market-based approach, the feebate is much simpler, and therefore less expensive to administer, and it continues to provide incentives to car buyers regardless of whether companies have attained a particular fuel efficiency average. Suggestive behavioral economics results indicate that feebates could even shape consumer choices that would be more beneficial to car buyers themselves, as well as to society.

2.3.1 How the CAFE Standards work

A full understanding of CAFE Standards requires advanced mathematics, so this review is confined to general terms and leaves out many details. Complexity is a major flaw of the program. The complexity of the standards increases each time policy makers seek to correct unintended consequences or meet unexpected circumstances. After more than 35 years, these patches and rewrites have evolved into a program that defies any simple description.

The concept begins with a fuel efficiency number in miles per gallon (MPG) that each automaker must meet, averaged over all the cars it sells. Under changes made in 2011, the average MPG requirement differs based on the size of the vehicle. Size is defined by a complicated formula based on the footprint of the wheels on the road. Vehicles with a larger footprint have an easier MPG target to meet, which critics point out is a benefit to US automakers that build more large vehicles.

The program also includes add-on taxes and penalties beyond the MPG average mandate. Inefficient vehicles other than minivans, SUVs and light trucks pay a “gas guzzler tax,” which begins at $1,000 for cars with a rating of 22.5 to 21.5 MPG, and rises to $7,500 at an MPG rating worse than 12.5 mpg. Another mechanism allows automakers unable to comply with the average MPG standard to get around it by paying a civil fine based on the degree to which they fall short, multiplied by the number of vehicles sold; however, this provision has been little used except by European automakers.

The CAFE Standards also provide various credits, which, like other parts of the plan, phase in and out in different years. Credits are provided to makers of ethanol flex-fuel vehicles, dedicated alternative fuels vehicles, vehicles with air conditioners that are efficient or that reduce loss of refrigerants, cars that can run on natural gas, and various other factors. New credits added in 2012 complicate the system and make it subject to criticism for unfairness. For example, Toyota has charged a bias for American automakers because large pickup trucks get credits for using hybrid technology, applicable only to a single GM model, while small hybrids such as the popular Toyota Prius do not get credits.

One earlier criticism of the program was that the averaging concept limited the improvement realized when low-emission vehicles are sold. An automaker meeting the standard has no incentive to do better; thus, the sale of each additional hybrid or electric vehicle merely becomes a license to sell another high-emission vehicle, canceling the improvement for energy savings and the environment. A system of tradable credits added for the 2011 model year is intended to address this problem, and to reduce the cost of the program.

Under the credit trading system, automakers that surpass their standard can sell excess credits to companies with less efficient fleets, or can exchange them within their own company or bank them for use in a future year when the standard becomes more difficult to attain. The credit system creates an economic incentive to improve fuel efficiency even after meeting the standard, as the credits have monetary value. However, the criticism remains that a buyer of a hybrid car merely creates permission for an automaker somewhere to sell an inefficient vehicle, even if that vehicle is built by a different company that buys a credit.

Like the tax code, the complexity and changing rules of the CAFE Standards reward cynicism and special-interest political pressure. The business and automotive press analyze each change for new


loopholes and evidence of winners and losers. The possibility of relaxing or reformulating the standards in the future undercuts the incentive for technological improvement, as automakers may find it more cost effective to invest in lobbying for special relief provisions than building better cars. The 2011 changes negotiated by the Obama administration with the auto industry call for an increase in average efficiency to 54.5 miles per gallon in 2025, but also include a 2021 review to determine if that will be technically feasible—which automakers may see as an “out” for escaping the rule when the time comes.

Part of adopting CAFE Standards as an element of our comprehensive energy policy should be the commitment to hold the line on backsliding. Automakers must invest in research and development to meet the standards in time. Firmness in maintaining a consistent program will provide the certainty necessary for success.

2.3.2 An alternative policy: feebeates

A key advantage of the feebate concept is its simplicity and transparency. Instead of mandating manufacturers to achieve an average fuel economy standard, the feebate imposes a fee on sales of high-fuel-use vehicles and rebates those funds to reduce the price of fuel-efficient vehicles. The feebate concept provides a financial incentive to increase fuel economy without a mandate to do so. It functions independently of technological considerations. Loopholes and special provisions are less likely to be inserted into the policy because complex rules are not needed in the first place. This simplicity should also make the policy less expensive to administer.

The effectiveness of the feebate is determined by two variables: the MPG pivot point below which fees are charged and above which rebates are given; and the rate charged for variation from the pivot point. A higher MPG pivot point would create a stronger financial incentive for fuel efficiency. In his work, Gillingham shows that a pivot point and rate can be selected to replicate the results of the CAFE Standards. The feebate can also be revenue neutral, like CAFE Standards, when the pivot matches the actual MPG average of the fleet. The price differential created by feebeates pushes car buyers toward higher-MPG vehicles, which motivates manufacturers to produce more efficient vehicles for them to buy. If the government decides to give a break to makers of larger vehicle classes, as in the CAFE Standards’ footprint formula, that can also be implemented through the feebate policy by setting a different pivot point for each size class.

As an example, a feebate designed to match the current CAFE Standards would, in 2017, provide a rebate of $313 for a vehicle that gets 40 MPG and charge a fee of $1,361 for one that gets 20 MPG (figures here are in 2010 dollars). Although the policy remains nearly revenue neutral, the feebate ramps up through the years to produce higher fuel efficiency. In 2025, the 40 MPG vehicle would earn a rebate of $1,493 while the 20 MPG vehicle would cost an extra $6,493.

The feebate policy could be designed to work at the manufacturer or consumer level without substantively affecting the results. We prefer the approach of charging the fees and issuing the rebates at the point of sale, perhaps showing the feebate as an item on the price sticker. Such transparency would take advantage of a tendency of consumers, found in some behavioral economics studies, to respond more strongly to costs that are shown explicitly than costs that are built into a total price. More research is needed to verify this effect, so we have not included it in our modeling, but it could increase the cost-effectiveness of the policy.

Behavioral economics research also suggests that consumers undervalue fuel economy in vehicle-purchase decisions. Researchers disagree on the strength or reason for this prejudice, which could be caused by buyers using an extreme discount rate (placing too low a value on future costs), or could reflect simple inattention on the part of buyers to their total costs. Either way, a consumer-level feebate could benefit car buyers by bringing the issue to the fore and influencing them to choose more efficient vehicles that will also save them money in the long run.

2.3.3 CAFE Standards benefits and modeling results

The modeled benefits of the new CAFE Standards are substantial and are expected to strain the technological limits of attainable vehicle fuel efficiency. The changes made in 2012 are
included in our comprehensive policy as an important part of meeting our goals. The alternative feebate policy does not strive for efficiency greater than that, but seeks the same benefit in a way that is simpler and more transparent.

The benefit of either program amounts to a reduction of 1.0 million barrels per day (mmbd) of oil in 2035 (of which 0.7 mmbd is imports), compared to the 2010 baseline. Carbon dioxide emission reductions are a cumulative 1.8 gigatons over the period.

