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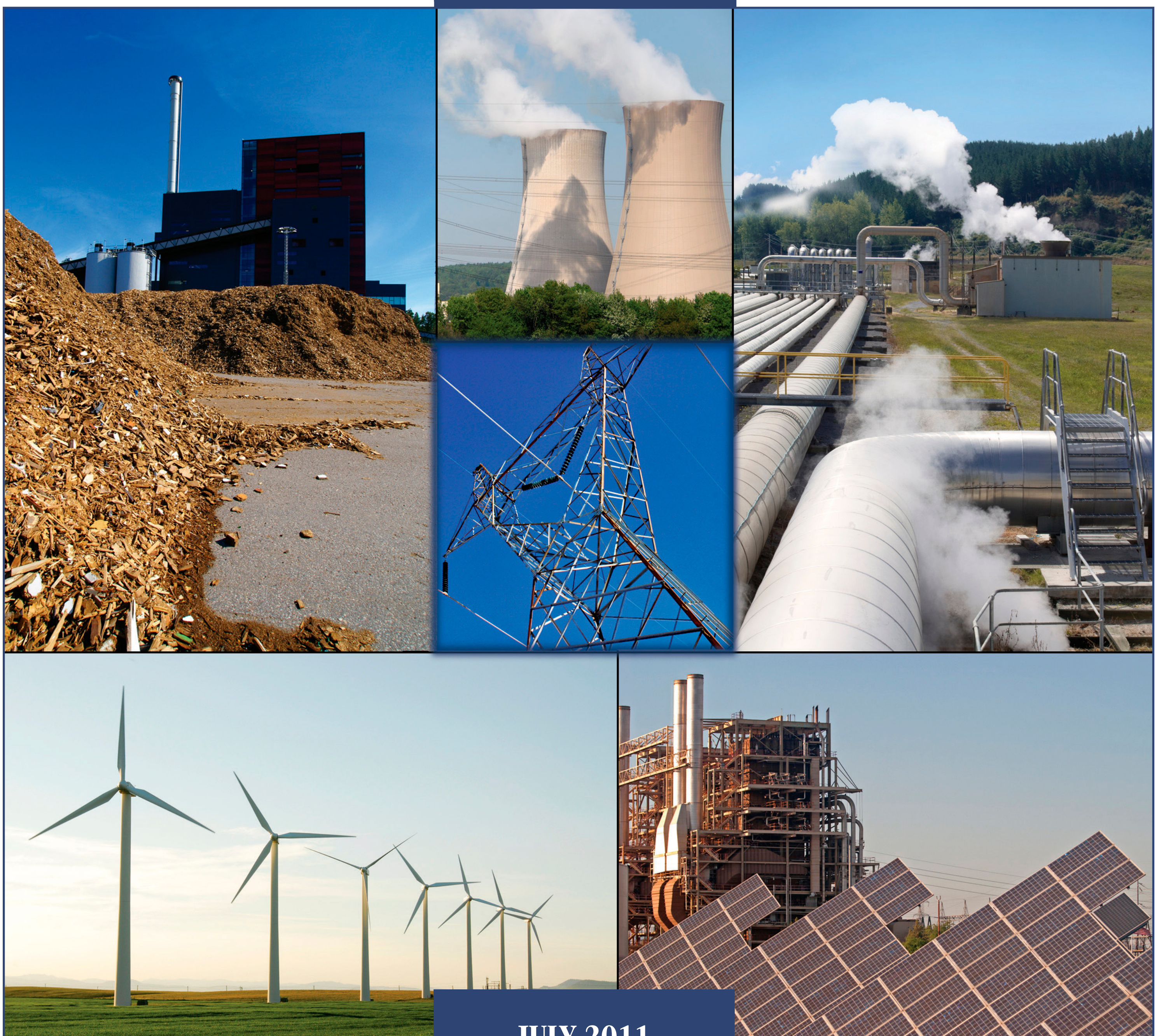
The Effects of Renewable or Clean Electricity Standards



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The Effects of Renewable or Clean Electricity Standards

July 2011

The Congress of the United States ■ Congressional Budget Office

Notes

Unless otherwise indicated, all years referred to in this report are calendar years.

Numbers in the text, tables, and figures may not add up to totals because of rounding.

The cover shows (clockwise from the top) the cooling towers of a nuclear power plant, a geothermal power station, an array of photovoltaic solar panels, wind turbines, a biomass power plant that burns wood chips, and power lines on a transmission tower. (The last photo is courtesy of the National Renewable Energy Laboratory; the others are copyrighted as indicated on the cover.)

Preface

Federal lawmakers have recently considered several policies to alter the mix of fuels used to generate electricity in the United States. Those policies—referred to here as renewable or "clean" electricity standards—would lead to greater reliance on energy sources that produce few or no emissions of carbon dioxide (CO_2), the most prevalent greenhouse gas contributing to climate change. Renewable electricity standards would require a certain share of the nation's electricity generation (say, 25 percent) to come from renewable sources, such as wind or solar power. Clean electricity standards would require a certain percentage of the nation's electricity generation to come from renewable sources or from nonrenewable sources that reduce or eliminate CO_2 emissions, such as nuclear power, coal-fired plants that capture and store CO_2 emissions, and possibly natural-gas-fired plants. Many renewable and clean electricity standards already exist at the state level.

This Congressional Budget Office (CBO) study—prepared at the request of the Chairman and Ranking Member of the Senate Committee on Energy and Natural Resources—examines how a federal renewable or clean electricity standard would change the mix of fuels used for electricity generation, the amount of CO_2 emissions, and the retail price of electricity in different parts of the United States. In particular, the study explores how some proposed features of such standards (such as various preferences, exemptions, and alternative compliance rules) would affect those outcomes and identifies underlying causes of uncertainty about such outcomes. The study also highlights key elements in designing a renewable or clean electricity standard that would help minimize its costs to U.S. households and businesses. In keeping with CBO's mandate to provide objective, impartial analysis, this report makes no recommendations.

The study was prepared by Terry Dinan of CBO's Microeconomic Studies Division and by Brian Prest, formerly of CBO, under the direction of Joseph Kile and David Moore. Justin Falk, Daniel Frisk, Ron Gecan, Robert Shackleton, and Julie Somers provided valuable input, and Marin Randall fact-checked the report. Helpful comments also came from Christopher Namovicz of the Energy Information Administration; Patrick Sullivan of the National Renewable Energy Laboratory; David McLaughlin, Karen Palmer, and Matthew Woerman of Resources for the Future; and Catherine Wolfram of the University of California at Berkeley. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.)

Chris Howlett edited the study, with assistance from Sherry Snyder, and John Skeen proofread it. Maureen Costantino and Jeanine Rees prepared the report for publication,

and Maureen Costantino designed the cover. Monte Ruffin printed the initial copies, and Linda Schimmel handled the print distribution. The report is available on CBO's Web site (www.cbo.gov).

Douglas W. Elmendorf
Director

July 2011

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Summary

Many policymakers have expressed interest in mandating that a minimum percentage of the electricity consumed in the United States be generated from renewable or "clean" sources of energy. A majority of states have implemented similar requirements in their jurisdictions. Such requirements—known as renewable or clean electricity standards—would reduce emissions of carbon dioxide (CO_2), the most prevalent greenhouse gas, by decreasing the percentage of electricity generated from fossil fuels. That change would not significantly reduce energy imports, however, because most of the energy used for electricity generation in the United States already comes from domestic sources.

How a Renewable or Clean Electricity Standard Would Work

Currently, only about 10 percent of U.S. electricity is produced from renewable sources of energy, such as hydropower, wind, and biomass (which includes waste products from the forest industry and farms). The bulk of electricity is produced using coal (45 percent), natural gas (24 percent), and nuclear power (19 percent).

Meeting a renewable electricity standard (RES) would generally entail replacing fossil-fuel-fired generation, which emits CO_2, with generation from renewable sources that would produce fewer, if any, CO_2 emissions. In particular, an RES would probably increase reliance on wind, biomass, solar energy, and geothermal energy to generate electricity. Hydroelectric power is usually excluded from RES proposals because of environmental concerns, although it accounts for more than half of all renewable generation at present.

A clean electricity standard (CES) would expand the set of qualifying sources to include not only renewable energy but also nuclear power, which produces no CO_2 emissions, and fossil-fuel-based generation that involves the capture and storage of CO_2 emissions (a process still under development). A more inclusive CES could allow the standard to be met with generation from natural-gas-fired plants, which release only about half as much CO_2 per unit of electricity produced as coal-fired plants do.

Utilities would typically be required to comply with a renewable or clean electricity standard by submitting "credits," each of which certified that a megawatt hour (MWh) of electricity had been produced from a qualifying renewable or other clean source. The number of credits that a utility would have to submit would depend on the standard and on the utility's electricity sales. For example, under a 30 percent RES or CES, a utility would have to submit 30 credits for each 100 MWhs of electricity it sold.

The federal government would give credits to generators that produced electricity from qualifying sources, and the generators in turn could sell the credits to the highest bidder. Utilities that generate at least some of their own electricity would comply with the policy either by using credits that they received for producing electricity from qualifying sources or by buying credits from other generators that use qualifying sources. Utilities that do not own generating facilities would need to purchase all of their credits. Utilities' demand for credits to comply with the standard would encourage generators to produce more electricity from qualifying renewable or other clean sources. If the credits were traded freely, the market could determine the least expensive method of achieving the desired increase in renewable or clean electricity generation.

Potential Effects on Power Generation, CO_2 Emissions, and Electricity Prices

A national RES or CES would alter the mix of energy sources used to produce electricity, the amount of CO_2

emitted, and the price of electricity, with those effects varying by region. To illustrate the effects, the Congressional Budget Office compared the results of seven analyses of different potential federal standards conducted in the past two years by the Energy Information Administration or the National Renewable Energy Laboratory (parts of the Department of Energy) or by the independent research organization Resources for the Future. Those analyses examined renewable and clean electricity standards with a variety of design features and relied on models of the electricity sector that incorporated different assumptions about the costs of relevant technologies. The comparison reveals some common findings about the potential impact of a national RES or CES policy, offers insights into the effects of specific design features, and highlights the uncertainties underlying projections of policy outcomes.

Most analyses concluded that the bulk of the increase in renewable generation resulting from an RES or CES would come from additional wind generation (mainly in the High Plains region of the western and central United States) and from biomass generation (mainly in the Southeast). The relative importance of those sources depends heavily on assumptions about the availability of resources in different regions and about the relative costs of various technologies.

Including certain design features in an RES or CES policy could cause the actual percentage of electricity produced from qualifying sources to be less than the standard. That could happen if some utilities were exempt from complying with the standard; if some technologies were given preferential treatment, allowing them to earn more than one credit per unit of electricity produced; or if utilities were allowed to make "alternative compliance payments" instead of submitting the necessary credits. Those features were either included in RES and CES policies proposed in the previous Congress or are part of some state programs.

Either an RES or CES would reduce CO_2 emissions in the United States compared with the amount that would occur in the absence of the policy. The actual reduction resulting from a given standard and set of design features would be uncertain, however. For example, generators that substituted biomass for coal would reduce emissions more than generators that substituted wind for natural gas, because a MWh of electricity generated from coal produces about twice as much CO_2 as one generated from natural gas.

Either an RES or CES would also raise the average cost of generating electricity in the United States because, in the absence of the standard, regulators and generators would generally choose the lowest-cost method of producing electricity. Higher generation costs in turn would lead to higher electricity prices for many businesses and households; however, the price effects would differ among regions. A federal electricity standard would cause prices to go up in most parts of the country but down in other parts. Predictions about effects on regional electricity prices vary significantly among policies and when different models are used to analyze similar policies. Those effects are strongly influenced by regional patterns of investment in new generating capacity and by the extent to which electricity prices in a given area are set by regulators or determined by market forces.

Changes in electricity prices offer an indication of the effects of an RES or CES on electricity consumers, but they do not provide a comprehensive measure of the policy's overall cost. To the extent that a standard reduced electricity prices in a particular region, the cost of the policy would be borne initially by electricity producers in that region, or by consumers in other regions where utilities (taken together) were net buyers of credits. The cost to electricity producers would take the form of lower returns on their existing capital. Those lower returns would discourage new capital from being invested in the electricity sector, eventually reducing the supply of electricity and causing the price to rise. Thus, ultimately, the cost of the policy would be borne by electricity customers.

Implementing a federal RES or CES would be complicated by the fact that 31 states and the District of Columbia have some form of renewable or clean electricity standard already in place. The incremental effect that a federal standard would have on the amount of renewable or clean generation would depend on the provisions of those state programs. If utilities could not count a given MWh of qualifying generation toward their compliance with both a state and a federal policy, the increase in renewable or clean generation necessary to meet the federal standard—and the cost of achieving that increase—would be much greater than would otherwise be the case. Moreover, regardless of whether a MWh of generation could qualify for credits at both the state and federal levels, the enactment of a federal standard would affect the prices of credits traded in state programs.

As a general rule, a given increase in renewable or clean generation, or a given decrease in emissions, could be accomplished at a lower cost through a single federal standard than through a combination of a federal standard and numerous state standards. The reason is that state policies would tend to constrain the pattern of renewable and clean generation across the United States, hindering the ability of a federal standard to spur the lowest-cost investments in such generation, at least in some regions.

Ways to Make an Electricity Standard More Cost-Effective

Although the costs of meeting a particular RES or CES cannot be predicted with certainty, they could be reduced by incorporating certain design features. For example, allowing unrestricted trading of credits, expanding the range of energy sources that could be used to comply with the policy, phasing in the standard gradually, and giving companies the flexibility to shift credits between years would all make an RES or CES policy more cost-effective.

Unrestricted Trading

The electricity market faces various regional limitations. For example, storing electricity or building transmission lines to move power over long distances is expensive and difficult, and some areas are better suited than others to certain types of generation. Letting utilities comply with a standard by submitting credits that could be bought and sold independently of the electricity generation with which they were associated—rather than requiring that each utility get a certain percentage of its electricity directly from renewable or other clean sources—would help overcome such limitations and thereby lower utilities' compliance costs.

Compliance costs could be reduced further by allowing financial firms that do not generate or distribute electricity to participate in credit trading. Participation by those firms would increase the liquidity of the market, meaning that utilities and generators could buy and sell large numbers of credits without affecting the price.

Expanded Compliance Options

Allowing as many energy sources as possible to qualify for credits (within the constraints of achieving the objectives of the policy, which might include reducing CO_2 emissions, avoiding further damage to the environment, or developing specific technologies) would help minimize the cost of meeting an RES or CES and of achieving any resulting emission reductions. In particular, a clean electricity standard would be likely to bring about a given reduction in CO_2 emissions at a lower cost than a renewable electricity standard because a CES provides incentives for a wider variety of low-emitting technologies than an RES does.

If regulators linked the amount of credits that various technologies could receive to their emissions, then letting both existing and new sources of electricity generation earn credits (rather than just sources that started operating after the policy began) could help better align financial incentives with actual emission reductions. For example, granting partial credits for both existing and new natural-gas-fired generation would give generators a larger financial incentive to substitute a megawatt hour of emission-free generation for a megawatt hour of generation from a high-emitting source, such as coal, than from a low-emitting source, such as natural gas.

Total costs of reducing CO_2 emissions could be lowered even further by allowing emission-reducing improvements in energy efficiency to qualify for credits. For example, generators could upgrade their plants in a manner that allowed them to produce the same amount of electricity from less fossil fuel, or large companies could install lighting that used less electricity. However, regulators would face significant challenges in accurately measuring the energy or fuel savings from such improvements.

Even with a wide variety of compliance options, neither an RES nor a CES would be as cost-effective in cutting CO_2 emissions as a "cap-and-trade" program. Such a program would involve setting an overall cap on emissions and letting large sellers of emission-creating products (such as electricity generators, oil producers and importers, and natural gas processors) trade rights to those limited emissions. In that way, a cap-and-trade program would create a direct incentive to cut emissions; in contrast, an RES or CES would create a direct incentive to use more renewable or other types of clean electricity but would have only an indirect effect on emissions.

Gradual and Flexible Timing

Electricity generation typically involves investments in large-scale and long-lasting physical equipment, and U.S. demand for electricity is growing slowly enough that the potential for investment in new generation and distribution capacity is fairly small. Utilities and generators would therefore benefit from provisions that phased in an RES or CES gradually over an extended period. They would also benefit from being allowed to transfer credits between different time periods—by "banking" current excess credits for use in later years or by "borrowing" credits that they expected to earn in the future for use now. Such provisions would make it easier for utilities and generators to comply with the standard in the course of planning for moderate increases in new capacity, without prematurely retiring existing capacity. However, the standard would not be met if firms that borrowed credits failed to fulfill their obligations.

