



**Union of
Concerned
Scientists**

A Bright Future for the
Heartland



POWERING THE MIDWEST ECONOMY WITH CLEAN ENERGY

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Chapter 1. Vision for a Clean Electricity Future in the Midwest

From the manufacturing centers, to the corn and soybean fields, to the major finance hubs, to the leading research universities, Midwest states have long served as an economic engine for the United States. Yet the region is still struggling to fully recover from a recession that has made it difficult for families to pay bills and for businesses to prosper and sustain job growth.

At the same time, the Midwest's energy system is not sustainable. The region's electricity supply is dominated by coal—largely imported from outside the region—which poses serious risks to public health and the environment, and leaves consumers vulnerable to price increases.

Practical and affordable solutions are available to help revitalize the Midwest economy and ensure a clean, safe, and reliable power supply. Energy efficiency technologies and renewable electricity resources, such as wind, biopower, and solar, offer a smart and responsible transition away from polluting fossil fuels to the new innovation-based economy of the twenty-first century. Investing in a clean energy economy can help spur entrepreneurship, create jobs, and keep the Midwest globally competitive, while enabling it to move toward greater energy independence and conserve resources for future generations.

The threat of rapid climate change adds urgency to this transition. Climate change is driven primarily by a buildup in the atmosphere of heat-trapping emissions from burning fossil fuels and other human activities. Failure to reduce these emissions will have significant consequences for the Midwest, including scorching summers, dangerous storms, more severe flooding, and greater stress on agriculture (Hayhoe et al. 2009). The Midwest is one of the biggest U.S. contributors to global warming pollution, with just 22 percent of the nation's population accounting for 27 percent of its heat-trapping emissions (Mackun and Wilson 2011; World Resources Institute 2011).¹

Fortunately, the region is home to some of the best renewable resources in the world, particularly wind and biomass. It also has a world-class manufacturing base and a skilled labor force that can support and benefit from the deployment of renewable energy and energy efficiency technologies. This gives the Midwest the unique ability to turn a challenge into an opportunity to spur economic growth and become a leader in the clean energy sector while reducing global warming emissions.

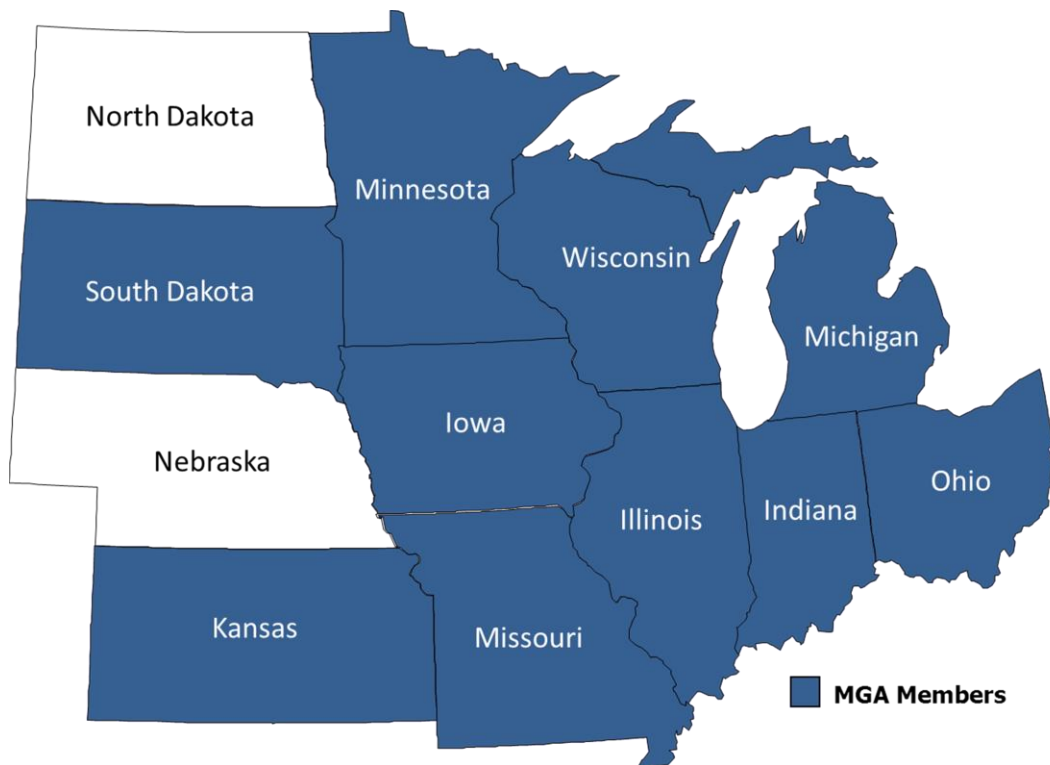
¹ This total for the Midwest includes the nine states that we included in our analysis (Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota, and Wisconsin), plus Kansas, Nebraska, and Missouri, which are often included in definitions of the Midwest.