### 2.3.4 Policy costs

The federal government has already adopted the CAFE Standards policy that we recommend as part of our comprehensive policy, so its inclusion here has no incremental cost to society. However, consistent with the rest of our analysis, we have calculated costs for the CAFE Standards and included them in our bottom-line costs. The costs for this policy are shown in Table 2.3.

Welfare costs for the CAFE Standards calculated by Gillingham have three major components: the increased cost of the more efficient vehicles, less the savings in fuel used, plus the cost incurred by the rebound effect—which is the additional cost imposed on society when greater fuel economy induces more driving. Additional driving creates costs for congestion, accidents, road construction, and so on. Our modeling shows the cost of this rebound effect to exceed the cost of the policy itself; as we shall see, however, combining the CAFE Standards policy in our comprehensive policy reduces overall vehicle miles traveled, thus eliminating this issue (see Section 3.2.1.1).

Our decision to use conservative assumptions in calculating welfare costs is particularly significant when looking at CAFE Standards. As explained in Section 1.6.1.1, consumers appear to undervalue energy savings when making investment decisions, a phenomenon especially prevalent in car-buying behavior. If this so-called market failure is real, then a policy which produces more fuel-efficient cars will save money for consumers, reducing the cost for society. However, this proposition is debatable: we do not know consumers’ motivations, and they may be responding to important hidden costs related to safety or other product attributes. We have chosen instead to assume that auto buyers are rational in their choices and accurately trade off their fuel savings with other vehicle attributes. In this case, CAFE Standards do not benefit consumers, and the cost of the policy includes more than the individual fuel savings. Our decision increases the cost of this policy by $125 billion to $180 billion, depending on the assumption used to quantify the market failure. The reason for our decision is that we lack a satisfactory basis upon which to quantify the market failure. We could have reduced these costs by assuming that consumers do not choose their vehicles rationally, but this approach would have required an assumption about how large the market failure is.

In allocating these welfare costs to our two goals, of reducing oil use and carbon dioxide emissions, we report the entire cost in the cost per barrel and cost per ton for each goal. This way of reporting the cost tends to double its impact: if the total cost is assigned to oil use reduction, then the carbon dioxide reduction would be free, and vice versa. This issue is explained in Section 1.6.3.

### Table 2.3 CAFE Standards Policy Key Metrics

<table>
<thead>
<tr>
<th>Policy</th>
<th>Progress on Oil Target by 2035</th>
<th>Cumulative CO2 Reductions v Reference Case</th>
<th>PDV Welfare Cost</th>
<th>Cost Effectiveness Oil</th>
<th>Cost Effectiveness CO2</th>
<th>Impact on Consumer Households in 2035</th>
<th>PDV of Cumulative change in Total Gasoline Cost v Reference Case</th>
<th>Impact on Federal Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Case</td>
<td>3.0</td>
<td>21,678</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Increment v Ref case</td>
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<td>55</td>
<td>112</td>
<td>a</td>
<td>a</td>
<td>(361)</td>
</tr>
</tbody>
</table>

1 Motor gasoline cost is for all light duty vehicles; declines in cost are due to reduced VMT and/or reduced gasoline price (excluding the phased oil tax component)

a. impact on residential electricity and natural gas costs are insignificant - these policies target oil consumption

b. administrative cost only
Consumer out-of-pocket costs for the policy are relatively simple: the fuel savings realized by drivers offset the increased cost of more fuel-efficient cars, leaving little increased expense for auto owners. Federal government costs are insignificant: the increased CAFE Standards cost EPA $8 million and the National Highway Traffic Safety Commission $3 million in FY 2013.

2.4 LNG Trucks

Technology will transform the commercial truck fleet that carries America’s freight in coming years. For many applications, trucking companies will find liquefied natural gas (LNG) is the best fuel choice for heavy and medium trucks. In our 2010 report, NEPI recognized this technology as an inexpensive way to reduce oil imports. Since then, lower LNG prices, technical advances, and fueling station construction have combined to make this fuel an economic winner regardless of policy interventions. Thus, our policy to encourage LNG can be modest, enhancing a beneficial change that is already beginning to happen.

Traditional internal combustion engines can be built or converted to burn LNG or compressed natural gas (CNG) instead of diesel or gasoline. Natural gas becomes compact enough to use as a vehicle fuel when stored under pressure, in the case of CNG, or cooled to negative 260 degrees F, for LNG. The smaller volume and lower pressure of LNG make it a more practical alternative than CNG in highway trucks.

For operators, LNG’s relatively clean exhaust eliminates the need for the expensive emissions control equipment required for diesel trucks. However, LNG adds cost to the engine and fuel system and increases the weight of the truck. Also, the fuel can vent from tanks when it gets too warm, creating safety issues and increasing greenhouse gas emissions. Maintenance facilities need special safety equipment to deal with lighter-than-air natural gas. An additional limitation, a lack of LNG engines powerful enough for many applications, is being resolved with the introduction of new equipment by manufacturers.

On the eve of game-changing technical and market changes, LNG is already the lowest-cost fuel option for long-haul trucks and is beginning to be used. But the industry is understandably conservative about investing in new equipment with unfamiliar characteristics for maintenance, operations, fueling and safety. Since we seek a practical policy, we have put these potential barriers at the center of our analysis, evaluating the real life issues and business case for an actual trucking company. That analysis, by Anna Lee Deal, forms the basis for this section.\(^\text{32}\) Deal is Coordinator of Green Initiatives for Lynden Incorporated, a multi-modal transportation company based in the Pacific Northwest and Alaska.

2.4.1 A policy supporting LNG trucks

Despite the many factors facing trucking companies in adopting LNG as a fuel, a simple, inexpensive policy prescription is most helpful to bring about conversions. Trucking company executives are focused on the cost savings of using LNG instead of diesel. The overriding importance of fuel cost is such that when operators gain confidence in sufficient savings, market forces will bring down barriers to conversion. Indeed, this process is already happening, as we will explore later in this chapter (see Section 2.4.5).

Our policy reduces the excise tax on natural gas as a motor fuel to zero, then brings it back to levels comparable with diesel over a 10-year period. Currently, LNG is taxed at the same rate per gallon as diesel, which puts it at a disadvantage because diesel contains more energy per gallon. Our policy would put LNG and diesel on a level footing after

\(^{32}\)Anna Lee Deal, “What Set of Conditions Would Make the Business Case to convert Heavy Trucks to Natural Gas? – a Case Study”, 2012.

the 10-year tax break, by setting the tax at a rate equivalent by Btu (a unit of energy) rather than by the gallon. The 10-year tax break would also affect compressed natural gas, or CNG, but we do not expect a large increase in use of CNG and its impact is insignificant in our modeling.

By temporarily lowering the price of LNG as a fuel, the policy helps push trucking companies and the fuel industry beyond the inertia that would otherwise slow conversion. New fueling stations and maintenance shops must be built, employees must be trained in new equipment and safety procedures, and new operating considerations must be accounted for. With sufficiently large savings on fuel, these changes, which are already impending, will happen more rapidly.

2.4.2 Alternative policies not selected

NEPI considered several other policy ideas to encourage faster LNG conversion. We were influenced by the recognition that conversion is beginning to happen without any policy influence, and by the desire to adopt a low-cost option.