CHAPTER

1

Introduction

In recent years, federal policymakers have proposed various ways to alter the mix of energy sources used to generate electricity in the United States. In many cases, those proposals have been motivated by a desire to decrease emissions of carbon dioxide (CO_2) that result from burning fossil fuels. CO_2 is the most prevalent of the greenhouse gases, whose accumulation in the atmosphere, if allowed to continue unabated, is expected by a strong consensus of experts to have extensive, highly uncertain, but potentially serious and costly impacts on regional climates throughout the world.

Some of those proposals involve renewable electricity standards (RESs), which would require utilities to meet at least a certain percentage of consumers' demand for electricity with power generated from renewable sources, such as wind or solar energy. Other proposals involve clean electricity standards (CESs), which would require utilities to use some minimum percentage of "clean" energy sources—generally defined to include renewable sources and also nuclear power (which emits no CO_2) and fossil-fuel-burning power plants that capture and compress their CO_2 emissions for storage underground (a technology that is still at the development stage). Some CES proposals would also define natural gas as a clean energy source because it emits roughly half as much CO_2 as coal does per unit of electricity produced. RESs and CESs in some form are already operating in a majority of U.S. states.

Under a federal renewable or clean electricity standard—as under many of the state policies—electric utilities would have to comply with the standard by submitting "credits" to the government. Each credit would represent a megawatt hour (MWh) of electricity that was generated from a qualifying renewable or other clean source. For example, a 30 percent RES or CES would obligate utilities to submit 30 credits for each 100 MWhs of electricity they sold. In general, utilities would buy the credits they needed from electricity generators, who would receive credits from the government for each MWh of qualifying electricity they produced. The demand for credits on the part of utilities would encourage generators to produce more electricity that qualified for credits. If the credits could be traded freely, the market could determine the least costly method of achieving the desired increase in renewable or clean electricity generation.

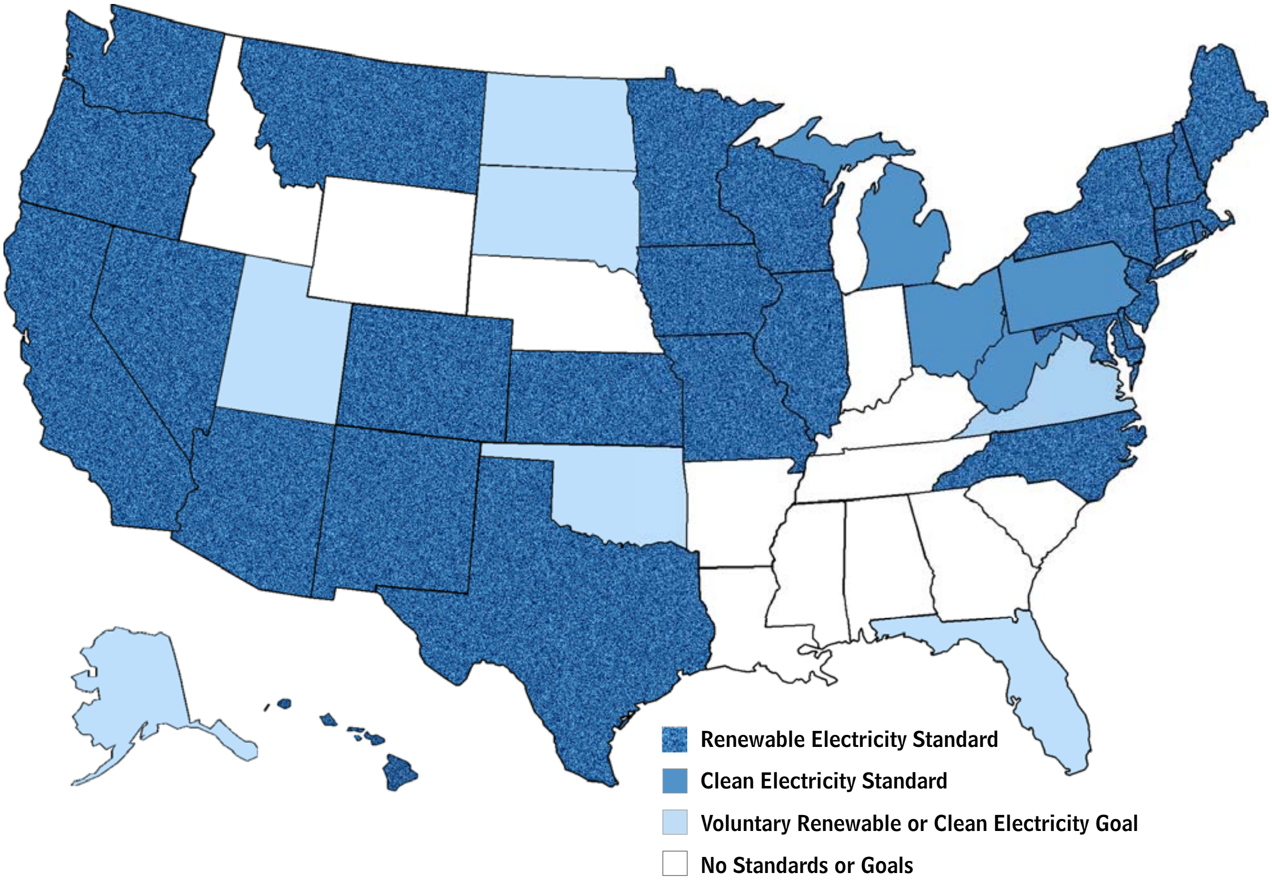
This chapter provides a brief overview of federal proposals and existing state standards for renewable and clean electricity, describes how a federal standard would work, examines the current mix of energy sources used to produce electricity, and discusses the challenges to increasing the use of renewable or other clean sources. Chapter 2 assesses how a federal RES or CES might affect power generation and electricity prices in various regions of the United States and the amount of CO_2 emitted by the electricity sector. It also discusses complications posed by layering a federal standard on top of existing state standards. Chapter 3 offers general observations about how an RES or CES policy could be designed to be cost-effective.

Federal Proposals and State Standards for Renewable and Clean Electricity

During the previous Congress (the 111th), several Senators proposed legislation to establish renewable or clean electricity standards. For example, Senators Jeff Bingaman and Sam Brownback proposed an RES in the Renewable Electricity Promotion Act of 2010 (S. 3813). Under that standard, 15 percent of U.S. electricity generation would have had to come from renewable sources by 2021. Senators Richard Lugar, Lindsey Graham, and Lisa Murkowski introduced the Practical Energy and Climate Plan Act of 2010 (S. 3464), which would have required that, by 2030, 30 percent of electricity generation come from renewable sources, from new nuclear capacity, or

Figure 1-1.

States with Renewable or Clean Electricity Standards or Goals



Source: Congressional Budget Office based on information from the Pew Center on Global Climate Change.

Note: States vary widely in which sources of electricity generation are eligible to receive credits under their standards. For example, West Virginia provides credits for certain types of coal technology, although most other states do not.

from coal plants that capture and store CO_2 emissions. Both of those proposals would have utilities meet part of their compliance obligation by submitting energy-efficiency credits. Such credits could be awarded to generators that upgraded their facilities in a manner that allowed them to generate more electricity with the same amount of fossil fuel, to states or utilities that sponsored programs to promote energy-saving improvements, or to large end users of electricity that made energy-saving investments. (Neither bill was brought to a vote, and neither has been reintroduced in the 112th Congress.)

In addition, in his 2011 State of the Union address, President Obama expressed support for a CES that would require 80 percent of electricity generation to come from clean sources by 2035. Under that proposal, clean sources would include renewable energy, nuclear power, "efficient" natural gas, and fossil-fuel-fired plants that capture, compress, and store their CO_2 emissions.

In recent decades, 31 states have implemented renewable or clean electricity standards of varying stringencies: 27 states plus the District of Columbia have renewable portfolio standards, which are similar to renewable electricity standards, and another 4 states have alternative energy portfolio standards, which are similar to clean electricity standards (see Figure 1-1).[1] In addition, 7 states have voluntary goals for electricity generation. (The other 12 states have no mandatory standards or voluntary goals.)

1. See Pew Center on Global Climate Change, "Renewable and Alternative Energy Portfolio Standards" (August 7, 2011), www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

How a Renewable or Clean Electricity Standard Could Work

Virtually any renewable or clean electricity standard would have some basic features, such as the standard itself (the minimum share of electricity generated by qualifying sources that the policy would require), definitions of the energy sources included in the policy, and credits that utilities would submit to comply. Typically, the standard would be phased in over time; for example, a CES might require that 50 percent of electricity be generated from clean sources by 2025, with lower but increasingly strict standards for each year leading up to 2025.

An RES or CES could have a variety of other design features as well, such as allowing credits to be traded widely, varying the number of credits that sources are awarded according to their CO_2 emissions, providing credits to existing generators (rather than limiting them to new generating capacity), allowing credits to be "banked" or "borrowed" for use in other years, and letting improvements in energy efficiency qualify for credits. Moreover, policymakers could opt to limit the cost of complying with the standard by letting utilities make alternative compliance payments instead of submitting credits, could give preference to certain energy technologies, and could combine an RES and a CES into a tiered standard. Those various design features, which are described below, would influence a policy's effects on electricity production, electricity prices, and CO_2 emissions (as discussed in Chapter 2) and the policy's cost-effectiveness (as discussed in Chapter 3).

Credits Could be Traded Widely

Credits would be tradable financial assets that could be bought and sold independently of the electricity generation with which they were associated. Generators would receive credits from the federal government when they produced electricity from qualifying sources and could sell those credits to utilities, either with or without the associated power. Utilities would use the credits to comply with the policy. Utilities that generate at least some of the electricity they sell would comply either by using credits that they received for producing electricity from renewable sources or buying credits from other generators that use qualifying sources. Utilities that do not own generating facilities would have to buy all of their credits.

The U.S. electricity market tends to be regional in scope. Once generated, electricity is difficult and costly to store, and moving it from one place to another requires the use of transmission lines, which are expensive and time consuming to build. In addition, as discussed later in this chapter, some areas are better suited than others to specific types of power generation. Allowing utilities to comply with an RES or CES by submitting credits would get around such constraints by decoupling utilities' compliance from the sources of energy used to generate the electricity they sold. Thus, for example, a utility in Ohio could comply with the standard by purchasing credits from a wind plant in North Dakota, without actually purchasing the plant's electricity (which, for logistical reasons, would probably be sold to a local utility).

As the market for credits developed, entities other than generators and utilities—such as banks and pension funds—could be allowed to trade credits. Participation by those entities would provide liquidity to the market, enabling utilities and generators to buy and sell large numbers of credits without affecting the price. Utilities would seek to purchase credits at the lowest possible price, and that competitive pressure would encourage generators that could expand their electricity production from qualifying sources at the lowest cost to do so. The price of credits would rise to the point at which the number of credits created by qualifying generators was large enough for utilities to obtain the credits they needed to comply with the standard.

Credit Amounts Could Be Related to CO_2 Emissions

The amount of credits that generators would receive for various types of electricity production could be adjusted to account for differences in the amount of CO_2 released. For example, a megawatt hour of electricity generated at a nuclear plant would produce no CO_2 emissions and thus would receive one credit under a CES policy. A megawatt hour generated at a natural-gas-fired plant would emit roughly half as much CO_2 as the same amount of generation at a coal-fired plant (in the absence of capture and storage technology) and thus might receive half a credit per MWh. Such weighting would give generators the greatest incentive to install the cleanest technologies and, as a result, would help achieve emission reductions in a cost-effective manner. However, it would require policymakers to define partial credits for all technologies in proportion to their emissions and update those definitions over time to reflect technological changes.

Credits Could Be Given to Existing Generators

An RES or CES policy could allow both existing and new sources of electricity generation to earn credits, or it could restrict eligibility to sources that began operating after the program started. In order to achieve the same amount of renewable or clean generation, the stringency of the standard would need to be adjusted accordingly. For example, nuclear power, hydropower, and other renewable sources currently account for about 30 percent of U.S. electricity generation; until the existing stock of power plants was replaced, a 40 percent CES in which existing generators of electricity from those sources were eligible to receive credits would lead to the same increase in clean electricity as a 10 percent CES in which credits were not granted to existing generators.

The decision about whether to allow existing sources of electricity generation to earn credits would have consequences for how the policy's effects were distributed as well as for its ability to motivate the lowest-cost emission reductions:

- If existing sources could receive credits—and thus more credits would have to be required and purchased to produce the same increase in qualifying generation—the additional purchases would transfer revenue from areas that were net buyers of credits to areas that were net sellers. In general, regions with existing plants that generate qualifying electricity—such as the Southeast, which has a significant amount of existing nuclear generation—would benefit from the sale of credits. At the same time, utilities (and ultimately their customers) in other regions would face higher costs because of the need to buy a larger number of credits.

- Granting credits to existing sources would also motivate lower-cost emission reductions than would otherwise be the case because the policy would provide incentives to retire relatively dirty sources of electricity generation earlier than relatively clean sources. For example, plant operators would be more likely to retire coal-fired plants first if existing nuclear or gas-fired plants received credits for the electricity they produced.

Credits Could Be Banked and Borrowed

An RES or CES program could allow utilities to transfer credits between years by letting them bank any excess credits they possessed for use in a future year. The program could also let utilities borrow credits from future years—for example, by permitting them to comply in 2015 with a credit they would obtain in 2016. A utility might want to borrow credits from the following year if it anticipated that a new qualifying plant would begin generating electricity in that year, increasing the supply and lowering the price of credits. As discussed in Chapter 3, banking provisions could help reduce the overall cost of complying with the standard by allowing utilities to stock up on credits in years when they were relatively inexpensive. Most state programs permit banking of credits, but not borrowing.

Improvements in Energy Efficiency Could Qualify for Credits

The types of activities that could earn credits could be expanded to include qualified electricity savings—reductions in electricity consumption resulting from efficiency improvements that would not have been made in the absence of an RES or CES. Such efficiency improvements could occur in the production of electricity; for example, plant operators could decrease the amount of fossil energy needed to produce a MWh of electricity. Efficiency improvements could also occur in the consumption of electricity; for instance, businesses and households could invest in insulation or energy-efficient lighting.

Granting credits for energy-efficiency improvements could, in theory, provide a financial incentive for low-cost reductions in CO_2 emissions. Implementing that feature would be challenging, however. Policymakers would need to clearly define criteria for what types of efficiency improvements might qualify for credits and then determine whether each improvement met the criteria. For instance, establishing the legitimacy of a firm's claim for energy-efficiency credits would require establishing a baseline to determine what the company's energy consumption would have been in the absence of the efficiency improvement. Ideally, that assessment would account for factors that affect the firm's energy use (independently of the efficiency improvements), such as variations in weather or demand for its products.

Compliance Costs Could Be Limited

Policymakers could set an upper limit on the cost of complying with the standard by letting utilities make an alternative compliance payment (ACP) instead of submitting a credit. In that case, utilities would be willing to purchase credits from generators up to the point at which the price of a credit equaled the ACP; beyond that point, they would choose to comply by making the alternative payment. As a result, renewable or clean generation would increase until the legislated standard was met or the additional cost of producing electricity from qualifying sources was equal to the ACP. If utilities complied with a standard by making alternative payments, the actual percentage of electricity coming from renewable or other clean sources would be less than the stated standard.

An ACP could dampen the price of credits and, if utilities were able to bank credits, could do so even when the market price for credits was less than the alternative payment. The reason is that utilities would attach a lower value to a credit today to reflect the fact that its price could not rise above the ACP at any future time.[2] Such price dampening would be most likely to occur when the market price of credits was near the ACP. Any reduction in the price of credits that resulted from the ACP would reduce the incentives for utilities to invest in renewable or other clean technologies.

If policymakers chose to include an ACP, they would need to decide how to allocate any revenue it raised. Those choices could have a variety of implications for the cost-effectiveness of the program and for the manner in which its costs would be distributed among regions or households.[3] Policymakers could use the revenue collected from the ACP to offset costs for some of the producers and consumers who would be affected by the standard.

Certain Technologies Could Receive Preferential Treatment

Policymakers could also design an RES or CES to favor selected technologies—either by establishing different standards for different technologies (referred to as tiered standards) or by providing extra credits for certain technologies. Several states' standards include provisions that provide such preferential treatment. For example, Nevada has a tiered standard requiring that, in 2013, 5 percent of electricity generation in the state come from solar power and a total of 15 percent come from all qualifying renewable sources.[4] In another example, Michigan provides triple credits for each MWh of electricity generated by photovoltaic solar power (which converts solar radiation into direct-current electricity using semiconductors).

The reasons for giving preferential treatment to particular technologies vary. In some cases, states want to encourage types of generation for which their state is particularly well suited. In other cases, favorable treatment goes to sources that are expected to have a large potential for cost reductions in the future because of "learning by doing" (the process through which innovations occur as a result of gaining experience with a technology). The potential for learning by doing is generally thought to be higher for fairly new sources of electricity generation, such as photovoltaic power, than for technologies that have been in use for many years, such as onshore wind generation. Advocates of extra incentives for relatively new or rapidly changing technologies suggest that such incentives could spur enough additional innovation to significantly lower the cost of those technologies.