The nine states included in our analysis account for 22 percent of total U.S. global warming emissions, and 4 percent of the world total. These states are part of the two independent transmission system operators in the Midwest: the Midwest Independent System Operator (Midwest ISO) and PJM. Unless otherwise noted, throughout this report "Midwest" means these states.

Midwest states can and must accomplish the transition to a robust and clean energy economy. *A Bright Future for the Heartland* focuses on the electricity sector, and assesses the economic and technological feasibility of achieving the recommendations of the Midwestern Governors Association (MGA), a collaboration of 10 states working on key public policy issues (Figure 1.1). The MGA’s targets include reducing electricity use by 2 percent annually by 2015 and thereafter, and supplying 30 percent of the region’s electricity from renewable sources by 2030 (MGA 2009).

Figure 1.1. States Participating in the Midwestern Governors Association

The Midwestern Governors Association (MGA) is a collaboration of 10 states working on key public policy issues. The MGA’s Energy Roadmap targets include reducing electricity use by 2 percent annually by 2015 and thereafter, and supplying 30 percent of the region’s electricity from renewable sources by 2030.



The Union of Concerned Scientists (UCS) focused on the nine Midwest states—Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota and Wisconsin—covered by the Midwest ISO and PJM, the region’s two independent transmission system operators. We analyzed electricity use and trends in the region, as well as energy technologies, policy initiatives, and sources of emissions, to develop a comprehensive course of action for affordably and effectively meeting the MGA goals. *A*

Bright Future for the Heartland provides a path for reducing dependence on fossil fuels from the electricity sector, revitalizing local and regional economies, and cutting heat-trapping emissions and other pollutants.

The Energy Roadmap of the Midwestern Governors Association

In 2009, an MGA Advisory Group released the *Midwestern Energy Security and Climate Stewardship Roadmap* (Energy Roadmap), which recommends targets for renewable energy and energy efficiency for the region's electricity system (MGA 2009):

- Midwest utilities will rely on wind, biopower, solar, and other renewable energy sources to generate 10 percent of their electricity by 2015, and 30 percent by 2030.
- Retail power providers will rely on improvements in energy efficiency to reduce annual sales of electricity by at least 2 percent annually by 2015 and thereafter.

Our analysis focuses on these two high-priority recommendations, which we model as a renewable electricity standard (RES) and an energy efficiency resource standard (EERS). An RES is a flexible, market-based policy that requires electricity providers to gradually increase the amount of renewable energy used to produce the power they supply. An EERS similarly requires utilities to meet specific annual targets for reducing the use of electricity. While the region will need other policies to overcome specific market barriers to clean energy, the RES and EERS have proven to be effective and popular tools for advancing renewable energy and energy efficiency at the state level. As of April 2011, eight Midwest states had adopted an RES (among 29 states nationwide, plus Washington, DC). Five of those states also have an EERS (among 26 states nationwide). However, while these are important steps, most Midwest states must go further to reach the targets established by the Energy Roadmap.

Many of the region's governors are newly elected, and therefore did not help develop those targets. However, a diverse group of bipartisan stakeholders crafted them to address the serious risks to public health and the environment of the region's existing power system.

The MGA Targets Create Jobs, Save Consumers Money, and Cut Climate Change Emissions

We used a dynamic energy forecasting model to examine the effects of the renewable energy and energy efficiency targets in the Energy Roadmap on the Midwest economy and environment through 2030.² We modeled several scenarios to analyze how to meet the targets under a range of conditions and available technologies. Our findings show that investing in clean energy is a smart and responsible course that will help Midwest revitalize their economies while leaving future generations with a clean, reliable, and sustainable power supply.

Meeting the MGA's renewable energy and energy efficiency targets would spur innovation, inject capital into the regional economy, and create tens of thousands of jobs in big cities, small towns, and rural communities across the Midwest. Cuts in power use and downward pressure on electricity prices stemming from gains in energy efficiency and competition from renewables would provide families and businesses much-needed savings on energy bills. Tapping the Midwest's wealth of wind, biopower, solar, and efficiency resources would diversify the power supply, making it more reliable and secure. That path would also move the region away from its overdependence on coal, which would improve public health and reduce the dangers of global warming.

While this report focuses on the transition to a low-carbon electricity sector, it does not include every step the Midwest must take to address climate change. That will require the participation and cooperation of local, state, regional, federal, and international leaders. Under such a partnership, state and regional leaders can push for comprehensive federal legislation while also enacting policies that can reduce emissions and spur innovation and clean energy economic development in the Midwest.