LNG trucks are more expensive than traditional, diesel-fueled trucks, a difference that could be addressed through a tax credit. But such tax credits would be a comparatively expensive means to encourage conversions. Trucking companies’ concerns with the cost of trucks is directly related to the long-term cost of fuel. Thus, addressing the cost of fuel through a tax break is simpler and probably more effective in bringing about purchase of LNG trucks.

Trucking companies would be strongly motivated by a policy that added confidence to fuel prices by somehow guaranteeing a given price differential between diesel and LNG. Our policy goes partway toward doing this by lowering taxes on LNG while leaving them in place on diesel. But a policy to control fuel prices would be too complex and potentially too expensive.

One could also imagine a policy that would go directly to the barriers to LNG truck mobilization, by somehow speeding construction of fueling stations and maintenance shops. But these issues are already being resolved by the market.

Finally, we could conceive of a policy to allow heavier LNG trucks on the road without diminishing their payload weight, a strong incentive for truckers. But vehicle weights are controlled by the states, which also pay for road damage from overweight trucks. A federal policy overriding this authority would be unfair to the states and thereby unlikely to be adopted.

2.4.3 LNG truck benefits and modeling results

To arrive at our modeling results, we adapted the AEO 2012 Reference Case. We used new information about the cost of LNG trucks, we included the increased weight of LNG equipment, which reduces truck payload capacity, and we incorporated changes the EIA had made for its 2013 outlook on vehicle miles traveled. When the EIA released a preliminary version of its AEO 2013, we found its results similar to ours, showing a faster increase in LNG truck sales than previously shown in the AEO 2012 Reference Case.

The NEMS-NEPI model shows LNG trucks contributing a reduction of 400,000 barrels a day of oil use by 2035 compared to the Reference Case in the EIA’s Annual Energy Outlook 2012. Total oil use in 2035 would be 16.7 million barrels a day. Of the 400,000 barrel reduction, our policy of excise tax reduction would contribute 100,000 barrels, and the balance comes about due to our updates to the modeling assumptions.

In 2010, only 0.1% of the 5 million trucks on the road operated on LNG. That share increases to just 0.2% by 2035 in the AEO 2012 Reference Case projection. Our analysis of the market instead shows LNG trucks increasing to 11.9% in 2035 without policy intervention; adding our policy brings LNG to 14.5% of the truck fleet by 2035.

The increase in LNG trucks contributes 0.1 gigatons to our carbon dioxide reduction goal.

2.4.4 Policy costs

Costs are summarized in Table 2.4. As with our other policies, the welfare costs here contain the assumption that the market accurately assesses the value of investments in energy technology. However, it is possible that fleet managers’ caution in adopting new technology may not be economically optimal. If that is the case, then our cost estimate would be too high, because the policy would tend to save money for companies that
otherwise would not do so. However, because we could not quantify the quality of these business decisions, we chose the most conservative assumption, which maximizes the cost. See Section 1.6.1.1 for a more complete explanation.

The numbers reporting the cost effectiveness of the policy also require explanation. The LNG truck policy impacts both of our goals, for oil use and carbon dioxide emissions. The figures for cost effectiveness, in dollars per barrel or per ton, show the entire cost of the policy allocated against each goal. This double-counts the costs. If the policy costs are attributed in whole to one goal, the cost of meeting the other goal would be zero. This issue is explained in Section 1.6.3.

Out-of-pocket costs for consumers relate to the impact of the policy on the price of natural gas per household and the electricity gas generates. Using more LNG for transportation does push gas prices up slightly, but the impact on consumers is small, $6 a year for electricity and $3 a year for natural gas for the year 2035.

The cost to the federal treasury comes in the reduction of the excise tax in the first 10 years of the policy, and the equalization of taxes for LNG with diesel by energy content, which results in a lower tax on LNG compared to the Reference Case. The initial tax cut reduces federal revenues by $800 million. After 2025, when the tax cut ends but equalization with diesel continues, the tax reduction totals $4.6 billion. For the entire 20-year period of the analysis, the loss of tax revenues totals $5.4 billion compared to the Reference Case. NEPI analyzed other options, including eliminating the excise tax entirely, but found little increase in LNG trucks for the increased cost.

### 2.4.5 Business case and challenges for LNG trucks

Our economic analysis of the shift from diesel to LNG trucks focuses primarily on the cost of fuel and of trucks. Trucks that burn LNG currently cost $30,000 to $70,000 more than comparable trucks that burn diesel. Conversion kits for existing diesel trucks cost $25,000 to $40,000. At the time Deal did her business analysis, natural gas prices were 65% to 70% lower than oil on an energy equivalent basis. As noted elsewhere, our modeling also included the reduced payload capacity of trucks fitted with LNG tanks, which weigh more than diesel tanks.

At the current diesel price of about $4 per gallon, Deal shows that trucking companies can make a return on investment of over 20% using LNG in line-haul trucks that drive at least 70,000 miles a year. With the introduction of new equipment by manufacturers, these results can be expected to improve.

Despite the attractiveness of this analysis, barriers stand in the way of greater LNG adoption that are not easy to model. These barriers include different maintenance and fueling needs, new safety procedures, and the understandable caution of trucking companies to embark on use of a new technology with unfamiliar characteristics. In each case, an increased return on investment can address these concerns, which is why our policy reduces LNG taxes for 10 years, followed by parity with diesel on an energy basis.

Since it isn’t practical to model the barriers to conversion to LNG, we address them individually in the following sections to show how they can be addressed by the market.

### Table 2.4 LNG Trucks Policy Key Metrics

<table>
<thead>
<tr>
<th>Policy</th>
<th>Progress on Oil Target by 2035</th>
<th>Cumulative CO2 Reductions v Reference Case</th>
<th>PDV Welfare Cost</th>
<th>Cost Effectiveness Oil</th>
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<th>Impact on Consumer Households in 2035</th>
<th>PDV of Cumulative change in Total Gasoline Cost* v Reference Case</th>
<th>Impact on Federal Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
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<td>0</td>
<td>6</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

*Motor gasoline cost is for all light duty vehicles.
2.4.5.1 Limited fueling infrastructure

An LNG fueling station receives deliveries in tankers and stores it with liquid nitrogen cooling equipment. Trucks’ tanks look similar to diesel tanks, but are larger and heavier, since LNG has lower energy density than diesel and must be isolated from the environment by a thermos-like vacuum container. Fueling lines attach differently than diesel pumps and operators must wear gloves, aprons and face shields for protection from the super-cooled material. Gas that escapes evaporates rapidly and disperses in open air.

These differences create no insuperable barrier to building LNG fueling stations if a profitable market exists. An LNG fueling station costs about $1.5 million to build. Until recently, stations were located almost exclusively in California, and most of those were not public. But in 2013, major companies in the truck fueling and natural gas industries plan to complete a national network of 150 stations to connect major Interstate Highway routes at intervals of 200 to 300 miles. By 2015, the investors expect to have covered all regional routes with 300 to 400 stations. Companies with large, busy fleets could also build their own fueling stations.