Clean and Renewable Standards Could Be Combined

A CES and an RES could be combined in a tiered fashion. For example, a program could require that, by a certain year, 50 percent of all electricity be generated from clean sources (including renewable energy, nuclear power, and coal- or natural-gas-fired plants with carbon capture and storage) and that at least 25 percent of electricity be provided exclusively from renewable sources. In that case, utilities would need to ensure that *at least* half of the credits they submitted came from renewable sources. Complying with that tiered standard could cost more than complying with a 50 percent CES. However, advocates of tiered standards suggest that the additional cost could be justified because renewable sources would impose lower environmental and health costs than alternative clean sources. For example, using renewable sources to generate electricity would not involve creating dangerous waste materials, as nuclear generation does, or

2. For a more detailed discussion of that point, explained in the context of a cap-and-trade program for greenhouse gas emissions, see Congressional Budget Office, *Managing Allowance Prices in a Cap-and-Trade Program* (November 2010).

3. For a discussion of those implications in the context of a cap-and-trade program, see Congressional Budget Office, *The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions* (September 2009).

4. See R. Wiser, K. Porter, and R. Grace, "Evaluating Experience with Renewables Portfolio Standards in the United States" (Lawrence Berkeley National Laboratory, March 2004), http://eetd.lbl.gov/ea/ems/reports/54439.pdf.

pollution runoff, as mining coal to use in coal-fired plants with carbon capture and storage would.

Trends and Challenges in Producing Electricity from Renewable and Other Clean Sources

An RES or CES would change the mix of sources for electricity generation. In the absence of additional policy initiatives, that mix is projected to remain fairly constant over the next two decades, in part because the expansion of renewable or clean generation is limited by various factors that make those sources relatively costly.

Trends in the Generation Mix

Coal is currently the leading fuel used to produce electricity in the United States, accounting for 45 percent of generation in 2010 (see Figure 1-2). It is followed by natural gas (24 percent), nuclear power (19 percent), petroleum (1 percent), and a variety of renewable sources (totaling 10 percent). According to the Department of Energy's Energy Information Administration (EIA), that mix of sources is unlikely to change much over the next 25 years under current policies. Coal is expected to remain dominant—declining only slightly as a share of total generation, to 43 percent in 2035—because it is abundant, relatively inexpensive, and well suited to the continuous operation of plants that provide "base-load" generation (electricity to meet the minimum level of demand around the clock). Natural gas and nuclear power are also expected to account for roughly the same shares of total generation in 2035 that they do today. Fossil-fuel-burning plants that capture and store CO_2 emissions do not yet exist on a commercial scale and thus do not provide any significant generation; in the absence of additional policies, no significant amount is projected for the next 25 years.

Of the sources of energy that are naturally replenished, hydroelectric power is the main one in use today, accounting for 6 percent of electricity generation. However, many RES programs exclude hydropower as a qualifying renewable source because of various concerns, such as those about the effects of dam construction on stream flow and fish migration and the displacement that occurs when land is flooded to create reservoirs.

Among renewable sources other than hydropower, wind currently accounts for the bulk of electricity generation (see Figure 1-3 on page 11), followed by biomass (materials such as municipal solid waste, residue from crops, and wood waste from the timber industry) and geothermal energy (the Earth's internal heat).[5] Solar power accounts for only a tiny fraction of electricity generation. EIA projects that biomass will make up a growing share of nonhydropower renewable generation in the future, roughly equaling wind power by 2035, and that most of the biomass will be used by industrial producers that generate electricity to use in producing finished goods.

The total share of U.S. electricity generated from sources with very low emissions of CO_2—renewable energy and nuclear power—was 29 percent in 2010 and is expected to grow only slightly, to 31 percent, by 2035. EIA projects only modest growth in those sources, for reasons discussed in the next section, despite the fact that various federal grants, tax credits, and subsidies are designed to encourage such generation (see Box 1-1).

Challenges Associated with Increasing Renewable or Clean Generation

Increasing the share of electricity generated from renewable sources, nuclear power, or fossil-fuel-fired plants with carbon capture and storage would reduce CO_2 emissions (compared with what they would be otherwise). Achieving such an increase, however, would require overcoming a variety of complications that generally make renewable or clean generation more costly than fossil-fuel-fired generation. Those complications include the location-specific and variable nature of some renewable energy sources, technological uncertainties, and environmental concerns. Substantially expanding the use of low-emitting sources to generate electricity—through an RES, CES, or other policy—would require addressing those factors.

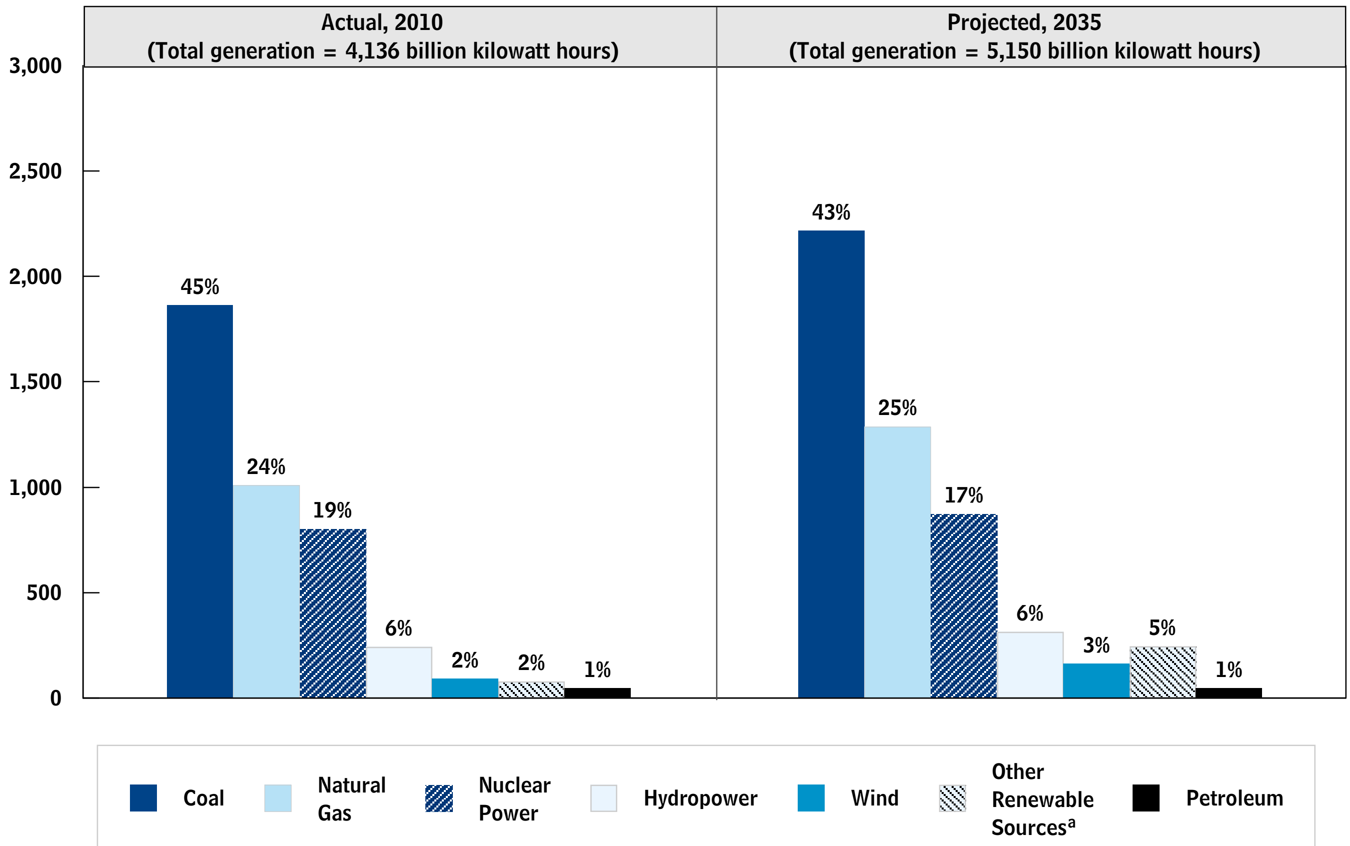
Location Constraints. Most forms of renewable generation are better suited to some locations than others, and many of those places are far from large population centers

5. Geothermal energy is considered to be sustainable because the heat extracted is small compared with the Earth's heat content.

Figure 1-2.

Mix of Sources Used to Generate Electricity in the United States in 2010 and 2035, by Amount of Electricity Provided and Share of Total Generation

(Billions of kilowatt hours)



Source: Congressional Budget Office based on data from Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011, with Projections to 2035* (April 2011), www.eia.gov/forecasts/aeo/.

a. Includes wood waste products and other biomass burned as fuel, geothermal energy, municipal waste (trash) burned to reduce its volume and to produce electricity, and solar energy.

that have high electricity demand.[6] For example, land areas that are well suited to wind generation—places with average annual wind speeds of at least 6.5 meters per second at a height of 80 meters—are concentrated in the middle of the United States (see Figure 1-4 on page 12), whereas the population is concentrated along the coasts.

Relatively modest increases in the use of renewable sources could be made without significantly changing the infrastructure for distributing electricity: Those increases could take place in windy or sunny areas and be used to meet local demand for electricity. However, substantially boosting reliance on renewable generation would require transporting the power to areas that consume large amounts of electricity—a process that would entail costly and time-consuming expansions of transmission capacity. Finding sites for new transmission lines can require

6. Geothermal power provides the most extreme example of this constraint. Conventional methods may be used to generate electricity from geothermal energy at a cost that is competitive with coal-fired generation; however, the locations at which that can take place are so limited that geothermal power currently accounts for less than 1 percent of U.S. electricity generation and is not expected to grow significantly over the next several decades. Enhanced methods might allow for greater reliance on geothermal energy, but successful research and development would be necessary to make those enhanced methods cost-competitive.

Box 1-1.

Current Policies Aimed at Lowering the Costs of Renewable and Other Clean Electricity Generation

The amount of U.S. electricity generated from renewable sources other than hydropower is small (currently about 4 percent of total generation), despite the fact that such generation has received significant subsidies over the past several decades. For example, renewable electricity production received more than $1 billion in federal subsidies in fiscal year 2007 (the most recent year for which comprehensive measures are available), or 15 percent of all subsidies for electricity generation that year (see the table on page 9). The bulk of the subsidies for renewable electricity production went to wind generation, amounting to $23 per megawatt hour produced, or 2.3 cents per kilowatt hour (kWh). By comparison, the average retail price of electricity sold in the United States in 2007 was 9.1 cents per kWh.[1]

Until 2009, federal support for renewable energy projects primarily took the form of tax credits for production or investment. For instance, qualifying wind generation was eligible for a production tax credit for 10 years after a facility was put in place. Solar generation, by contrast, mainly received support through a 30 percent investment tax credit.

Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA, Public Law 111-5) created a $5.6 billion program to provide cash grants for renewable energy projects that were placed in service during the 2009 or 2010 tax years or that met certain start-of-construction requirements before the end of 2010. Firms could choose to receive those grants instead of the production or investment tax credits for which they would otherwise be eligible. Projects involving most forms of renewable electricity generation could receive grants equal to 30 percent of their eligible cost basis.[2] The grant program was later extended through 2011 by the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 (P.L. 111-312).

Wind generation has received about 84 percent of that ARRA grant money.[3] As a result, such generation is on track to more than double over a four-year period, rising from 56 billion kWhs in 2008 to 143 billion kWhs (or about 4 percent of projected U.S. electricity generation) in 2012. However, the Energy Information Administration projects that after the cash grant program expires in 2012, wind generation will remain fairly flat, rising only to 159 billion kWhs by 2030.[4]

Nonrenewable "clean" energy sources have also received major federal support over the years. Significant incentives for building new nuclear power plants were included in the Energy Policy Act of 2005. They included production tax credits (1.8 cents per kWh for qualifying new generation), loan guarantees, insurance against regulatory delays, and extension of the Price-Anderson Act, which set a cap on the total amount of liability that the industry could incur and defined rules for apportioning that liability. In fiscal year 2007, nuclear generation received more than $1.2 billion in subsidies, or about 0.16 cents per kWh. Even with those subsidies, future growth in

1. See Department of Energy, Energy Information Administration, "Average Retail Price of Electricity to Ultimate Customers: Total by End-Use Sector" (revised April 2011), www.eia.gov/cneaf/electricity/epm/table5_3.html.

2. See Phillip Brown and Molly F. Sherlock, *ARRA Section 1603 Grants in Lieu of Tax Credits for Renewable Energy: Overview, Analysis, and Policy Options,* CRS Report for Congress R41635 (Congressional Research Service, February 8, 2011).

3. Ibid.

4. See Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011, with Projections to 2035* (April 2011), www.eia.gov/forecasts/aeo/.

Continued

Box 1-1. **Continued**

Current Policies Aimed at Lowering the Costs of Renewable and Other Clean Electricity Generation

Federal Subsidies and Support for Electricity, Fiscal Year 2007

	Net Generation in 2007 (Billions of kilowatt hours)	Federal Subsidies and Support in 2007: Millions of 2007 Dollars	Federal Subsidies and Support in 2007: Dollars per Megawatt Hour of Electricity Produced
Electricity Generation			
Coal	1,946	854	0.44
Refined coal	72	2,156	29.81
Natural gas and petroleum liquids	919	227	0.25
Nuclear power	794	1,267	1.59
Renewable energy			
Biomass (and biofuels)	40	36	0.89
Geothermal energy	15	14	0.92
Hydropower	258	174	0.67
Solar energy	1	14	24.34
Wind	31	724	23.37
Landfill gas	6	8	1.37
Municipal solid waste	9	1	0.13
Unallocated renewable energy[a]	*	37	*
Subtotal, renewable	360	1,008	2.80
Electricity Transmission and Distribution	n.a.	1,235	n.a.
Total	**4,091**	**6,747**	**1.65**

Source: Congressional Budget Office based on Department of Energy, Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 2007* (April 2008), Table 35, p. 106.

Note: * = reported as too small to be meaningful; n.a. = not applicable.

a. Includes projects funded under the Clean Renewable Energy Bonds and Renewable Energy Production Incentive programs.

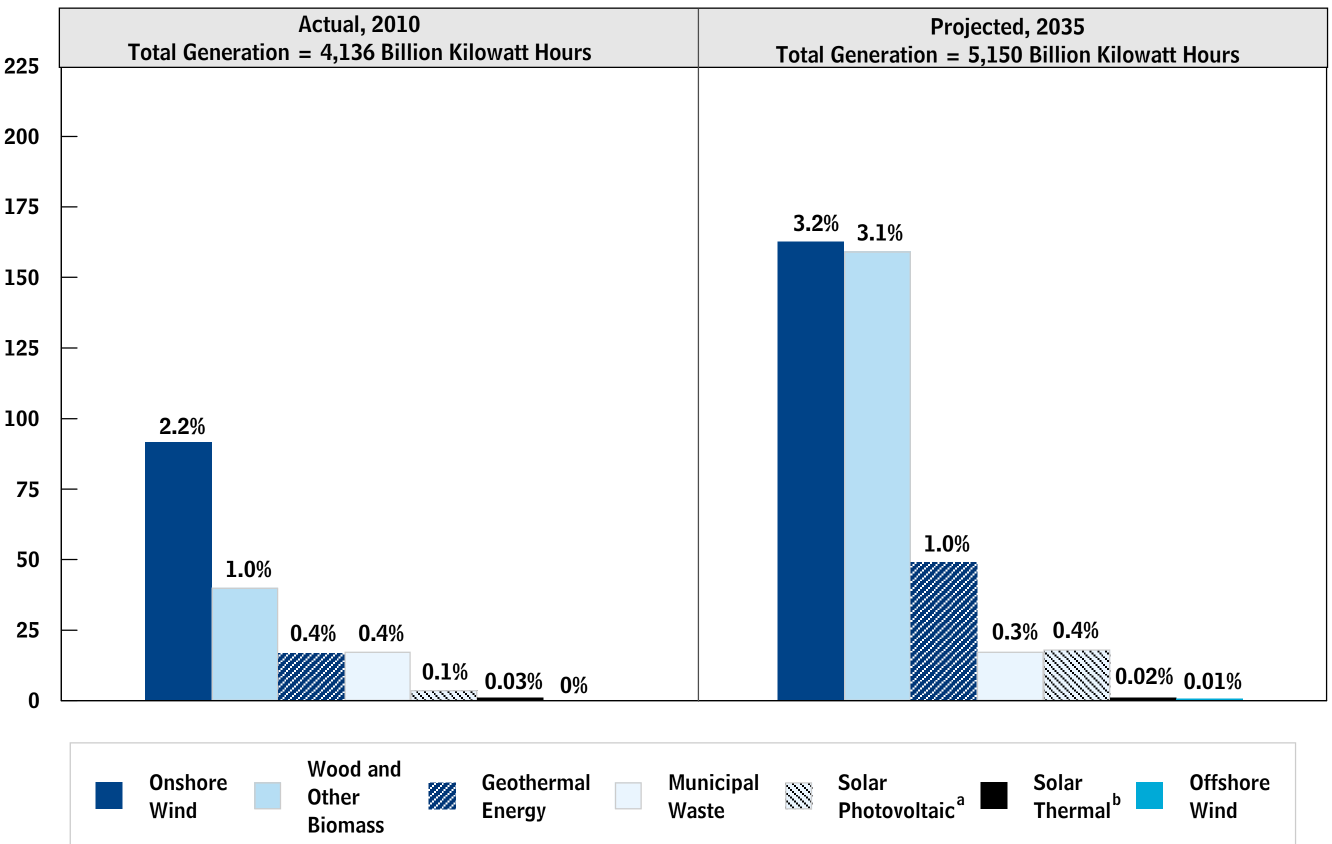
nuclear generation is uncertain. New federal subsidies and incentives had prompted some renewed interest (a conditional commitment was made for an $8.3 billion guarantee for a loan to finance the addition of two reactors at Southern Company's Plant Vogtle in Georgia). However, concerns about financial risks and health and environmental safety persist, particularly in light of the recent disaster at the Fukushima Daiichi nuclear plant in Japan.