Chapter 2 explores major renewable energy and energy efficiency solutions available today, identifying their potential, challenges in reaching widespread use, and the policy approaches that can help overcome those challenges. Chapter 3 explains our modeling approach and major assumptions. Chapter 4 presents the overall results of our analysis, and Chapter 5 provides recommendations to policy makers and other stakeholders.

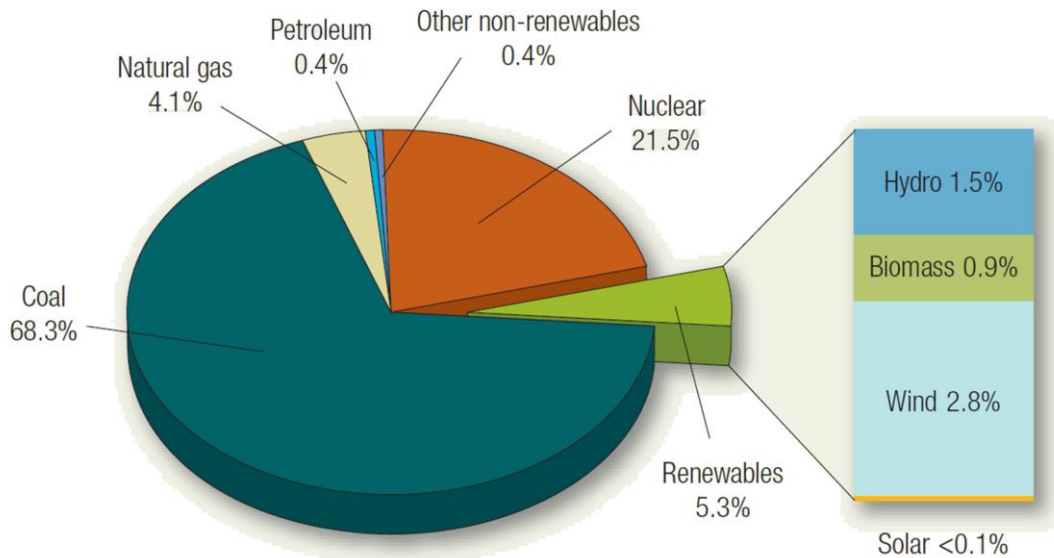
Our report also includes fact sheets showing key findings for each state, as well as a Technical Appendix that allows readers to delve more deeply into our methods, assumptions, and results. All materials are available online at www.ucsusa.org/brightfuture.

Chapter 2. Opportunities and Challenges for Renewable Energy, Energy Efficiency, and Other Low-Carbon Technologies in the Midwest

Coal now dominates the Midwest power supply, accounting for 68 percent of the region's electricity generation (Figure 2.1). Midwest states depend far more on coal than the nation as a whole—about 45 percent of U.S. electricity comes from this polluting fossil fuel—and the region must import much of its coal supply.

Figure 2.1. Sources of Midwest Electricity, 2009

Most of the electricity in the Midwest comes from coal, the majority of which is imported from outside the region.



Source: EIA 2010c.

Note: Includes electricity generated in the Midwest that serves other regions.

In 2008, Midwest states imported 190 million tons of coal from outside of the region—63 percent of their total coal use—at a cost of \$7.5 billion. Every state in the Midwest was a net importer of coal that year, and seven states had to import all or nearly all the coal their power plants burned (Deyette and Freese 2010). Coal-burning power plants in the Midwest are the single-largest source of carbon emissions in the region: they account for

44 percent of the region's emissions, and 10 percent of total U.S. carbon emissions (EIA 2010a).

Midwest states could greatly reduce their reliance on coal to generate electricity by moving to renewable resources such as wind, sustainable forms of biopower, and solar. These homegrown energy sources are widely available in the Midwest, and ready to be deployed today. They are also increasingly cost-effective for producing electricity (Freese et al. 2011; Goossens 2011), and they create jobs while reducing pollution (UCS 2009b).

Midwest states also have the potential to reduce electricity use by improving the energy efficiency of their buildings and industries (Stratton and York 2009). This chapter describes the current status and future prospects for using local renewable energy and energy efficiency to provide a growing share of the Midwest's electricity needs.

Renewable Energy Technologies and Their Potential in the Midwest

The Midwest is rich in renewable energy resources. Wind, solar, and biopower together have the technical potential to generate more than 18 times the amount of electricity the Midwest needs today.³

Economic, physical, and environmental limitations mean that not all of that potential can be tapped. Issues such as potential land-use conflicts; the higher short-term costs of some resources; constraints on ramping up their use, such as limits on transmission capacity; barriers to public acceptance; and other hurdles place limits on how much of this resource the Midwest can tap over the short and medium term. However, after accounting for many of these factors in our analysis, we find that renewable energy can provide a significant share of the Midwest's current and future electricity needs.