A network that covers major trucking routes on the interstates will create a positive business opportunity for truckers. However, early adopters of LNG trucks will still sacrifice the flexibility of diesel trucks, which go almost anywhere and find fuel for sale.

2.4.5.2 Fuel temperature issues

Truck fuel tanks keep LNG cold with highly effective insulation, but after four or five days the fuel warms and expands to the point that it must vent to the atmosphere. Venting wastes fuel and emits greenhouse gas 25 times as potent as carbon dioxide. Venting also degrades the fuel left in the tank, as the lighter portions of natural gas that vent leave behind residual fuel that is of lower quality.

To avoid the venting problem, trucks must be used enough to require refueling every two days. For line-haul trucks driving the number of miles that would support the LNG investment, this frequency of refueling would be expected. However, the issue does add an operational consideration that trucking companies must account for.

The tanks also require special maintenance to retain the super-insulating quality that prevents venting. After about five years, the vacuum degrades and must be re-established with special equipment; subsequent servicing is needed every year or two. Accidents can also damage the vacuum layer of the tank and cause venting.

2.4.5.3 Cost to upgrade maintenance shops

The potential escape of natural gas creates special safety hazards in repair shops that service LNG trucks. Fire codes address these issues with requirements such as improved ventilation and explosion-proof lighting. A trucking company adopting LNG must either contract with a shop already equipped to meet these codes, which increases the cost of maintenance, or must build its own LNG maintenance shop, at a cost of up to $200,000 per repair bay. Other than the capital cost of the shop, maintenance costs for LNG trucks are about the same as for diesel trucks that have required emission control equipment.

2.4.5.4 Limited engine options

The lack of infrastructure for LNG trucks has retarded adoption of the technology, which has in turn discouraged manufacturers from producing a full range of LNG truck engines. Large-displacement engines suitable for heavy trucks have been unavailable. That logjam appears to be breaking, however, as three manufacturers are bringing out more powerful engines. As more trucking companies start using these money-saving trucks, construction of fueling stations and maintenance shops will become profitable, which, when built, will in turn improve the economics of adding more LNG trucks.

2.5 Energy efficiency

Avoiding energy waste in homes and businesses is a simple, inexpensive and obvious way of reducing carbon dioxide emissions. When efficient appliances and buildings require no sacrifices from users in terms of their costs or comfort, they will deliver the same benefits for less energy. These savings can be slow to accumulate, since policy changes mainly affect investments that last a long
time, but the savings made are real and permanent.

For the most part, the federal government has adopted effective policies to improve the energy efficiency of appliances and buildings. For example, an efficiency standard for lightbulbs, one of 55 Standards adopted for various products since 1987, effectively made most incandescent bulbs unavailable as of 2013. Rather than recommend a new strategy, we can accomplish enough by continuing efficiency policies that would otherwise sunset, and by gradually strengthening standards and codes through existing administrative processes.

2.5.1 A policy for energy efficiency

The Energy Information Agency gathered a basket of energy efficiency policies to study for its Annual Energy Outlook 2012, called the Extended Policies Side Case. The purpose of this side case was to look at the impact of extending and incrementally expanding the impact of existing federal energy efficiency and renewable energy policies. We have adopted much of the Extended Policies Case as our own energy efficiency policy.

Using the EIA’s case yields several benefits besides saving effort with an already-completed analysis. The policy follows a clear path that has mainstream acceptance, as demonstrated by the fact that large portions have already been made law in some form. Like the rest of our comprehensive policy, the energy efficiency element relies on existing or predictably feasible technology, offers a real and measurable impact, and faces no insuperable political barriers.

The three main components of the policy are: Energy standards for appliances and other equipment; energy-saving building codes; and tax credits for investments in renewable energy and combined heat and power production in homes and buildings, known as end-user tax credits. In each case, the policies exist today, but are scheduled to end or will need to be updated to maintain effectiveness. We would continue and update the policies through 2035.

We left out portions of the EIA’s Extended Policies Case that are addressed in other ways elsewhere in our plan. We excluded CAFE standards, because we addressed them as a separate policy. We also excluded tax credits for renewable energy investment and production by utilities. Our modeling shows that the NEPI Clean Energy Standard will bring about as much renewable energy as would be driven by the tax credits, and providing tax relief as well is unnecessary.

Appliance standards require manufacturers to attain minimum efficiency in the products they sell. For example, the lighting standard set in 2007 required bulbs to be at least 25% efficient, meaning at least 25% of the electricity flowing to the bulb would create light rather than heat or another form of waste. Since incandescent bulbs could not meet this standard, they were no longer legal after regulations took effect.

Federal standards exist for a broad range of products, and some states have their own additional standards. Past energy savings from these rules are difficult to quantify precisely. A standards advocacy group reported that electricity use in 2010 was reduced by 7% over what it would have been without federal standards. Other estimates for particular programs have ranged from 4% to 25%.

To continue working, a standard must be updated and tightened as technology improves. The detailed technical process can take place within the existing federal system. To model the progress of improving standards, the EIA assumed the standards would be based on voluntary Energy Star standards or the Federal Energy Management Program, which provides purchasing guidelines for federal agencies, and also assumed introduction of new standards on products not now covered.

For building codes, energy efficiency typically is improved by specifying materials rather than setting efficiency goals. For example, a code could require insulation of a certain material and thickness, or windows with certain specifications. In the United States, building codes are established and enforced at the state and local level, where model national codes can be adapted to the local climate, materials, and cultural patterns. Some areas have not adopted energy efficiency building codes, but mandating codes under federal law is problematic, as we discuss in Section 2.5.4.

This analysis assumes a 30% increase in a


We have not independently evaluated the technical feasibility of these higher standards. However, when the EIA put together the policies, the standards were kept within maximum technological feasibility levels already established by the Department of Energy.

The final part of the policy provides tax credits to building owners for investments in renewable energy equipment and combined heat and power equipment. These tax credits are already on the books; our policy merely extends them to 2035.

2.5.2 Energy efficiency benefits and modeling results

The outlook of NEPI-NEMS modeling extends to 2035, but much of the benefit for energy efficiency work, especially in buildings, will take many years to show up, and will last well beyond the end of our modeling horizon. Appliances and equipment last a long time, and building energy codes drive change primarily for new construction. But the long-lasting benefits of these changes should be recognized in policy evaluations even if the results don’t accrue to a single generation.

Energy efficiency improvements for buildings only modestly reduce oil use, because oil heats only 6 percent of U.S. homes and generates only 1 percent of the electricity powering appliances. Compared to the Reference Case, these efficiency policies would reduce oil use by a very small amount.

The policy reduces cumulative carbon dioxide emissions 2.1 gigatons, down from 144.5 gigatons in the Reference Case, or 1.4%. Total delivered energy in the residential sector is reduced by 1.0 quads (quadrillion Btus) in 2035, from 11.9 quads in the Reference Case, a cut of 9%. In the commercial sector, the reduction is 0.5 quads in 2035, from 10.3 quads in the Reference Case, or 5%.