Moreover, in recent years, the Congress has appropriated an average of about $400 million annually to develop technology to reduce carbon dioxide (CO_2) emissions from coal, most notably by capturing and storing CO_2 produced by coal-burning plants and industrial facilities. (That 2007 funding is included in the $854 million for coal shown in the table.) The Congress also appropriated $3.4 billion in 2009 under ARRA for those activities. In spite of such support, no significant fraction of current electricity generation involves carbon capture and storage, and none is projected to do so for the next two decades.

Figure 1-3.

Nonhydropower Renewable Sources of Electricity Generation in 2010 and 2035, by Amount of Electricity Provided and Share of Total Generation

(Billions of kilowatt hours)



Source: Congressional Budget Office based on data from Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011, with Projections to 2035* (April 2011), www.eia.gov/forecasts/aeo/.

a. Solor photovoltaic power involves converting sunlight directly into electricity through the use of special cells.

b. Solar thermal power involves using sunlight to create heat, which can then serve as a power source in a conventional electricity-generating plant (among other applications).

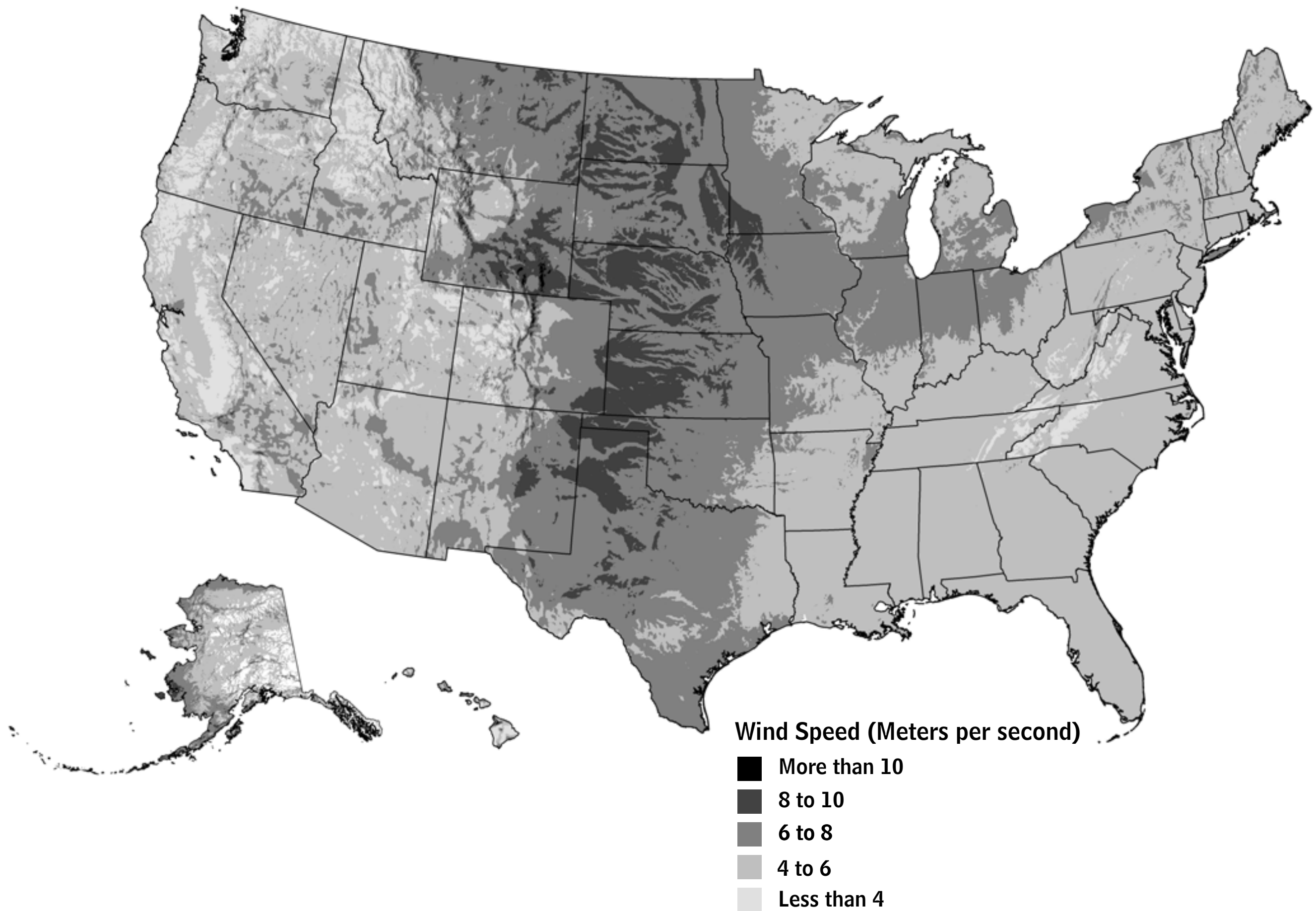
obtaining permission from numerous government entities, because many lines cross multiple counties and states. On average, siting a new transmission line takes 14 years.[7] In addition, building transmission lines entails resolving difficult questions about how the cost of that capacity should be allocated.[8] Once constructed, transmission lines could be used by generators or customers who were not envisioned in the initial plan; thus, the

7. Charles Ebinger, remarks given at the Brookings Institution seminar "Energy and Climate Change 2010: Back to the Future," Washington, D.C., May 18, 2010, www.brookings.edu/~/media/Files/events/2010/20100518_energy_climate/20100518_energy_climate_change_II.pdf.

8. For a discussion of siting and cost-allocation issues, see Stan Mark Kaplan, *Electric Power Transmission: Background and Policy Issues*, CRS Report for Congress R40511 (Congressional Research Service, April 14, 2009); and Mason Willrich, "Electricity Transmission Policy for America: Enabling a Smart Grid, End-to-End" (seminar presentation to the Center for Environmental Public Policy, Goldman School of Public Policy, University of California, Berkeley, November 18, 2009), http://gspp.berkeley.edu/programs/docs/CEPP_Willrich_111809.pdf.

Figure 1-4.

Average Annual Wind Speeds in the United States at 80 Meters Above the Ground



Source: Congressional Budget Office based on information from the National Renewable Energy Laboratory, www.windpoweringamerica.gov/wind_maps.asp.

Note: Locations with an average annual wind speed of at least 6.5 meters per second at a height of 80 meters are considered well suited to generating wind power.

generators and customers who agreed to an initial allocation of cost might need to renegotiate that plan as additional generators and customers wanted to make use of the new lines.

Intermittency. Wind and solar plants can be operated only part of the time because the wind does not always blow and the sun is not always visible. On average, wind plants produce just 34 percent of the electricity that they could if they operated continuously; solar plants produce 22 percent to 31 percent of their theoretical full capacity, depending on the type of plant.[9] As a result of those low "capacity factors," the capital costs of building wind and solar plants are spread over a fairly small amount of generation, and hence the plants tend to have relatively high average costs. That intermittency, together with a lack of a low-cost way to store electricity, also means that wind and solar power cannot serve as a source of continuous electric power, as base-load generation through coal combustion does. Finally, periods of high wind or bright sunshine may not correspond with the periods when the value of electricity, and thus the price that generators

9. See Department of Energy, Energy Information Administration, "2016 Levelized Cost of New Generation Resources from the Annual Energy Outlook 2010" (no date), www.eia.doe.gov/oiaf/aeo/pdf/2016levelized_costs_aeo2010.pdf.

could charge for it, is highest.[10] That fact tends to limit the potential for renewable generation to be dispatched (or increased quickly) when the demand for electricity is greatest.

In general, wind and solar plants are more frequently substituted for natural-gas-fired generation than for coal-fired generation, because natural gas tends to have higher operating costs than coal and because coal plants tend to operate continuously. However, for the reasons described above, an additional megawatt of solar or wind capacity cannot substitute for an additional megawatt of nonrenewable capacity. For example, given the current generation mix in the United States, EIA estimates that 50 megawatts of wind capacity would be required to replace 20 megawatts of natural-gas-fired capacity. In the absence of a low-cost means of storing electricity, the intermittent nature of wind and solar energy would significantly limit their ability to provide the majority of the nation's electricity, even if all regions were equally well suited for such generation.

Potential Effects of Large-Scale Use of Biomass. Unlike wind and solar power, biomass can be used to produce electricity around the clock; therefore, biomass may be able to substitute for coal in supplying continuous base-load generation. However, as reliance on biomass grows—for producing biofuels for the transportation sector as well as for use in the electricity sector—its price may increase. Current biomass sources include waste products generated by the forest products industry and by farms. Increased reliance on biomass to generate electricity and to supply transportation fuels could involve growing crops explicitly for that purpose, which could drive up prices for land and for the agricultural commodities that the biomass crops would displace.[11] One estimate suggests that growing enough biomass to satisfy 6 percent of total U.S. electricity demand in 2008 would have required an amount of land roughly equal to that currently being farmed for all types of crops in Iowa.[12]

Burning biomass specifically grown for electricity generation in place of fossil fuels could also raise questions about the extent to which such a substitution would actually reduce CO_2 emissions. Determining the ultimate effect of that substitution would require comparing all of the emissions that result from producing, distributing, and burning both types of fuel (so-called life-cycle emissions). Such calculations are complicated and depend on assumptions about whether land-use patterns would be altered by growing biomass for energy production.[13]

Technological, Safety, and Environmental Uncertainties. No commercial-scale electricity plants currently exist that capture, compress, and store CO_2 emissions. As a result, the cost of building such a plant is uncertain, although both construction and operating costs would be higher than for an equivalent new plant without that capability. A generating plant designed for carbon capture and storage would need additional equipment to separate CO_2 from the rest of the exhaust gases, capture it, and compress it so that it could be transported to storage sites. Moreover, capturing and compressing CO_2 is an energy-intensive process, which would consume 15 percent to 30 percent of the total electricity that the plant would produce. As a result, the plant would need to be larger than one that sold the same amount of electricity but did not capture and store its CO_2 emissions, and it would require more inputs for each MWh of electricity that it sold. Because no full-sized plants with that capability have yet been built, available cost estimates rely on engineering designs. However, as technologies pass through different stages from development to commercialization, researchers often discover that the actual implementation of a concept is more complicated, and hence more expensive, than it first appeared.[14]

10. Failure to account for that fact can lead to misleading comparisons between the market value of wind or solar plants and conventional alternatives. See Paul L. Joskow, *Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies* (Massachusetts Institute of Technology, Center for Energy and Environmental Policy Research, September 2010).

11. See Congressional Budget Office, *The Impact of Ethanol Use on Food Prices and Greenhouse-Gas Emissions* (April 2009).

12. See Kelsi Bracmort, *Biomass Feedstocks for Biopower: Background and Selected Issues*, CRS Report for Congress R41440 (Congressional Research Service, October 6, 2010), www.fas.org/sgp/crs/misc/R41440.pdf.

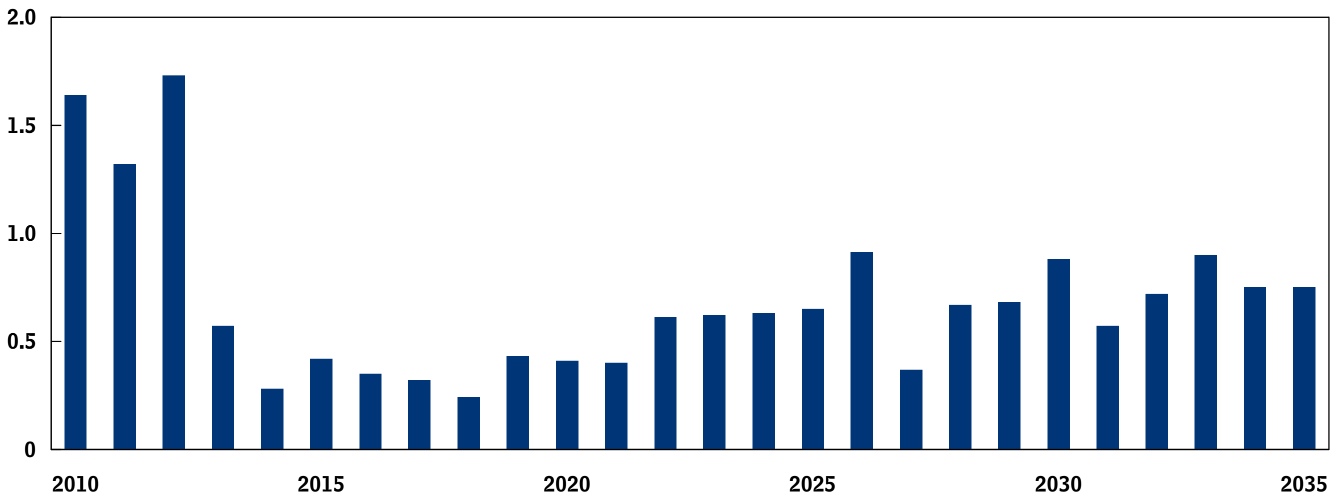
13. See Congressional Budget Office, *The Impact of Ethanol Use on Food Prices and Greenhouse-Gas Emissions*.

14. That phenomenon is so common that energy modelers often include a "technological optimism factor" to compensate for early underestimates of final costs. See Department of Energy, Energy Information Administration, "The National Energy Modeling System: An Overview—Electricity Market Module" (October 2009), www.eia.doe.gov/oiaf/aeo/overview/electricity.html.

Figure 1-5.

Projected Annual Additions to U.S. Generating Capacity Through 2035

(Percentage of total generating capacity)



Source: Congressional Budget Office based on data from Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011, with Projections to 2035* (April 2011), www.eia.gov/forecasts/aeo/.

Note: Added capacity is relatively high from 2010 through 2012 in part because of cash grants provided through the American Recovery and Reinvestment Act of 2009 that are set to expire at the end of 2011.

Expanding carbon capture and storage could also be hampered by environmental or safety concerns about the potential for unintentional releases of compressed CO_2. Likewise, new nuclear power plants would raise safety and environmental concerns. Opponents of nuclear power cite potential risks and environmental damage from mining, processing, and transporting uranium; the risk of nuclear weapons proliferation; the unsolved problem of storing nuclear waste safely; and the potential hazard of a serious accident. Such concerns make developing new nuclear generating capacity difficult, time consuming, and costly. As a result, no new nuclear plant has begun operating in the United States during the past 15 years.

Limited Growth in New Capacity. Altering the generation mix could be achieved at the lowest possible cost through an RES or CES if generators could simply invest in qualifying generation when they needed to add capacity. In that case, the share of generation provided by qualifying sources would increase gradually, without forcing the premature retirement of existing capacity.[15]

15. That approach would also mean that the reduction in CO_2 emissions induced by the policy would occur slowly.

However, the demand for new generating capacity in the United States is expected to be relatively low in coming decades. Predictions from EIA suggest that annual construction of new capacity will account for less than 1 percent of total generating capacity each year between 2013 and 2035 (see Figure 1-5), and cumulative new capacity over that period will make up just 12 percent of generating capacity in 2035. Capacity growth is projected to be particularly slow in the near future: Annual construction of new capacity is expected to be less than 0.7 percent of total capacity each year between 2013 and 2025, and cumulative new capacity over that time frame is expected to account for only 6 percent of capacity in 2025.