2.5.3 Policy costs

Energy efficiency provides the most cost-effective carbon dioxide reduction of all of our policies. However, the scale of the improvement is limited because of the limited opportunities for increasing energy efficiency. Cumulative carbon dioxide reduction through 2035 is 2.1 gigatons. Figures are shown in Table 2.5. As we will see in Part 3, energy efficiency policies have positive interactions with the other components of the comprehensive policy.

In addition, encouraging energy efficiency probably saves money for building owners. Investments that deliver fuel savings in excess of the up-front costs would seem to need no encouragement from government. However, homeowners and other building owners show reluctance to make these apparently attractive investments, for reasons that may be justified by hidden costs, or may be related to behavioral quirks or market inefficiencies. In our welfare cost analysis, we take no credit for building owners’ energy savings, assuming that all their decisions are economically optimal. While this assumption is not

<table>
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<th>Key Metrics Table</th>
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<td>Policy</td>
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<td>Target</td>
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<td>Reference Case</td>
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<tr>
<td>Energy Efficiencies</td>
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<td>a. oil reductions are insignificant - this policy is directed at CO$_2$ emissions reductions</td>
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supported by the evidence, we have chosen it as a conservative upper bound on our policy cost, since we cannot quantify the degree to which these costs represent market failures. A fuller explanation is found in Section 1.6.1.1.

The energy efficiency policy is not effective in reducing oil use. For this reason, our cost-effectiveness number references only our goal of reducing carbon dioxide emissions, which is given in the cost per ton reduction of carbon dioxide emissions.

Out-of-pocket costs for the policy are negative. The energy efficiency policy reduces residential expenditures for electricity in 2035 by $182 per household and natural gas in 2035 by $41 per household, both by cutting energy use and by cutting energy price. Reductions in price come about due to lower demand.

Federal outlays for the energy efficiency policy are inconsequential, but the tax incentives affect revenues, which impact deficits equally as if they were expenses. As explained in Section 2.5.1, our policy differs from the EIA Extended Policies Side Case in AEO 2012 by allowing expiration of current tax incentives for utilities to invest in and produce renewable energy. Expiration of these Investment Tax Credits and Production Tax Credits reduces the cumulative cost to the treasury from $19 billion in the Reference Case in 2035 to $14.3 billion in our policy.

The $4.7 billion in federal savings on tax incentives for utilities partly offsets extended tax credits for end users. The Energy Efficiency Policy retains the Investment Tax Credit for renewable energy facilities installed by end users, which primarily go to owners of residential properties. The credits total $95 billion by 2035, an average of $3.7 billion per year. With the expected expiration of these tax breaks in the Reference Case, the cumulative credits in 2035 would be $22 billion, or an average of $900 million per year.

2.5.4 Challenges for building energy codes

Building codes assure quality and durability of construction—as well as safety—to protect the interests of future owners of structures that last generations, and the interests of society as a whole in its investment of resources. The market alone cannot protect these interests, because the complexity of construction and longevity of buildings create barriers to knowledge of construction practices and quality by future buyers. These reasons hold equally for codes for energy efficiency, as many jurisdictions have already recognized.

Despite the clear-cut case to be made for energy building codes, however, two challenges limit the effectiveness of this strategy as part of a national energy policy.

First, the time span of modeling does not reach far enough into the future to take into account the full benefit of the improvements, or even the full implementation of the policy. Energy improvements made in products such as insulation and windows can easily last 50 years or more, but our modeling reaches out only about 20 years. Even if all buildings were brought to code immediately, our numbers would capture only a fraction of the total benefit of the investment. But, of course, many decades will pass before all buildings meet energy codes. For the most part, codes are relevant only to new construction, and new buildings replace old buildings slowly. The impact is lasting, but takes a long time to show up.

The other major challenge to the strategy arises from U.S. federalism. Building codes are adopted and enforced at the state and local level. While the federal government probably could impose a national energy building code, it lacks an enforcement mechanism. Replicating the myriad of building code authorities that function at various levels of government would be an expensive, bureaucratic and likely unwelcome change to the way communities have done business for generations.

Instead, the federal government should use persuasion and incentives to influence state and local governments to adopt and enforce increasingly stringent model codes on their own. This is the process that has been used to date. It is the simplest and most politically palatable approach, and it has the benefit of harnessing the desire of citizens and their representatives to address energy and climate needs. Most American progress on climate change mitigation has come from individuals, businesses and state and local governments, and it is reasonable to count on those efforts continuing.
Part 3: Conclusion: Combining policies into a complementary, integrated whole

The ideal national energy policy would combine elements that, like our 50 unique states, build upon one another’s strengths to create a united whole much more powerful than its individual or collective parts. Our five most promising policies do just that. Standing alone, each contributes effectively and at low cost to meeting our goals, reducing oil use and imports and reducing carbon dioxide emissions. Together, they also interact to magnify their effectiveness and produce a larger positive result. In fact, we find that when we combine the policies, key costs go down even as effectiveness increases.

This result is not a surprise. We originally set out, beginning with the many studies that contributed to our 2010 report with Resources for the Future, to identify practical, low-cost policies that would interact positively with one another. A broad pricing methodology such as a carbon tax or a cap-and-trade system could perform better than any other single policy, but we recognized the political unlikeliness of such a tax being enacted. Instead, this package of five policies delivers nearly the same result at low cost, but without political implausibility. Indeed, two of the five policies in the package are substantially in place and a third is trending strongly in the direction we call for.

Other policies could be found that would accomplish progress toward the same goals. The purpose of this report is not to advance a prescription or legislative agenda. Adopting policy for the nation as a whole requires balancing of interests and consideration of complex social and political forces. This work proves, regardless of the details chosen, that our nation’s energy problems are not intractable, but can be addressed aggressively and well, using policies that carry affordable costs in return for important accomplishments for our nation, our economy and individual citizens.

The purpose of this part of the report is to deliver the results of modeling that looks at the outcome and costs of the combined policies. Next, we review factors in the five policies that create positive synergies for particular costs and outcomes. Finally, the report concludes with our overall message.

3.1 Review of policies and goals

Our national energy policy goals are to reduce oil use and imports and to reduce carbon dioxide emissions. The reasons for adopting these goals and the numeric targets for the reductions are explained in Part 1. Each of the five policies we recommend contributes in a different degree to each goal. The policies and their importance for each goal are explained in Part 2. To help orient the reader, here is a summary of the policies, with qualitative notes on the importance of each in contributing to each of the two goals.

- **NEPI Clean Energy Standard**: Establishes a 2035 goal for clean electrical generation and requires technology-neutral, market-driven decisions by utilities to use low-carbon and renewable fuels to achieve this target.
  Impact: Major reduction of carbon dioxide emissions and other airborne pollutants, insignificant reduction of oil consumption.

- **Oil security dividend**: Imposes a modest, graduated oil products tax that is fully rebated through the tax system to the public.
  Impact: Significant reduction of oil consumption, moderate reduction of carbon dioxide emissions, increases economic growth.

- **Automotive fuel economy**: Follows the Corporate Average Fuel Economy (CAFE) Standards as adopted in 2012, and considers an alternative ‘feebate’ mechanism with similar impact and potential advantages.
  Impact: Significant reduction of oil consumption and moderate reduction carbon dioxide emissions, which are already built into adopted CAFE Standards.

- **LNG trucks**: Provides a temporary fuel tax reduction to encourage the nascent shift in the heavy truck market from diesel to liquefied natural gas (LNG).
  Impact: Increases an already-expected moderate reduction of oil consumption, with modest reduction in carbon dioxide emissions.

- **Energy efficiency**: Extends existing incentives for energy-saving appliances and building codes and home-based renewable energy.
  Impact: Significant reduction in carbon dioxide emissions, insignificant reductions in oil consumption.
3.2 Policy benefits and targets

The integrity of NEPI’s process demanded that we adopt numeric targets for our goals of reducing oil importation and carbon dioxide emissions before designing the policies to meet those goals. In our 2010 report with RFF, we screened three dozen policies. In this report, we refined our understanding and design of the five most promising policies and modeled the contribution and cost of each policy. Only at the final stage, in this part of the report, do we model the combination of policies and compare the outcome to our targets.

Given this sequential process that holds ends independent of means, it is not surprising that the combination of policies does not precisely deliver the results called for in our targets. As detailed in the next section, our policies overshoot the target for reducing oil consumption but accomplish 85% of the target for reducing carbon dioxide emissions. To some extent, this outcome is a result of our process: we did not adjust the targets to match the results. But the relative difficulty of achieving the targets is also a factor.

Since we began our work, the nation’s outlook for reducing dependence on oil, and especially foreign oil, has markedly improved, making that target easier to reach. Much of the reduction in imported oil consumption came about because of the economic recession, an influence which presumably will reverse with an economic recovery, but technology and policy have also played a part in lowering EIA projections of future oil use, including adoption of much-improved vehicle fuel efficiency standards, the new viability of LNG technology for heavy trucks and new technology for increasing domestic production of natural gas and oil. (See sidebar “Reduction of Oil Use: Imports or Domestic?” below.)

We welcome and incorporate those positive developments as part of our policy, and add more. In light of the reasonable cost of the five most promising policies, there would be no reason to pull back because the target has been surpassed. Instead, we would take advantage of the additional benefit that is available.

In contrast, the target for carbon dioxide emissions has become more difficult to reach. The United States has seen progress in recent years, an advance coming both from the reduction of energy use due to bad economic conditions and because technology has lowered the price of natural gas, leading to displacement of dirty coal-powered electricity generation. However, much more progress would be needed to avoid falling farther behind the scientific and internationally recognized target for carbon dioxide reductions.

Time is a key factor. In this report, we have adjusted our targets by pushing them farther into the future, in part to reflect the time that has passed since our 2010 report was released. The details of these adjustments are beyond the scope of this explanation, but it is important to understand the impact of the passage of time and our 2035 horizon for analysis, because these issues illuminate a fundamental part of the problem we are addressing.

By the nature of our two goals, the time horizon differently affects the difficulty of attaining the two targets. The target for reducing oil consumption (and hence imports) reflects a need to cut the amount of oil used per day. Extending the target into the future can make it easier to attain, as policy-driven changes have more time to reduce daily oil use. The target for reducing carbon dioxide emissions, on the other hand, reflects a need to cut the cumulative amount added to the atmosphere, which only becomes more difficult as the years pass.

Reduction of Oil Use: Imported or Domestic?

Oil is a fungible product. All units are interchangeable and consumers neither know nor care about the source of the oil when they drive up to the gas pump. However, dependence on foreign oil is an issue of national interest and the question of whether a reduction in the use of oil will affect domestic or imported sources is important.

The international oil market is complex but the market demand and supply signals to domestic producers and consumers are generally straightforward albeit, sometimes in different directions. The supply of U.S. domestic production is influenced by world oil prices. High prices encourage exploration and production in areas often requiring new technology and sometimes in remote and difficult locations. The demand for oil by consumers is predominately based upon the economy, fuel prices at the pump, and fuel efficiencies.

Given these economic forces, the result is that imported oil becomes the marginal source for market changes. If oil demand (consumption) is reduced the principal effect will be a reduction of imported oil. Conversely an increase in consumption will initially be predominately supplied by imported oil, although, increasing prices may over time increase domestic production.

The historical role of imported oil at the margin is seen in the activity of oil flow from 2008 to 2011. The demand for oil in the U.S. declined by 0.6 million barrels per day (mmbd) during this period. The primary cause was the severe recession beginning in 2008. However, even with the reduced demand, the production of domestic oil actually increased 1.5 mmbd due to new technologies and a rebounding price of world oil. The consequence of an overall reduced consumption of oil with an increase in domestic production was imported oil being reduced by 2.7 mmbd. The difference between domestic production and total use, whether up or down, is the marginal barrel of imported oil.
We look at a cumulative target for carbon dioxide because our emissions are essentially permanent contributions to the climate warming problem. Each ton of carbon dioxide we emit remains in the atmosphere and drives warming until it is removed by geologic processes, which act so slowly as to be irrelevant on human time scales. Each year the target is extended is another year that carbon dioxide can accumulate and worsen the problem, making the goal progressively more difficult to attain. This issue is basic to the climate problem and its urgency, and so it is not surprising it should arise in our analysis. Mostly, it underlines the need to take action as soon as possible along the lines of the policies we have studied.

### 3.2.1 Policy combination modeling results

Our overall target was to reduce oil consumption to 15.2 million barrels per day (mmbd) by 2035. The combination of policies reduces consumption to 14.4 mmbd in 2035. This represents a reduction of 3.8 mmbd from the 2010 baseline of oil use, and a reduction 2.4 mmbd better than the Reference Case. See Figure 3.1.

The NEPI Clean Energy Standard (NCES) does the heavy lifting in our carbon dioxide emission scenario, contributing three-quarters of the benefit achieved. Looking at reductions within the NCES, the positive impact closely tracks the retirement of coal-fired generation capacity, which is replaced by natural gas generation. Later in the policy, natural gas is replaced by nuclear and renewable energy. See Figure 3.3.

**Figure 3.1** Oil Use
Reference, Oil Security Dividend, CAFE Standards, LNG Truck Policy, Combination of Policies, Target 2010 - 2035 (million barrels per day)

**Figure 3.2** Cumulative Total Energy-related CO\(_2\)-e Emissions
Reference, NCES, Energy Efficiency, Combination of Policies Compared to Target 2010-2035 (gigatons of CO\(_2\)-equivalents)

**Figure 3.3** Annual Total Energy-related CO\(_2\)-e Emissions
Reference, NCES, CAFE Standards, Oil Security Dividend, Energy Efficiency, Combination of Policies 2010 - 2035 (million metric tons of CO\(_2\)-equivalents)
3.2.1.1 Effectiveness of combined policies

A significant part of the study’s reduction in oil consumption results from the positive interaction of the combined policies. When the impact of the five policies is merely summed, the oil use reduction is not as great as when we model the interaction of the combined policies.