The limited demand for construction of new generating capacity stems from a variety of factors, including:

- Excess generating capacity in the electricity sector today—driven in part by incentives for new wind generation (see Box 1-1 on page 9)—which lessens the need for firms to replace capacity that is due to be retired in the next decade;

- The fact that virtually no existing capacity is scheduled to be retired between 2021 and 2031; and

- Slow projected growth in the total demand for electricity in the United States over the next 25 years. The growth rate of electricity production has gradually declined over the past several decades, from an average of 4 percent a year in the 1970s, to 3 percent in the 1980s, 2 percent in the 1990s, and less than 1 percent in the past decade. Much of that slowdown in growth reflects the fact that the U.S. economy has become less electricity intensive per unit of output. For example, between 1980 and 2009, electricity generation grew much more slowly, on average, than real (inflation-adjusted) gross domestic product (by 1.8 percent a year versus 2.8 percent).[16]

By itself, slow growth in the demand for electricity could reduce the cost of meeting an RES or CES. The reason is that achieving the standard would require a smaller absolute increase in qualifying generation if growth in demand was slow than if it was rapid. However, coupled with slow turnover in the existing capital stock, slow growth in demand for electricity could increase the likelihood that meeting the standard would force the premature retirement of existing power plants.

16. See Department of Energy, Energy Information Administration, *Annual Energy Review 2009* (August 2010), Table 8.1, www.eia.gov/emeu/aer/pdf/pages/sec8_5.pdf; and Pew Center on Global Climate Change, "Electricity Overview" (June 2011), www.pewclimate.org/technology/overview/electricity.

CHAPTER 2

Potential Effects of a Renewable or Clean Electricity Standard

A renewable or clean electricity standard would directly alter the mix of sources used to generate electricity in the United States, which in turn would change the amount of greenhouse gases and other pollutants emitted by electricity generators and the prices charged for electricity. Those effects would vary across the country.

In addition, some advocates of a federal RES or CES suggest that it would reduce U.S. dependence on foreign sources of energy. Such an outcome is unlikely, however, because the vast majority of fuel used to generate electricity in the United States—primarily coal and natural gas—already comes from domestic sources. (The United States produces enough coal to be a net exporter, and only about 12 percent of the natural gas it consumes is imported, on net.) Further, because petroleum accounts for just 1 percent of electricity generation, an RES or CES would not significantly affect U.S. oil consumption or imports.[1]

To better understand the potential impact of a renewable or clean electricity standard, the Congressional Budget Office (CBO) examined seven recent analyses of potential federal standards conducted by various government or independent organizations (see Table 2-1).[2] Each policy that was analyzed represents a unique combination of features. Three of the policies would establish a 25 percent RES, but they differ in terms of whether utilities could make an alternative compliance payment (ACP) instead of submitting credits and whether generators would receive multiple credits for certain technologies (those design features are described in Chapter 1). Two of the policies would establish a 25 percent CES, one of which would allow natural gas generation at plants that began operation after the policy took effect to qualify for credits and one of which would not. The other two policies would establish a 20 percent RES, one with an ACP provision and one without. The seven analyses simulated the effects of those policies using three models of the electricity sector:

- The National Energy Modeling System (NEMS), which was developed by the Department of Energy's Energy Information Administration (EIA);
- The Regional Energy Deployment System (ReEDS) model, which was created by the National Renewable Energy Laboratory (NREL), also part of the Department of Energy; and
- Haiku, which was developed by the independent research organization Resources for the Future (RFF).[3]

1. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011, with Projections to 2035* (April 2011), www.eia.gov/forecasts/aeo/.

2. For descriptions of each analysis, see Department of Energy, Energy Information Administration, *Impacts of a 25-Percent Renewable Electricity Standard as Proposed in the American Clean Energy and Security Act Discussion Draft* (April 2009), www.eia.gov/oiaf/servicerpt/acesa/index.html; Patrick Sullivan and others, *Comparative Analysis of Three Proposed Federal Renewable Electricity Standards,* Technical Report NREL/TP-6A2-45877 (National Renewable Energy Laboratory, May 2009), www.nrel.gov/docs/fy09osti/45877.pdf; and Alan J. Krupnick and others, *Toward a New National Energy Policy: Assessing the Options* (National Energy Policy Institute and Resources for the Future, November 2010), http://nepinstitute.org/publications/toward-a-new-national-energy-policy-assessing-the-options/.

3. For documentation on NEMS, see Department of Energy, Energy Information Administration, "The National Energy Modeling System: An Overview" (October 2009), www.eia.gov/oiaf/aeo/overview/index.html; on ReEDS, see National Renewable Energy Laboratory, "Regional Energy Deployment System" (no date), www.nrel.gov/analysis/reeds/; and on Haiku, see Anthony Paul and Dallas Burtraw, *The RFF Haiku Electricity Market Model* (Resources for the Future, June 2002), www.rff.org/RFF/Documents/RFF-RPT-haiku.pdf.

Table 2-1.

Effects of Seven Potential Federal Renewable or Clean Electricity Standards

	25 Percent RES			25 Percent CES		20 Percent RES	
	With $50 ACP (EIA)	Without ACP (NREL)	With $50 ACP (RFF)	With $50 ACP (RFF)	With Natural Gas and $50 ACP (RFF)	With $25 ACP (RFF)	Without ACP (RFF)
Model Used	NEMS	ReEDS	NEMS	NEMS	NEMS	Haiku	Haiku
Final Year of Projection	2030	2030	2030	2030	2030	2035	2035
Unique Policy Features	Selected generation receives triple credits; small utilities exempted	Selected generation receives triple credits; small utilities exempted	None	Credits for CCS and nuclear[a]	Credits for CCS and nuclear; partial credits for natural gas[b]	Energy baseline against which policy is measured includes hydropower	Energy baseline against which policy is measured includes hydropower
Amount of Qualifying Generation in Final Year of Projection[c]							
Without Policy (Baseline)							
Billions of kilowatt hours	472	699	471	558	788	423	423
Percentage of electricity sales	10	14	10	12	18	9	9
With Policy							
Billions of kilowatt hours	887	867	1,001	1,005	1,151	613	905
Percentage of electricity sales	20	18	22	22	26	14	20
Policy-Induced Change in Generation in Final Year of Projection, by Source (Billions of kilowatt hours)							
Renewable							
Wind	41	81	106	30	8	157	373
Biomass	360	14	410	125	117	33	100
Geothermal Energy	6	18	8	3	*	3	6
Solar Energy	8	55	7	6	4	0	0
Nonrenewable							
Coal with Carbon Capture and Storage	0	0	0	0	0	0	0
Coal	-257	-161	-298	-234	-228	-102	-275
Natural Gas	-150	1	-223	-216	-38	-84	-194
Nuclear Power	-31	0	-41	283	127	-63	-94
Policy-Induced Change in Renewable Generation in Final Year of Projection, by Region (Billions of kilowatt hours)							
West	50	76	96	19	5	74	174
Plains	115	20	156	59	51	92	154
East Central	65	38	85	31	28	5	59
Southeast	146	30	153	45	45	24	83
Northeast	39	4	41	10	-1	*	12
Policy-Induced Change in CO_2 Emissions from Electricity Sector in Final Year of Projection							
Millions of Metric Tons of CO_2	-307	-150	-375	-307	-241	-138	-355
Percent	-12	-6	-14	-12	-9	-5	-14

Continued

Table 2-1. **Continued**

Effects of Seven Potential Federal Renewable or Clean Electricity Standards

	25 Percent RES			25 Percent CES		20 Percent RES	
	With $50 ACP (EIA)	Without ACP (NREL)	With $50 ACP (RFF)	With $50 ACP (RFF)	With Natural Gas and $50 ACP (RFF)	With $25 ACP (RFF)	Without ACP (RFF)
	Average Policy-Induced Change in Electricity Prices Between 2020 and 2030, by Region (Percent)						
West	1	**	1	**	**	**	-3
Plains	-3	-1	-4	**	1	1	2
East Central	2	-1	2	2	1	2	-1
Southeast	3	**	4	3	3	5	10
Northeast	3	**	2	1	2	-2	-4

Source: Congressional Budget Office based on analyses by the Energy Information Administration (EIA), the National Renewable Energy Laboratory (NREL), and Resources for the Future (RFF).

Notes: RES = renewable electricity standard; ACP = alternative compliance payment; CES = clean electricity standard; NEMS = National Energy Modeling System; ReEDS = Regional Energy Deployment System; CCS = carbon capture and storage; CO_2 = carbon dioxide; * = between -0.5 billion and 0.5 billion kilowatt hours; ** = between -0.5 percent and 0.5 percent.

The amounts shown here for alternative compliance payments are for the first year of the policy; those amounts rise over time with inflation.

a. Facilities that began operations after the policy went into effect and produce electricity using either nuclear power or fossil fuel with CCS would receive one credit for each kilowatt hour of electricity generated.

b. Facilities that began operations after the policy went into effect and produce electricity using either nuclear power or fossil fuel with CCS would receive one credit for each kilowatt hour of electricity generated. Natural-gas-fired facilities without CCS that began operations after the policy went into effect would receive a fraction of a credit for each kilowatt hour of electricity generated; depending on the type of natural gas technology used, that fraction would vary from 0.33 to 0.59, reflecting each technology's rate of CO_2 emissions relative to that of a new pulverized-coal-fired boiler.

c. For RES policies, qualifying sources of electricity generation consist of renewable energy (except hydropower and municipal solid waste). For CES policies, qualifying sources of generation also include integrated gasification combined-cycle plants with carbon capture and storage, as well as advanced nuclear and (if noted) natural gas plants completed after the policy took effect. A few of the policies in this table include municipal solid waste as a qualifying source of generation; however, for consistency among the policies, CBO excluded that source from the numbers shown here.

CBO's aims in examining the seven analyses were to determine general trends in generation patterns resulting from RES and CES policies, to identify the effects that particular design features would have on policy outcomes, and to examine the extent to which models that reflect different assessments about the underlying costs of various technologies would predict different effects for similar policies. Those findings offer insights into the potential impact of any renewable or clean electricity standard that policymakers might consider.

Unless otherwise indicated, all of the policies examined here had the following features:

- Qualifying sources of energy included wind (both offshore and onshore), certain types of biomass, geothermal energy, and solar energy (both thermal and photovoltaic);
- Hydropower and electricity derived from municipal solid waste were not considered qualifying renewable sources and were excluded from the base to which the standard was applied—that is, utilities would not have to purchase credits for their sales of electricity that was generated by hydropower or municipal solid waste;
- Both existing and new sources of renewable generation were eligible for credits;
- Utilities could trade credits freely but could not bank or borrow them;

- The presence of states' renewable or clean electricity standards was accounted for in the baseline (that is, modelers increased the amount of renewable or clean electricity predicted to occur in the absence of a federal policy by the amount that would be mandated by state policies); and

- The federal policy would begin in 2012 and be phased in gradually. (All of the 25 percent RES and CES policies would be fully phased in by 2025; the two 20 percent RES policies would be fully phased in by 2020.)

Some of the policies included additional qualifying sources of electricity, such as ocean energy (power generated from tides or waves), landfill gas, and hydroelectricity from newly constructed facilities that met very specific restrictions. However, those sources were not projected to add significantly to renewable generation during the forecasting period—which ran through 2030 for analyses using the NEMS and ReEDS models and through 2035 for analyses using the Haiku model.

Each analysis reported regional changes in electricity generation and prices, but they defined regions in different ways. For example, ReEDS predicted changes at the state level, and NEMS produced estimates for 13 regions. For purposes of comparison, CBO adapted all of the models' results to the five regions used in the Haiku model (see Figure 2-1).[4]

Effects on Sources and Locations of U.S. Electricity Generation

The seven RES and CES policies examined here showed some similarities in their projected effects on the mix of energy sources used to generate electricity. Nevertheless, the effects varied significantly depending on the specific features included in the policies and the assumptions used in the models. Policy features such as an alternative compliance payment can cause otherwise identical policies to have widely varying outcomes. In addition, the three models used to analyze the policies incorporated different estimates of the cost of producing electricity from various sources in the coming decades. As a result of those differences, the three models would predict different outcomes even if they were used to analyze the exact same policy.

Similar Patterns in Findings

Most of the analyses concluded that the bulk of the increase in renewable generation caused by an RES or CES would come from wind and biomass (see Figure 2-2). Analyses conducted using NEMS predicted that, on average, roughly 80 percent of policy-induced increases in renewable generation would stem from increases in biomass generation and that most of the rest would come from wind generation. Analyses using Haiku, which incorporated different estimates of the availability of renewable resources, also found that most new generation would be in the form of biomass and wind, but in a different proportion than NEMS; they estimated that wind would account for nearly 80 percent of policy-induced increases in renewable generation and that biomass would account for the rest. The NREL analysis, conducted using ReEDS, estimated a significantly larger increase in geothermal or solar generation than the other analyses did. As discussed below, that outcome stems from specific assumptions in the ReEDS model about the relative cost of various forms of renewable generation, as well as specific provisions in the policy that ReEDS was used to analyze.

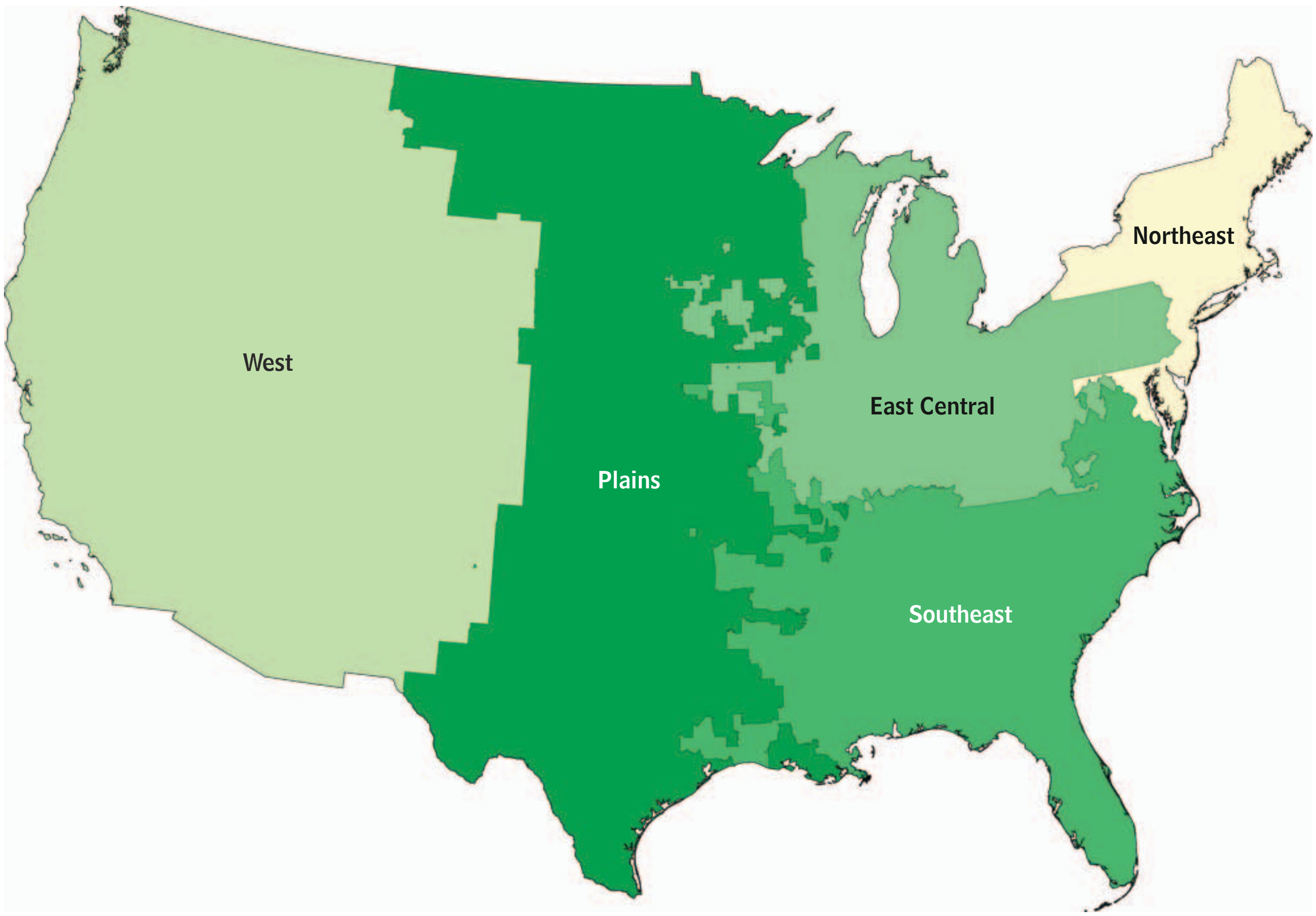
In general, the three models projected that most of the increase in renewable generation would occur in the Southeast, the Plains, and the West (see Figure 2-3 on page 21). Analyses using NEMS, which predicted that the bulk of new renewable generation would come from biomass, concluded that the largest increases would occur in the Plains and the Southeast. Analyses using Haiku, which predicted that most renewable generation would come from wind, found the largest increases in renewable generation occurring in the West and the Great Plains—areas that tend to have the best conditions for wind generation (see Figure 1-4 on page 11). The analysis conducted with ReEDS found new renewable generation more evenly distributed across the country. However, all of the models predicted that the Northeast would see the smallest increase in renewable generation.