Much of this improvement results from interaction between the Oil Security Dividend and the LNG truck policy. As we have seen in Section 2.4.5, the differential in fuel costs between diesel and LNG is the primary factor influencing decisions by trucking companies as to whether to convert to LNG. The Oil Security Dividend policy increases this cost differential, leading to more LNG trucks on the road and a greater reduction in oil use. This difference is substantial: our Reference Case projects LNG trucks to achieve 12% market share by 2035; our LNG policy by itself increases penetration to 14%; our combined policies increase LNG to 20% of the total heavy truck fleet. See Figure 3.4.

Fig. 3.4 Natural Gas Heavy Trucks as % of Heavy Truck Fleet Reference, LNG Truck Policy, Combination of Policies 2010 - 2035

A similar positive interaction occurs between the CAFE Standards policy and the Oil Security Dividend. The Reference Case, which includes CAFE Standards before the 2012 increases (see Section 2.3), contributes a reduction in gasoline use of 9% from 2010 to 2035; adding the Oil Security Dividend nearly doubles that to 17%. The new CAFE Standards produce a 25% reduction in gasoline use by the end of the period (the feebate policy is designed to perform identically; see Section 2.3.2). The new CAFE Standards interact strongly with the Oil Security Dividend, delivering a 32% reduction in gasoline use between 2010 and 2035 in the combination of policies case. These benefits eventually plateau, as the CAFE Standards become fully implemented in 2025. See Figure 3.5.

Fig. 3.5 Motor Gasoline Use Reference, CAFE Standards, Oil Security Dividend, Combination of Policies 2010 - 2035 (million barrels per day)

Several other interesting beneficial impacts also result from the combination of policies, in electricity demand, price, and generation mix, and in natural gas prices.

Two of our policies contribute to reducing electricity demand. The NCES reduces demand by increasing price, primarily because it drives a switch from some coal-powered generation towards more expensive nuclear and renewables. The energy efficiency policy reduces electricity sales by saving electricity and by inducing on-site renewable generation by users. In the Reference Case, electricity demand increases 18% from 2010 to 2035. Taken individually, the NCES cuts that increase to 12% and energy efficiency cuts it to 10%. Combined, they interact to produce a demand increase of only 4% over the entire 25 year period. See Figure 3.6.

Fig. 3.6 Electricity Sales Reference, NCES, Energy Efficiency, Combination of Policies 2010 - 2035 (billions of kilowatt hours)
Electricity demand in turn affects price by changing generation mix. The NCES causes the price increase noted above because of the higher cost of generation, but that increase is moderated when the energy efficiency policy is included, because it lowers demand. The increase in the average price of electricity in the NCES by itself amounts to 21% over the 25-year period. The energy efficiency policy, considered separately, holds the price flat. However, when we model the combination of policies the total increase is limited to 16%. See Figure 3.7.

The combination of policies also drives more generation to renewables than the policies taken individually. As explained in Section 2.1, the increasing standard and trading system of the NCES first cause replacement of coal generation by natural gas, and then produce nuclear and renewable energy at the expense of natural gas. By adding the energy efficiency policy, the power generation mix in 2035 has less nuclear energy and an increased percentage of wind, solar and biomass than in the NCES alone. Two factors produce this altered mix. Reduced demand decreases the use of the more expensive generation source, which in this case is nuclear rather than renewables. And the energy efficiency policy provides incentives for end-use renewable generation, enhancing the role of solar energy. See Figures 3.8 and 3.9 to see the generation mix in each case.

Three policies impact the price of natural gas through the study period: the LNG truck policy, which tends to increase demand and price for natural gas; the energy efficiency policy, which tends to reduce demand and price; and the NCES, which first pushes price higher, and later helps bring it down. The NCES has this effect because natural gas generation receives credits in the early years of the policy, but later must obtain credits as the standard becomes more difficult to meet. Fitting its role as a bridge fuel toward cleaner energy, gas is prioritized then discouraged. The Oil Security Dividend is indirectly involved, too, as its tendency to increase diesel pump prices helps put more LNG trucks on the road, further increasing natural gas demand and price. The combination of policies reflects these interactions, as the price of natural gas
gas rises above the Reference Case in the early years and falls below it by the end, in 2035. See Figure 3.10.

Fig. 3.10  Natural Gas Spot Prices (at Henry Hub)
Reference, LNG Truck Policy, NCES, Energy Efficiency, Combination of Policies, 2010 - 2035
(2010 $ per million Btu)

Combining the policies significantly reduces the welfare cost and out-of-pocket costs.
We do not include cost effectiveness, as we do for individual policies in Part 2—wherein we quote costs for reductions per unit, using barrels of oil and tons of carbon dioxide emissions. As explained in Section 1.6.3, we have no rationale to allocate these costs among the two goals. This joint cost allocation problem is more manageable when looking at individual policies, because the reader can evaluate the relative contribution of each policy to each goal. But if we were to show cost effectiveness figures for the mix of five policies to achieve two goals, the numbers would be difficult to interpret and potentially misleading. Consequently, we report only total costs for the entire policy, not per-unit costs.
Welfare cost (in 2010 dollars) for the comprehensive policy is $313 billion or less, present value, for the entire 25 years of the study. Amortized over the study horizon, the cost averages $25.6 billion per year over the 23-years from 2013 to 2035.

Table 3.1  Policy Key Metrics

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<th>Key Metrics Table</th>
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<td>Progress on Oil Target by 2035</td>
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<tr>
<td>Target</td>
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<tr>
<td>Reference Case</td>
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<tr>
<td>NCES</td>
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<tr>
<td>Oil Security Dividend</td>
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<tr>
<td>CAFE Standards</td>
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<tr>
<td>LNG Trucks</td>
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<tr>
<td>Energy Efficiencies</td>
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<td>Combination of Policies</td>
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1 Motor gasoline cost is for all light duty vehicles; declines in cost are due to reduced VMT and/or reduced gasoline price (excluding the phased oil tax component)
a. oil reductions are insignificant - these policies are directed at CO2 emissions reductions
b. impact on residential electricity and natural gas costs are insignificant - these policies target oil consumption
c. administrative cost only

3.2.1.2 Policy cost of combined policies

In this section and the associated key metrics table (Table 3.1) we report bottom-line costs for the combination of policies in three metrics: welfare cost, consumer out-of-pocket cost, and federal budgetary impact. It is worthwhile to note that the effect on the Gross Domestic Product, a measurement of the whole economy, is too small to accurately model in the combination of policies.
especially with respect to investments in more energy efficient autos and buildings, which consumers tend to under-value compared to their true economic worth. Since we cannot quantify such market failures, we have chosen to ignore those savings, a decision that results in reporting a higher welfare costs for the policies. The decisive advantage of this approach is analytical clarity. By removing the variable of market failure, we narrow our view to the benefit of addressing broad societal externalities through a mix of complementary policies that are measured on a single basis. However, as a result, our reported cost of $313 billion—while reasonable in scale and well within the capacity of the economy to absorb—does not represent the cost we actually expect to be incurred, but instead represents an upper boundary of cost.

The synergistic combination of the five policies significantly reduces the welfare cost of the entire package. By simply adding the welfare cost of each policy without looking at their interactions, we obtain a total of $387 billion. The combination cuts that cost by $74 billion, or 19%.