The two analyses of a clean electricity standard predicted, not surprisingly, that because the CES would be met in part by increases in nuclear generation, a 25 percent CES would result in much less expansion of renewable

4. Because the smaller geographic areas used in ReEDS and NEMS did not have boundaries that corresponded to those of the larger areas used in Haiku, CBO constructed weighted averages of the smaller areas such that their population matched that of the five regions in the Haiku model in the initial period of each projection.

Figure 2-1.

The Five Regions Used for Reporting Changes in Prices and Generation in This Study



Sources: Congressional Budget Office; Resources for the Future.

Note: The five regions shown here correspond to the regions used in reporting results from the Haiku model used by Resources for the Future. The regions are aggregations of electricity markets, which do not necessarily correspond to state boundaries.

generation than a 25 percent RES would (see Figure 2-2). For example, according to analyses by Resources for the Future, generation from wind and biomass would be 106 billion and 410 billion kilowatt hours higher, respectively, in 2030 as a result of a 25 percent RES but would be just 30 billion and 125 billion kilowatt hours higher, respectively, under a 25 percent CES without natural gas (see Table 2-1 on page 16). Allowing natural gas to qualify as a clean source under a CES would reduce the net increase in wind and biomass generation even more.

Effects of Policy Design Features on the Amount of Renewable or Clean Generation

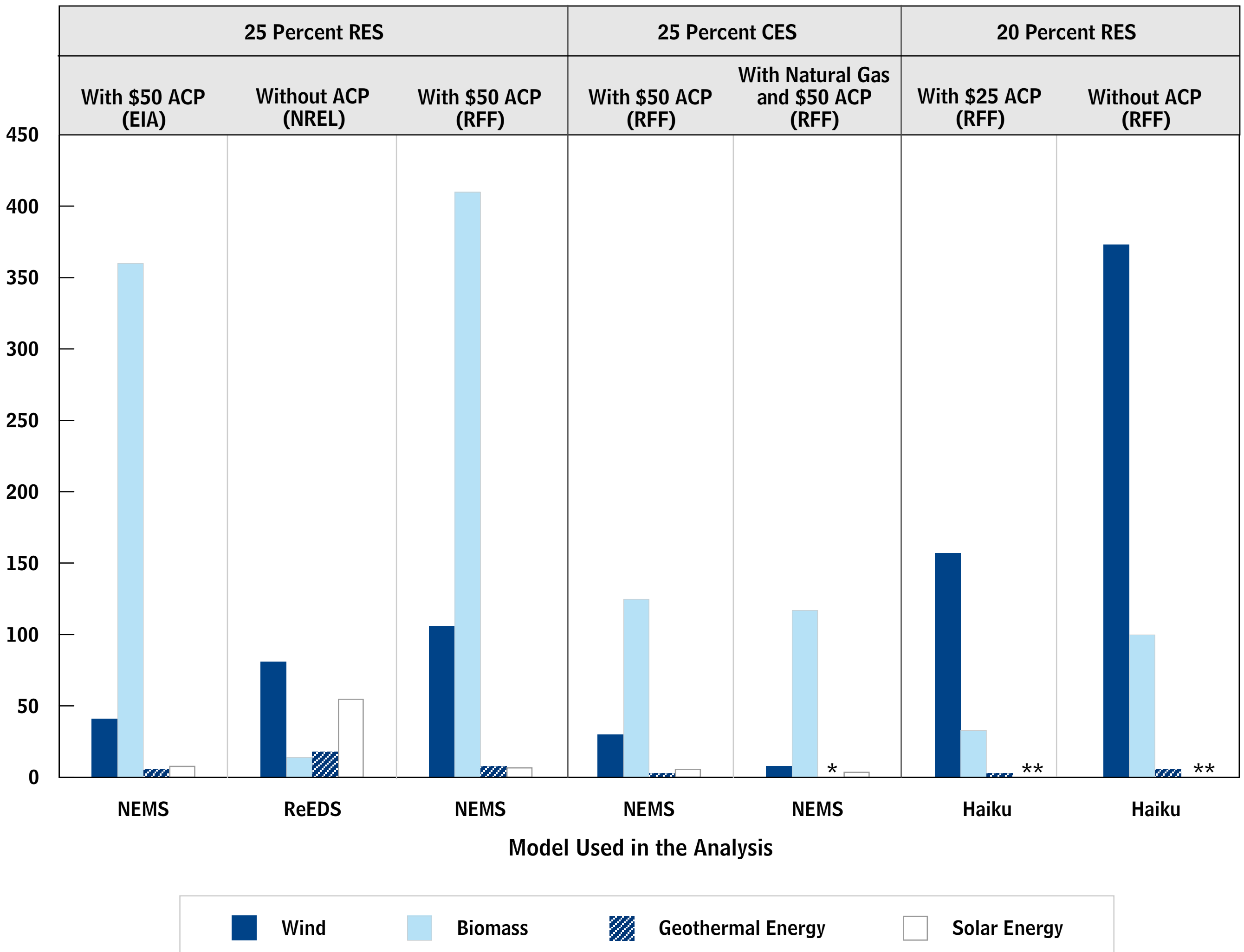
Variations in the details of otherwise similar policies can create large difference in the policies' effects. The actual percentage of electricity generated from renewable or other clean sources under an RES or CES would most likely differ from the stated standard. The size of that difference would depend on specific design features—such as exemptions for certain utilities, preferences for selected technologies, and alternative compliance payments. In five of the seven analyses that CBO examined, the projected share of generation from qualifying sources was 3 to 7 percentage points less than the stated standard. In the other two analyses, the percentage of qualifying generation either met or exceeded the standard (for reasons explained below).

Exempting certain utilities from the standard, and excluding some types of generation from the base to

Figure 2-2.

Policy-Induced Change in Renewable Generation for the Final Year of the Projection, by Source

(Billions of kilowatt hours)



Source: Congressional Budget Office based on analyses by the Energy Information Administration (EIA), the National Renewable Energy Laboratory (NREL), and Resources for the Future (RFF).

Notes: RES = renewable electricity standard; ACP = alternative compliance payment; CES = clean electricity standard; NEMS = National Energy Modeling System; ReEDS = Regional Energy Deployment System; * = no significant change in generation using geothermal energy; ** = no change in generation using solar energy.

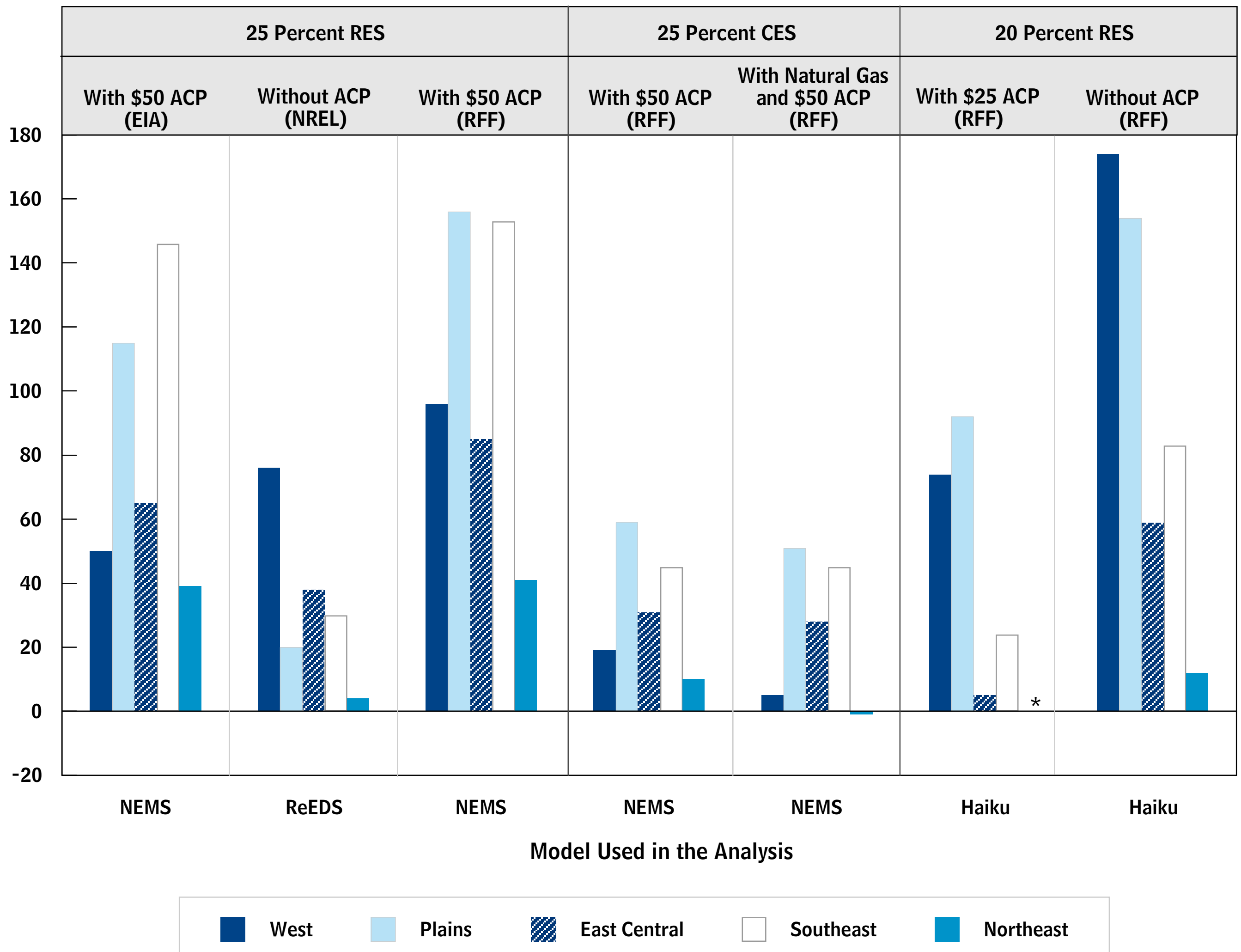
The final year of the projection is 2030 for the 25 percent RES and the 25 percent CES and 2035 for the 20 percent RES.

which the standard was applied, would tend to cause the percentage of generation provided by qualifying sources to be less than the standard. Two of the versions of an RES examined here would exempt small generators, thereby reducing the share of electricity sales covered by the standard. Both EIA and RFF analyzed a 25 percent RES using NEMS; however, RFF found that the policy would induce more renewable generation than did EIA (see Figure 2-4), in part because EIA assumed that small utilities would be exempt from complying with the standard. Further, five of the seven policies would exclude existing generation from hydropower and municipal

Figure 2-3.

Policy-Induced Change in Renewable Generation for the Final Year of the Projection, by Region

(Billions of kilowatt hours)



Source: Congressional Budget Office based on analyses by the Energy Information Administration (EIA), the National Renewable Energy Laboratory (NREL), and Resources for the Future (RFF).

Notes: RES = renewable electricity standard; ACP = alternative compliance payment; CES = clean electricity standard; NEMS = National Energy Modeling System; ReEDS = Regional Energy Deployment System; * = no significant change in generation in the Northeast.

The final year of the projection is 2030 for the 25 percent RES and the 25 percent CES and 2035 for the 20 percent RES.

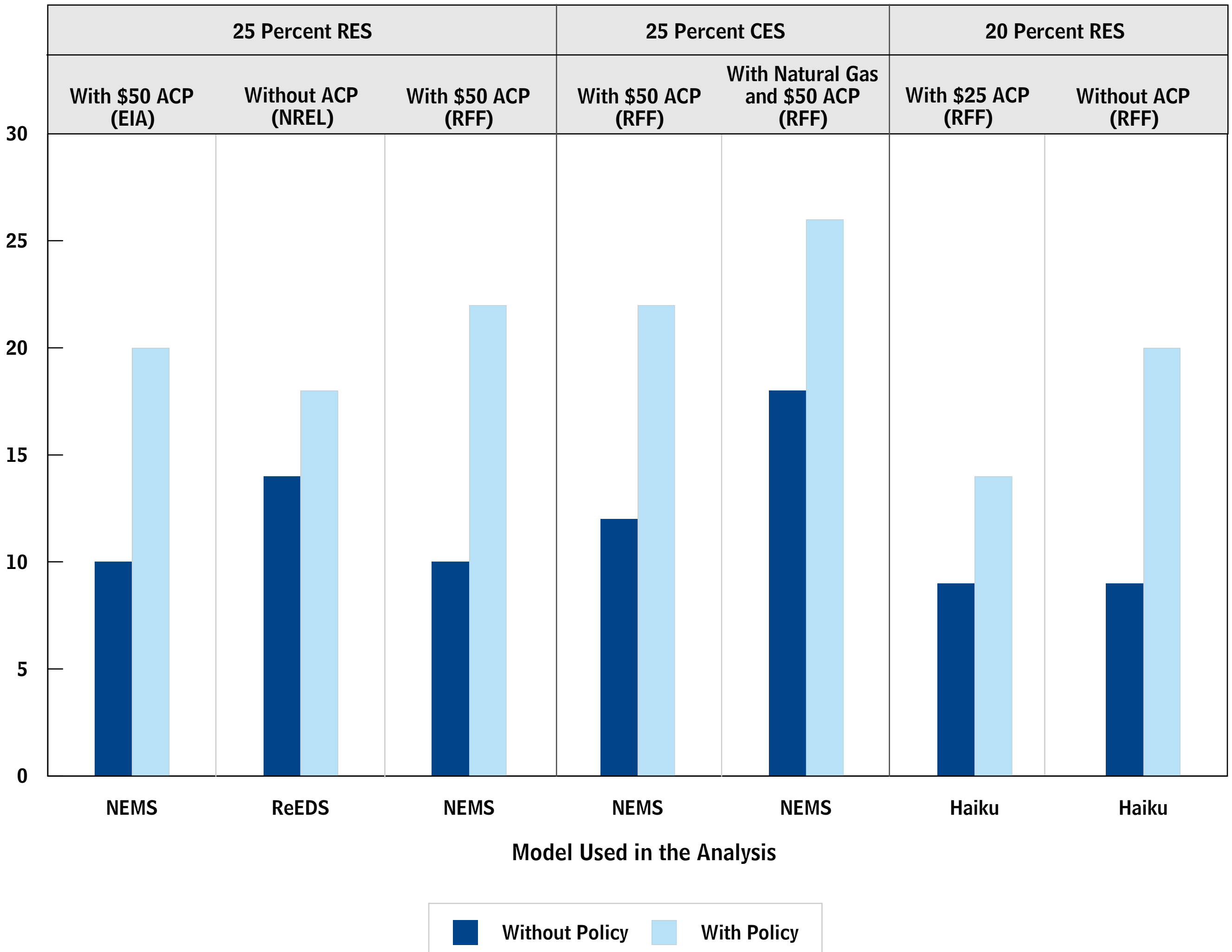
solid waste (which together account for 6.3 percent of current generation) from the base to which the standard was applied. That exclusion alone would mean that the share of generation provided by qualifying sources could not exceed 93.7 percent (100 – 6.3 percent) of the stated standard. RFF's analysis of a 20 percent RES was the only one that did not exempt sources from the base to which the policy was applied and, as a result, was the only policy in which the share of qualifying generation was equal to the standard, but only if an ACP was not included (see Figure 2-4).

Giving preference to certain technologies by awarding them more than one credit for each MWh of electricity that they produced would allow the standard to be met

Figure 2-4.

Percentage of Qualifying Generation for the Final Year of the Projection, Without and With the Policy

(Percent)



Source: Congressional Budget Office based on analyses by the Energy Information Administration (EIA), the National Renewable Energy Laboratory (NREL), and Resources for the Future (RFF).

Notes: RES = renewable electricity standard; ACP = alternative compliance payment; CES = clean electricity standard; NEMS = National Energy Modeling System; ReEDS = Regional Energy Deployment System.

The final year of the projection is 2030 for the 25 percent RES and the 25 percent CES and 2035 for the 20 percent RES.

with a smaller rise in qualifying generation, increasing the extent to which the actual percentage of generation from qualifying sources would be less than the standard. The 25 percent RES policies modeled by the Energy Information Administration and the National Renewable Energy Laboratory (using the NEMS and ReEDS models, respectively) both contained a provision that would provide three credits for each MWh of electricity produced using solar photovoltaic technology. Because the ReEDS model included relatively optimistic assumptions about the cost of generating solar photovoltaic electricity (as discussed in the next section), that triple credit led to a much larger increase in solar generation in NREL's analysis than in EIA's analysis (see Figure 2-3 on page 21).

That increase in turn contributed to the substantial difference between the standard (25 percent) and the actual share of generation from renewable sources (18 percent) in NREL's analysis (see Figure 2-4). Providing additional credits for particular technologies would also alter the mix and location of qualifying electricity generation used to meet the standard.