This reduction is caused mainly by savings in the CAFE Standards policy. Gillingham’s analysis of this policy includes a costly rebound effect, which addresses the expectation that drivers with more fuel-efficient vehicles will drive more, creating traffic congestion and other social costs. This rebound effect disappears in the combination of policies, because the Oil Security Dividend taxes fuel sufficiently to offset drivers’ savings from owning more efficient vehicles. Without a reduction in the cost of driving, there is no increase in the miles of travel, and no social costs for additional congestion, traffic accidents, etc. Under the dividend concept, all taxpayers receive the oil tax funds back through their income taxes, so that policy carries no welfare cost (indeed, as seen in Section 2.2.1, the policy’s welfare cost is negative, because it reduces inefficiencies in the tax system). Out-of-pocket costs are partly addressed in the discussion of electricity, natural gas, gasoline and diesel in Section 3.2.1.1.

At the end of the study period, in 2035, annual residential electricity expenditures have decreased by $89 per household compared to the Reference Case. The upward pressure on power prices caused by the NCES is more than offset by savings from the energy efficiency policy, which drives down usage and helps reduce prices by lowering demand.

The cost of natural gas also goes down, with a reduction of $37 per household compared to the Reference Case. Savings in both price and demand caused by the energy efficiency policy offset the upward price pressure caused by LNG trucks using more natural gas.

Combining policies does not reduce federal costs for the energy policy. However, the numbers are small. Over the 25 years of the policies, federal tax revenues are reduced $120 billion (in 2010 dollars) due to tax subsidies in the combination of policies case.

### 3.3 Conclusions

NEPI has presented a coordinated portfolio of five energy policies that, by 2035, reduce carbon dioxide emissions by a cumulative 18.4 gigatons and reduce oil use by 2.4 mmbd compared to the Reference Case, and do so at a total welfare cost of $313 billion or less, present value. As seen in the previous paragraph, federal tax subsidies, primarily credits for renewable energy, are $120 billion. Consumer out-of-pocket costs for electricity and natural gas decline, federal administrative expenses are insignificant, and impact on GDP is too small to accurately model.

The rubric of cost hardly fits our Oil Security Dividend policy, a gradually increasing oil tax that is fully rebated to Americans through the income tax system. Its cost is less than zero, because it yields significant economic benefits even without considering its impact on energy. By raising revenues more efficiently, the policy boosts the economy by $117 billion over the period of the study. This negative “cost” buys a policy that interacts positively with the other policies in our portfolio, significantly cutting their cost and increasing their effectiveness. Consequently, the total cost of the comprehensive policy is considerably lower.

These costs are affordable, but the cost of inaction is not. Natural processes will not appreciably scrub our carbon dioxide emissions from the atmosphere within the lifetime of anyone now living. Each ton emitted by a power plant or vehicle is essentially a permanent contribution to a fundamentally altered planet. The business-as-
usual Reference case (Figure 3.11) shows that the temporary, recession-driven annual carbon-dioxide reduction which began in 2008 will resume its multigenerational increase starting around 2014. Only with the Combination of Policies is this trend reversed sufficiently to put the U. S. on the right track to accomplish national goals. We cannot know with precision what this new planetary environment will look like, but we can get an idea from recent events, such as Superstorm Sandy and the ongoing national drought. Patchy, sudden and potentially catastrophic changes can be expected to accumulate as carbon dioxide accumulates in the air. The policy costs we cite in this study can be considered a small insurance premium to reduce these unknown hazards.

America’s need to break our addiction to oil is a goal of a different kind, but also critically important for the economic well-being and national security of the nation. The modest price we pay for this comprehensive policy can fairly be called a down payment for peace and stability, buying a measure of safety for service personnel who defend current U. S. supplies of oil, and a measure of confidence for businesses wary of supply and price shocks. Action is necessary despite the current, temporary decline in oil imports. The Combination of Policies continues to decrease overall consumption of oil while domestic production actually increases. As a result, imported oil use is driven down to the lowest level in 50 years. (Figure 3.12). In addition, the overall reduction of oil consumption is an important contributor to the reduction of CO₂ emissions. We will likely regret it later if we miss the current opportunity to fundamentally change the transportation and industrial use of oil. Failure to set in place the mechanisms for gradually achieving such a change will only make the day of reckoning more painful.

These twin primary goals are compelling enough, but our subsidiary goals are important as well. This comprehensive policy would save Americans’ lives and health by cleaning the air of hazardous pollution. It would also maintain the freedoms and prerogatives of reasonably priced energy for us all. And these are changes that can really happen. We do not have to believe in political miracles to envision its adoption in part or in whole, nor do we have to pin our hopes on a technological silver bullet not yet discovered.

The most efficient single policy to reach our goals would be a single pricing methodology such as a broad-based carbon tax or cap-and-trade scheme, but political events of recent years have demonstrated that this is not a realistic prospect. Our combined policies instead deliver similar benefits at an affordable cost and with greater political palatability. Our second most expensive policy, CAFE Standards, is already on the books and needs only to be implemented as adopted to produce all the benefits we call for. The energy efficiency policy merely calls for extension of existing policies, and the LNG truck policy requires no more than a temporary LNG tax break followed by tax parity among fuels. The Oil Security Dividend costs nothing in the aggregate.
Indeed, by recycling oil tax revenues, it makes the nation’s system of taxation simpler, saving money over all. Moreover, while the policy increases the retail price of fuel, the change comes so slowly as to be unnoticeable. The NCES would produce America’s biggest contribution to addressing climate change and significantly decreasing other health hazardous emissions. The fundamental structural change in our generation of electricity, from a coal-dominated fuel mix to substantially more low carbon and renewable fuels, is shown in Figure 3.13. This will be accomplished within an economic framework of market-driven carbon dioxide credit trading among utilities, providing a least-cost pricing approach rather than a regulatory mandate.

No doubt an actual national energy policy that is adopted will contain different policy ingredients in a mix that will come into focus through the political process. Our goal has not been to provide a recipe to Congress. Instead, we have shown that, for reasonable cost, America has within its grasp solutions to energy problems that threaten the national security, our economy, and the environment that sustains us.
Appendix

The findings in this study draw on various technical and background papers commissioned by the National Energy Policy Institute as part of this project. These papers are or will be available on the NEPI website (http://nepinstitute.org/publications/).

- **Consequences of U.S. Dependence on Foreign Oil.** Stephen P. A. Brown and Ryan T. Kennelly (Center for Business and Economic Research, University of Nevada, Las Vegas)

- **Small Modular Reactors: Costs, Waste and Safety Benefits.** Geoffrey Rothwell (Department of Economics, Stanford University)

- **The Economics of Fuel Economy Standards versus Feebates.** Kenneth Gillingham (Yale University)

- **A Review of the Impacts of an ALL CLEAN Clean Energy Standard for Selected Regions and States.** Mark A. Foster, MAFA

- **Oil Security Dividend: Research on the economic effect of a federal oil tax and the consequences of recycling of funds using various methods.** Roberton C. Williams (University of Maryland)

- **What Set of Conditions Would Make the Business Case to Convert Heavy Trucks to Natural Gas? – a Case Study.** Anna Lee Deal (Lynden Incorporated)