Another policy feature that could cause the share of generation provided by qualifying sources to be much lower than the stated standard is allowing utilities to comply through an alternative compliance payment. Resources for the Future's analysis of a 20 percent RES (conducted using the Haiku model) demonstrates the potential effect of an ACP. The same 20 percent standard resulted in an actual share for renewable electricity of 14 percent when an ACP of $25 per MWh was included, compared with a 20 percent share when no ACP was included (see Figure 2-4). The lower that policymakers set an ACP relative to the anticipated price of a credit, the larger would be the difference between the actual percentage of qualifying generation and the standard, because utilities would have a greater incentive to pay the ACP instead of submitting credits. Most of the other analyses that CBO examined included ACPs, but those payments had little impact because they were set at a high enough level ($50 per MWh) that they affected compliance in few, if any, years of the projections.

Unlike the foregoing policy features, providing partial credits to certain technologies could cause the share of generation from qualifying sources to exceed the standard. For example, in Resources for the Future's analysis of a 25 percent CES in which electricity generated from natural gas would receive a fraction of a credit, the share of generation provided by all qualifying sources was projected to be slightly higher than the 25 percent standard once the policy was fully in place.[5] Providing partial credits for a particular technology would also create an upper limit on the use of that technology. For example, if an 80 percent CES program provided half a credit for each MWh of electricity generated from natural gas and a full credit for electricity from all other designated clean sources, the share of total generation provided by natural gas could not exceed 40 percent even if all other generation was from zero-emission sources.

Effects of Models' Differing Estimates of Costs

The future cost of generating electricity—whether from renewable or other clean sources or from conventional sources—is uncertain. Models that use different assumptions about costs will yield different predictions of the increase in renewable or clean generation that would be required to comply with a policy, as well as the mix of renewable or other clean sources that would result from a given standard. Differences between models' outcomes are an indication of the uncertainty about the actual effects of a policy.

The extent to which any particular RES or CES would increase renewable generation depends on the baseline against which the policy is measured—that is, on the amount of renewable generation that is predicted to occur in the future in the absence of the policy. Analyses in which the estimated cost of renewable generation is low relative to the cost of nonrenewable generation envision a larger share of renewable generation in the baseline. Thus, they predict that a smaller increase in renewable generation would be necessary to comply with a given standard. For example, the ReEDS model includes relatively low estimates of the cost of generating electricity from renewable sources, and it predicts that, in the absence of a standard, renewable generation will account for 14 percent of electricity sales in 2030—4 percentage points higher than in any of the other RES analyses examined. As a result, ReEDS would predict a smaller increase in renewable generation from any particular standard than other models would (see Figure 2-4).

In addition to the total change in renewable or clean generation, the mix of energy sources that each model predicts depends on many different factors. An increase in renewable or clean generation would tend to displace the most costly nonqualifying generation for which it could serve as a substitute. If all else was equal, such substitutions would be cheapest to make in places that

5. That analysis also concluded that the use of natural gas would decline because of the policy even though utilities would comply in part by purchasing credits for electricity generated at new natural gas plants. That outcome illustrates the potential efficiency cost associated with providing credits only for generation from new, rather than all, natural gas plants. The policy would give utilities an incentive to invest in new natural gas plants but not an incentive to operate their existing plants more than they would otherwise. Thus, the policy could cause new plants (which would generate both electricity and credits) to be built while existing plants were being used less. Providing credits for existing sources could solve that problem, but, as described in Chapter 1, it would also have significant distributional effects that policymakers might find undesirable.

required new capacity, because generators could add renewable or other clean capacity, rather than nonqualifying capacity, to meet that need but would not have to scrap existing generating capacity. Thus, differences in models' outcomes will depend on differences in assumptions about the costs of all types of generation, as well as on projections about the demand for new capacity in various regions. As a result, estimates of how the mix of generation would change because of a policy are uncertain, and estimates of the regional effects of a policy are even more uncertain.

Effects on Greenhouse Gas Emissions

An RES or CES would be likely to reduce greenhouse gas emissions, but the size of the reduction associated with a given standard is difficult to predict. It would depend in part on how much additional renewable or clean generation resulted from the standard. For example, although EIA's and NREL's analyses of a 25 percent RES showed similar shares of electricity being generated from renewable sources (20 percent and 18 percent, respectively), EIA predicted that the resulting decrease in CO_2 emissions in 2030 would be more than twice as large as the decrease projected by NREL (see Table 2-1 on page 16). That disparity stems mainly from differences in the baseline amount of renewable generation predicted by EIA's NEMS model and NREL's ReEDS model. The ReEDS model predicted 40 percent more renewable generation in the absence of a standard than the NEMS model did. Consequently, the analysis using ReEDS projected that the RES would lead to a smaller increase in renewable generation and hence a smaller reduction in CO_2 emissions.

The actual decrease in CO_2 emissions that would result from a policy would also depend on the type of generation being displaced by new renewable or clean generation. The reduction in emissions would be greater if renewable generation displaced coal-fired generation rather than natural-gas-fired generation, because generating a MWh of electricity from coal produces roughly twice as much CO_2 as generating the same amount of electricity from natural gas.[6] In general, biomass generation is somewhat more likely to displace coal-fired generation, and wind generation is somewhat more likely to displace natural-gas-fired generation (because of their locations and differences in their ability to provide base-load generation). Thus, if everything else is equal, models that predict that generators will rely on increases in biomass generation to comply with a policy will project larger reductions in CO_2 than will analyses that predict greater reliance on wind generation.[7]

Policymakers could set a more ambitious standard for the amount of generation to come from clean sources than for the amount to come from renewable sources. The reason is that a CES would allow for the use of technologies—such as nuclear power and coal- or natural-gas-fired generation with carbon capture and storage—that could probably be deployed on a large scale (setting aside concerns about health and environmental effects and costs, as well as technological uncertainty about carbon capture and storage) and that could provide a reliable source of base-load generation. As noted in Chapter 1, the potential for large-scale deployment of renewable technologies is much more limited, because such technologies are typically well suited to only certain parts of the country and, in the case of wind and solar generation, are dependent on fluctuating conditions.

Effects on Prices for Electricity

Either an RES or a CES would raise the overall cost of producing electricity in the United States. Without such a standard, generators in competitive electricity markets would choose the mix of sources that maximized their profits, and in regulated markets, regulators would tend to require a mix that minimized the cost of electricity production. An RES or CES would induce them to alter that mix and produce electricity in a more costly manner (not accounting for any environmental or other benefits of changing the mix).

6. See Alan J. Krupnick and others, *Toward a New National Energy Policy: Assessing the Options* (National Energy Policy Institute and Resources for the Future, November 2010), p. 99, http://nepinstitute.org/publications/toward-a-new-national-energy-policy-assessing-the-options/.

7. Some studies suggest that renewable electricity standards would be more likely to reduce use of natural gas than of coal. See Krupnick and others, *Toward a New National Energy Policy,* p. 100; and Carolyn Fischer and Louis Preonas, "Combining Policies for Renewable Energy: Is the Whole Less Than the Sum of the Parts?" *International Review of Environmental and Resource Economics,* vol. 4, no. 1 (June 2010), pp. 51–92.

Factors Affecting Electricity Prices in Different Areas

The change in the generation mix prompted by an RES or CES, and the fact that utilities would have to buy (or in some cases could sell) credits, would alter electricity prices throughout the country. Regional price changes would depend on changes in regional production costs, the amount of electricity and credit revenue flowing into and out of regions, and the manner in which prices were determined in each location.

The majority of states have regulated electricity markets (known as "cost-of-service" markets). In those areas, policy-induced changes in electricity prices would reflect changes in the average cost of producing electricity in the region as well as purchases and sales of credits. Prices would go up in regulated areas if average production costs increased because of generators' efforts to use qualifying sources to meet the region's compliance obligations or if the region became a net purchaser of credits. Prices could fall in a regulated region if it became a net seller of credits. For example, electricity prices could fall in a regulated market under a 25 percent RES if, before the policy, 30 percent of the region's electricity came from wind. In that case, existing wind generators would be able to sell more credits than the region would need to comply with the policy, and the revenue from the additional sales would be passed on to electricity customers in the form of lower prices.

Electricity prices could also rise or fall in the 14 states that have restructured their markets to give consumers access to competitive interstate electricity markets. Electricity prices in those competitive markets reflect the cost of the "marginal" supply of electricity (that is, the incremental cost of the most expensive generation used to meet demand). In those markets, the effects of an RES or CES on retail electricity prices would depend on how the increased reliance on renewable sources affected the incremental cost of the marginal supplier. Average costs would be higher with a standard, but those averages could include high fixed costs and low variable (and thus, low incremental or marginal) costs for some generation sources. Thus, prices based on marginal costs could either rise or fall in competitive electricity markets under an RES or CES.

If a standard caused electricity prices to rise in a region, the costs of the policy would be borne by local consumers of electricity; but if prices fell in a region, the costs would be borne by electricity producers in that region or by consumers in *other* regions (areas that were net buyers of credits would subsidize production in areas that were net sellers of credits). Costs would tend to be borne by producers in places where wholesale electricity prices were set in competitive markets and where the policy altered the generation mix in such a way that the marginal cost of producing electricity in the region declined. That outcome was predicted for the Northeast under both of the 20 percent RESs analyzed using the Haiku model: Additional wind generation was predicted to displace natural-gas-fired generation there, causing the marginal cost of producing electricity in the region to fall.

Although producers could bear the costs of a reduction in prices in a region for some time (until existing plants were retired), such an outcome could not be sustained over the very long run. Policy-induced decreases in electricity prices in a region would cause the value of existing capital for nonqualifying generation to decline, because the present value of the anticipated revenue from using that capital stock would be lower. That decline in value would cause less new capital to enter the industry and could cause existing capital to be retired sooner than it would be otherwise. Having less generating capacity, in turn, would decrease the supply of electricity and eventually lead to higher electricity prices. Thus, consumers would bear the costs of meeting the standard in the very long run.

Results of Specific Analyses

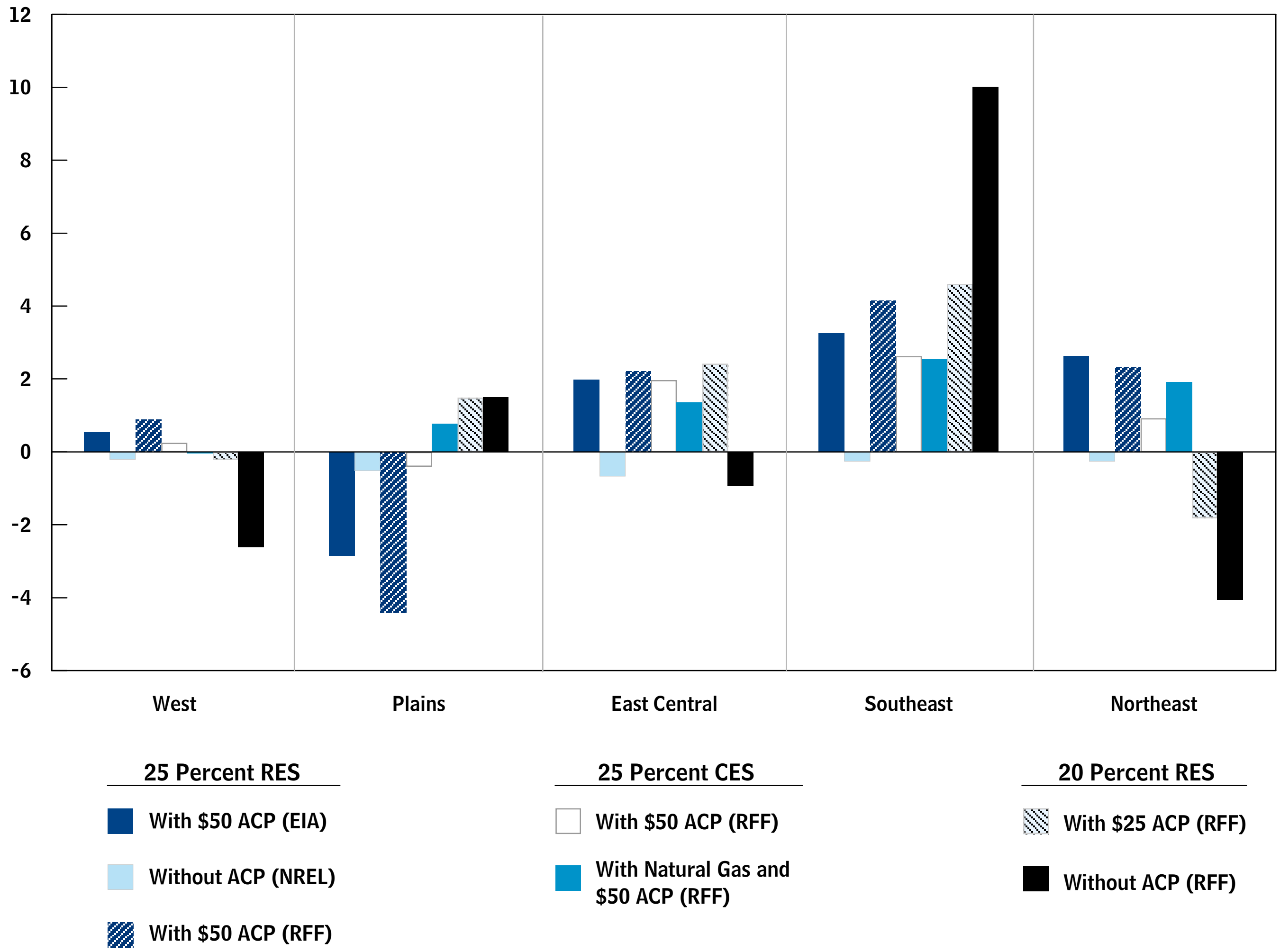
All of the analyses that CBO examined reported policy-induced changes in retail electricity prices; however, they reported the changes for different years and different geographic areas. For purposes of comparison, CBO looked at average changes in retail electricity prices between 2020 and 2030—the period when most of the policies would have the largest impact on prices—and mapped the price results into the five regions used above to compare the estimated effects of policies on the sources and locations of electricity generation (see Figure 2-1 on page 19).

The RES and CES policies examined in this study tended to produce small increases in average retail electricity prices in the United States. Those price effects varied significantly, however, among models and policies. For example, the two 25 percent RES policies modeled by EIA and RFF and the 25 percent CES that excluded natural gas were predicted to reduce electricity prices in the

Figure 2-5.

Average Change in Electricity Prices Between 2020 and 2030, by Region, Under Seven Potential Federal Electricity Standards

(Percentage change)



Source: Congressional Budget Office based on analyses by the Energy Information Administration (EIA), the National Renewable Energy Laboratory (NREL), and Resources for the Future (RFF).

Notes: RES = renewable electricity standard; ACP = alternative compliance payment; CES = clean electricity standard.

The regions used in this figure correspond to those shown in Figure 2-1 on page 19. For more information about the seven electricity standards analyzed, see Table 2-1 on page 16.

Plains region but to increase prices in the other four regions (see Figure 2-5). Including natural gas as a qualifying source in the CES caused electricity prices to be virtually unchanged in the West but led to higher prices in the four remaining regions, including the Plains.

The two 20 percent RES policies (with and without an ACP) modeled using Haiku produced their largest price increases in the Southeast and their largest price decreases in the Northeast. Including the ACP significantly dampened the price changes that would otherwise result from that policy.

The 25 percent RES modeled by NREL using ReEDS produced very small decreases in electricity prices in all five regions. As described above, the ReEDS model projected more renewable generation in the baseline than other models did and thus required less change in the generation mix—and less additional cost—to meet any particular standard. That lower additional cost, however, does not explain ReEDS's projection of price declines in all regions. Prices would drop everywhere only if producers, rather than consumers, bore the cost of the policy. But as noted above, such losses would manifest themselves as a reduction in the value of existing capital in the electricity-generating sector and would ultimately decrease the amount of generating capacity. That decrease, in turn, would eventually cause prices to rise, meaning that the cost of the policy would ultimately be borne by electricity consumers.

The large variation in price changes found by different models and for different policies indicates the substantial uncertainty about regional price effects. The price changes predicted for a given policy in a given area are highly dependent on the baseline generation mix projected for that area, the investment in qualifying sources that takes place, and the manner in which prices are determined. Thus, although the price effects of any given RES or CES will inevitably vary among regions, the pattern of that variation is difficult to predict with certainty.

Interaction of a Federal Standard with Existing State Standards

The wide variety of renewable and clean electricity standards that exist at the state level make it harder to assess the impact of imposing a federal RES or CES. Moreover, enacting a federal standard would alter the effects of states' policies. The combined effects of federal and state standards would depend on details of all of the standards, such as whether a single MWh of renewable or other clean electricity generation could qualify for both a federal and a state credit. Because of the additional constraints that state standards could impose on the mix of qualifying generation, any desired increase in the overall percentage of electricity produced from renewable or other clean sources in the United States could be achieved at a lower cost through a well-designed federal standard than through a combination of a federal standard and numerous state standards.

Effects on the Total Amount of Qualifying Generation

If a federal RES or CES existed alongside current state standards, a central question in predicting the impact on the total amount of renewable or clean electricity generation is whether the policies would overlap (so the same unit of power generation could be used to comply with both standards) or whether they would be cumulative (so more qualifying generation would be needed to satisfy both policies).

If the same MWh of qualifying electricity generation could be used to comply with both a federal and a state standard, the total amount of renewable or clean generation in the United States would be determined by either the combined effect of the state standards or by the federal standard—whichever was more stringent. That situation would arise if state governments and the federal government operated their own programs, issuing their own credits and monitoring compliance with their particular standard. That approach would allow both levels of government to define their own program rules and to ensure their own standards for monitoring and enforcement; however, it would entail duplicative administrative and enforcement efforts.

If, by contrast, a MWh of qualifying generation could not be used to comply with both the federal standard and a state standard, total renewable or clean generation nationwide would be greater than either the amount required by the federal standard or the aggregate amount mandated by state standards. That situation would arise if state-issued credits could be used only to comply with state programs and federal-issued credits only with the federal program, and if each qualifying MWh of electricity could be issued a credit under either program but not both. For example, if utilities in Nevada simultaneously had to comply with that state's 15 percent RES and a 5 percent federal RES in 2015, and if they could not use the same unit of renewable generation to meet both standards, they would have to obtain enough credits to cover 20 percent of their electricity sales, a percentage greater than either the state or the federal RES.

The existence of numerous state standards makes it more difficult to predict not only the total amount of qualifying generation that would occur in the absence of a federal policy but also the incremental increase in such generation that a federal RES or CES would bring about. As discussed above, the renewable or clean generation induced by state standards is typically built into baseline projections of the mix of generation that would occur in the absence of a federal RES or CES. That baseline is thus heavily dependent on state policies that may change over time. More-stringent state standards diminish the incremental impact of any particular federal standard.

Effects on Credit Prices

State standards that motivate more renewable or clean generation in a state than would have occurred in the absence of those standards would tend to lower the price of a federal credit and the cost of complying with the federal program, provided that a single MWh of generation could qualify for credits under both programs. In essence, each MWh of renewable or other clean electricity that is generated in a state as a result of the state's standard simultaneously would produce a credit for use in the federal program at no additional cost. That "free" credit would lower the cost of meeting the federal standard and the price of credits traded in the federal program—but only because the cost of producing that credit would be attributed to the cost of meeting the state program and be reflected in the price of state credits.

Just as the existence of state programs would affect the price of credits traded in a federal program, enactment of a federal program would affect the price of credits traded in state programs. For example, if a federal standard induced more qualifying generation in a particular state than required under the state standard, the federal program would drive down the price of that state's credits to zero.

Effects on the Overall Cost of Increasing Renewable or Clean Generation

Regardless of what increase policymakers wanted to achieve in the share of U.S. electricity generated from renewable or other clean sources, it would cost less to produce that increase with an appropriately designed federal standard than with a combination of federal and state standards. By itself, a federal standard would create a national credit-trading program that would allow market forces to determine where and how investments in qualifying sources of electricity generation would occur. The existence of state standards, however, would constrain that mix, potentially forcing higher-cost generation to be used for compliance than would otherwise be the case.

CHAPTER

3

Considerations in Designing a Cost-Effective Renewable or Clean Electricity Standard

The overall cost of meeting a renewable or clean electricity standard cannot be known with certainty, but policymakers could help minimize those costs by adding various design features, such as allowing credits to be traded freely among interested parties, letting as many energy sources as possible generate credits, gradually phasing in the standard, and permitting utilities to shift credits between years through banking and borrowing. The seven analyses that the Congressional Budget Office examined in Chapter 2 assumed that credits could be traded and that a wide variety of sources, but not all potential sources, would be allowed to generate credits. (For example, none of the analyses assumed that electricity generated by existing natural-gas-fired plants would be eligible for partial credits.) Finally, all of the policies analyzed assumed that the standards would be phased in gradually but that firms would not be allowed to bank or borrow credits.

If the objective is to reduce carbon dioxide emissions, a program in which the government set a nationwide cap on such emissions and created tradable emissions allowances could offer a lower-cost method of achieving that goal than either an RES or a CES (see Box 3-1). Such a cap-and-trade program could be more comprehensive than an electricity standard. It would also provide a direct incentive to curb CO_2 emissions in many different ways, could motivate low-cost reductions throughout the entire economy, and could guarantee that emissions stayed below a defined level. By contrast, an RES or CES would provide direct encouragement for the use of renewable or other clean energy sources, but CO_2 emissions would be reduced only as a by-product of utilities' compliance with the standard.

Effects of Credit Trading on Costs

Because opportunities for expanding renewable and clean electricity generation vary greatly among regions, credit trading would enable the nation to meet an RES or CES by using the lowest-cost opportunities. (That variation reflects, among other things, differences in the availability of renewable resources and the need for additional generating capacity.)

As a further step, allowing entities other than generators and utilities—such as financial firms—to trade credits could provide substantial cost savings. Having a broader range of participants would increase the liquidity of the market for credits, making it easier for utilities and generators to identify other parties with whom to trade and to complete large transactions without affecting the market price of credits. Another benefit of broad participation would be to improve the quality of the information underlying credit prices. Like traders in any market, active credit traders would have a financial incentive to study the market and the industries underpinning it, because their profits from providing liquidity would depend on their ability to forecast the future price of credits. As a result, those traders would bring to the bargaining table up-to-date information about the factors that would determine credit prices, such as the demand for electricity and the cost of adding qualifying generation.

Allowing a wide variety of entities to trade credits would be likely to spawn a market for credit derivatives—financial contracts whose value would depend on the future price of credits. Utilities, electricity generators, and other participants in the credit market could use derivatives to protect themselves from changes in prices (just as farmers use derivatives on agricultural commodities to lock in prices for their crops before the crops are harvested or

Box 3-1.

The Cap-and-Trade Alternative for Decreasing CO_2 Emissions

Neither a renewable electricity standard (RES) nor a clean electricity standard (CES) could achieve a desired reduction in carbon dioxide (CO_2) emissions at as low a cost as a "cap-and-trade" program could. Under such a program, the federal government would set increasingly tight annual limits on greenhouse gas emissions (including CO_2, the primary greenhouse gas emitted as a result of human activity) over the course of several decades. The government would distribute rights (or allowances) for those emissions by either selling them, possibly in an auction, or by giving them away. Companies that would be subject to the cap—such as electricity generators, oil importers, and natural gas producers—would be permitted to buy and sell allowances after the initial distribution. They could also shift allowances over time to some degree by "banking" unused allowances for future use or by "borrowing" allowances designated to permit emissions in future years. The price of allowances would rise to the level necessary to ensure that the limit on cumulative emissions over the life of the policy (implied by the annual caps) was met.

A federal cap-and-trade program has been operating in the United States since 1995 to limit emissions that cause acid rain, and the European Union and a number of U.S. states have implemented cap-and-trade programs to curb greenhouse gas emissions.[1] The 111th Congress debated, but did not pass, a federal cap-and-trade program for greenhouse gas emissions.[2]

A cap-and-trade program could cover the whole economy, or it could be limited to the electricity sector. The wider the coverage, the more cost-effective the policy would be. Even a cap-and-trade program that was limited to the electricity sector could achieve a given reduction in CO_2 emissions at a lower cost than an RES or CES could. A cap-and-trade program that covered the entire economy could achieve that cut at an even smaller cost.

The main advantage of a cap-and-trade program over an electricity standard is that it could provide a direct and comprehensive incentive to decrease the CO_2 emissions caused by burning fossil fuels. An economywide cap-and-trade program would cause the price of all goods and services to rise in proportion to the amount of emissions associated with their production and use. As a result, companies and

1. For more about the U.S. cap-and-trade program for emissions that cause acid rain, see Dallas Burtraw and others, "Economics of Pollution Trading for SO^2 and NOx," *Annual Review of Environment and Resources*, vol. 30 (2005), pp. 253–289. For a discussion of the European cap-and-trade program, see A.D. Ellerman and P. Joskow, *The European Union's CO_2 Cap-and-Trade System in Perspective* (Pew Center on Global Climate Change, 2008).

2. For more details of how a federal cap-and-trade program for CO_2 emissions might work, see Congressional Budget Office, *The Economic Effects of Legislation to Reduce Greenhouse-Gas Emissions* (September 2009) and *Issues in the Design of a Cap-and-Trade Program for Carbon Emissions* (November 2003).

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even planted). The availability of derivatives would lower a utility's compliance costs by giving it a relatively low cost and convenient way to reduce uncertainty about the cost of acquiring credits in the future. In the absence of derivatives, utilities' main option for avoiding that uncertainty would be to buy and hold large amounts of credits themselves.

At the same time, observers worry that permitting third parties to trade credits and allowing the use of derivatives could foster complex or opaque transactions, price bubbles, market manipulation, or other instabilities that could raise the cost of complying with the standard and harm the broader economy. In the case of a proposed national cap-and-trade program, that potential spurred calls to prohibit or otherwise limit certain types of market participants or transactions. An earlier CBO analysis of such proposals concluded that less restrictive limits would generally have a greater chance of addressing observers'

Box 3-1. Continued

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households throughout the economy would have an incentive to take actions that cut emissions. For example, electricity generators would have an incentive to make efficiency improvements to their boilers, switch to low-emitting fuels, and conserve energy in the operation of their facilities (such as by installing more-efficient lighting). Households, manufacturers, businesses, government agencies, and other entities would face a similar incentive: They would save money by altering their production and consumption in ways that reduced emissions, including by driving less or purchasing vehicles that have greater fuel efficiency. (Such activities would decrease the use of fossil fuels in the transportation sector, which emits about 40 percent of all CO_2 emitted in the United States.) Besides being direct and comprehensive, the incentive that entities faced to change their production processes or consumption patterns would be directly proportional to the cut in emissions that those changes would bring about. Finally, a cap-and-trade program could ensure that emissions remained below a desired level.

In contrast, the incentive to reduce CO_2 emissions that would result from an RES or CES would be neither comprehensive nor direct. An electricity standard would provide a direct economic incentive to increase generation from renewable or other clean energy sources; CO_2 emissions would be reduced only as a by-product of achieving that goal, and the scale of the reduction would be uncertain.

Moreover, the design of an RES or CES would determine the extent to which the size of the incentive to produce electricity from qualifying sources (rather than nonqualifying ones) was linked to the size of the cut in emissions that such a change would bring about. A policy in which a wide variety of sources qualified for credits and in which the amount of credits was related to a source's CO_2 emissions would more closely align financial incentives with actual cuts in emissions than would a policy lacking those design characteristics. For example, if a CES included partial credits for both existing and new natural-gas-fired generation, generators would receive a larger financial reward if they substituted a megawatt hour of emission-free generation for a megawatt hour of generation from a high-emitting source, such as coal, than from a low-emitting source, such as natural gas. The former substitution would result in nearly twice the emission reductions as the latter.

Even in a comprehensive CES, however, financial incentives and emission cuts could be aligned only imperfectly. Although regulators could assign credits on the basis of a given technology's average emissions, actual performance (and thus emissions) would vary around those averages. Further, regulators would need to update the amount of credits awarded for various technologies as the technologies changed over time.

concerns, with fewer negative effects, than outright prohibitions would.[1]

Effects of Maximizing Compliance Options on Costs

A CES could bring about any specified reduction in CO_2 emissions at a lower cost than an RES would: By allowing a wider set of qualifying sources of electricity, it would provide more options for reducing emissions. If technologies that emit significant amounts of CO_2 were included as qualifying sources, the credits that each type of generation earned per megawatt hour could be adjusted to account for the differences in emissions. Such weighting would help induce cost-effective cuts in CO_2 emissions because it would provide the largest financial incentive for generators to rely on sources with the lowest emissions. For example, if the price of a credit was $20, each MWh of electricity produced at new nuclear plants, which do not emit any CO_2, could receive a full credit,

1. See Congressional Budget Office, *Evaluating Limits on Participation and Transactions in Markets for Emissions Allowances* (December 2010).

worth \$20, whereas each MWh of electricity produced at a new natural-gas-fired plant, which emits about half as much CO_2 as electricity generated by coal, could receive a half credit, worth \$10. As a result, all else being equal, generators would be more likely to build a new nuclear plant (earning \$20 in credit revenue for each MWh of electricity it produced) than a new natural gas plant (earning only \$10 in credit revenue for each MWh of electricity it produced).

Another way to increase compliance options would be to award credits for qualified electricity savings (cuts in electricity use that result from efficiency improvements that would not have occurred in the absence of the policy). Some of the electricity standards proposed in the 111th Congress would have let utilities, generators, and other entities obtain credits for qualified improvements in energy efficiency.

In theory, allowing efficiency improvements to earn credits could decrease the cost of both complying with a CES and reducing CO_2 emissions. Because such improvements reduce the total amount of electricity generated, they would lessen the increase in qualifying generation that would be necessary to meet the standard. (In other words, electricity savings would shrink the base to which the standard was applied.) Further, some energy-efficiency improvements would represent low-cost ways of cutting CO_2 emissions.

In practice, however, measuring the amount of energy saved through an efficiency improvement and ascertaining that the savings would not have happened in the absence of the policy could pose administrative challenges.[2] Calculating how much energy was saved because of an efficiency improvement would require determining a baseline measure of the energy consumption that would have occurred without the efficiency upgrade. Under some Congressional proposals, qualifying energy-efficiency credits would be determined by comparing a facility's energy use before and after an efficiency improvement (for example, comparing the electricity consumption at a facility that installed more-efficient lighting with its average electricity consumption in the five years before the improvement) or, in the case of a generating plant, by comparing the amount of fossil fuel used to produce a kilowatt hour of electricity before and after a facility upgrade.[3]

Even if such energy savings could be measured accurately, it would be hard to gauge whether generators and utilities would have made such improvements in the absence of the program—that is, whether the energy savings were truly "additional" or whether entities were receiving credits for improvements they would have found it profitable to make anyway. By allowing utilities to submit energy-efficiency credits in lieu of credits earned by generating clean or renewable electricity, policymakers essentially would be agreeing to a relaxation of the CES or RES in return for a reduction in either the consumption of electricity (as in the case of the replacement lighting) or the emissions per MWh of electricity generated from a given source (as in the case of the facility upgrade). But if the activities generating the energy-efficiency credits would have been undertaken even in the absence of the policy, awarding credits for them would result in a relaxation of the standard but not yield a return. (In contrast, in the absence of energy-efficiency credits, the standard would be met regardless of whether generators would have found it profitable to install wind or biomass generation without a standard.) For all of those reasons, allowing energy efficiency to earn credits might undermine the credibility of the standard and could increase the net cost of implementing an RES or CES despite the two types of cost savings noted above.

Effects of Timing on Costs

An RES or CES would be less expensive to meet if it was phased in gradually and then held constant at the desired level for a long period. Gradually phasing in the standard would increase the extent to which generators could comply through substituting new qualifying generating capacity for their planned replacements or expansions of nonqualifying capacity. In contrast, compliance costs would be higher if the standard was phased in so quickly that generators did not have time to recoup their investments in existing capital. Signaling credibly that the policy would remain in place over a period of several decades would make it easier to finance a renewable or clean generating facility by providing a degree of certainty

2. Similar challenges would arise in the determination of qualifying "offsets" under a cap-and-trade program; see Congressional Budget Office, *The Use of Offsets to Reduce Greenhouse Gases,* Issue Brief (August 2009).

3. Those approaches were included in the Renewable Electricity Promotion Act of 2010 (S. 3813) and the Practical Energy and Climate Plan Act of 2010 (S. 3464).

about how long the facility would receive credits. Again, in contrast, if the policy was not expected to persist well into the future, the cost of adding qualifying capacity would be high because generators would expect that they could obtain credits for only a few years. Providing certainty about the policy for an extended period would also let utilities enter into long-term contracts with generators for purchases of electricity and credits.[4]

Allowing utilities to bank and borrow credits would affect the rate at which the amount of qualifying generation grew by letting utilities tailor the timing of their compliance to the actual cost of increasing qualifying generation. Banking would lower costs by allowing companies to save excess credits obtained in years when renewable or clean generation exceeded the amount needed to meet the standard and then use the credits in later years. Borrowing credits expected to be earned in the future could be helpful in lowering compliance costs if it prevented the need for existing generating facilities to be retired prematurely. The standard would not ultimately be met, however, if firms that borrowed credits declared bankruptcy and the borrowed credits were never repaid. Policymakers could reduce that possibility by restricting the number of credits that utilities could borrow—to 10 percent of their compliance obligation, for example—and by limiting how far in advance credits could be borrowed.

In essence, phasing in a standard would let policymakers balance the desire to change the generation mix quickly with the fact that faster changes entail higher costs. The cost side of that trade-off would be based on projections of future conditions. Giving firms the ability to bank and borrow credits would let them modify the time path selected by policymakers. Those modifications would be based on unfolding information about the cost of changing the generation mix at various points in time.

4. See Ryan Wiser and others, "The Experience with Renewable Portfolio Standards in the United States," *Electricity Journal,* vol. 20, no. 4 (May 2007), pp. 8–20.