More than 20 comprehensive analyses over the past decade have found that using renewable sources to provide at least 25 percent of U.S. electricity needs is both achievable and affordable (Nogee, Deyette, and Clemmer 2007). For example, a 2009 UCS analysis—using a modified version of the model we used in this study—found that a national renewable electricity standard of 25 percent would lower electricity and natural gas bills a cumulative \$15.2 billion in the Midwest by 2025, by reducing demand for fossil fuels and increasing competition among power producers (UCS 2009b).

A 2010 UCS analysis examining how the United States could reduce heat-trapping emissions by 80 percent by 2050 found that renewable energy could affordably and reliably supply 40 percent of the U.S. electricity mix by 2030—after reductions in energy demand stemming from energy efficiency and the use of combined-heat-and-power systems (Cleetus, Clemmer, and Friedman 2009). Other analyses have found that

³ Electricity use in the Midwest in 2009 totaled 678 billion kilowatt-hours (kWh). The Department of Energy estimates Midwest wind resource potential at 12,000 billion kWh (NREL 2010). UCS estimates regional biomass potential at 190 billion kWh (see the Technical Appendix for sources and methodology). An analysis of solar photovoltaics that considered only viable rooftop locations put available Midwest potential at more than 97 gigawatts (Paidipati et al. 2008)—enough to generate 120 billion kWh with today's technology (assuming 13.5 percent efficiency per module and a capacity factor of 14 percent).

expanding the share of renewable energy in the Midwest in line with the Energy Roadmap targets is feasible (ELPC 2001). In many of these analyses, Midwest states were key in deploying the renewable energy capacity needed to achieve those goals.

Wind Power

Wind turbines convert the force of moving air into electricity using lift to turn the blades. Wind power is one of the world's fastest-growing sources of electricity, having expanded by about 30 percent per year, on average, over the past decade (GWEC 2010). In the United States, developers added wind capacity at an average annual growth rate of 35 percent from 2005 to 2010, installing five times as much capacity during that period as in the previous 25 years.

By the end of 2010, wind installations with more than 40,000 megawatts (MW) of capacity were producing power in 38 states. More than one-third of that capacity (13,800 MW) is in the Midwest, where it provides enough electricity to power the equivalent of more than 3 million homes (AWEA 2011a). Nine of the 12 Midwest states rank in the top 20 nationwide for installed wind capacity (AWEA 2011c).⁴

Wind power has become one of the more cost-effective sources of electricity in the United States. The up-front costs of wind power are typically higher than those of conventional sources of electricity. However, low maintenance costs compared with most other power sources—and a lack of fuel costs—mean that the price of wind power while it is operating is relatively low and stable.

Technological advances and growing economies of scale have driven down wind costs by about 80 percent over the last three decades. U.S. prices for wind turbines did begin to rise in 2005 owing to global demand, higher costs for materials, and a weak U.S. dollar (Wiser and Bolinger 2010). However, the U.S. Department of Energy (DOE) found that prices for wind were roughly competitive with the overall cost of wholesale electricity from 2003 to 2009. In 2009, that cost was about 4.5 cents per kWh (Wiser and Bolinger 2010).⁵

Today the cost of wind turbines is once again declining, and as the nation's economy recovers, experts project that wind at good sites will continue to compete as a low-cost power option (Wiser and Bolinger 2010). Natural gas prices have declined sharply in the last two years, because of new technologies to extract gas from shale rock, reducing the economic competitiveness of wind in some locations.⁶ However, in the long-term, the

⁴ While developers have sited all U.S. wind projects on land through 2010, there has been some interest in developing offshore wind along the Eastern Seaboard and in the Great Lakes. However, the availability of low-cost wind on land, particularly in the Midwest, as well as uncertainty around several factors, including siting and permitting, has slowed U.S. progress (Wiser and Bolinger 2010). In the Midwest, at least one proposal—a 20-MW project on Lake Erie near Cleveland, Ohio, is moving forward (Gallucci 2011).

⁵ This cumulative capacity-weighted average price for wind power reflects the bundled price of electricity and renewable energy tax credits, including available state and federal incentives, as sold by project owners under a power purchase agreement. The average price includes price data for 180 wind projects installed from 1998 to 2009.

⁶ The average annual U.S. price for electricity from natural gas dropped from \$9.36 per thousand cubic feet in 2008 to \$5.26 per thousand cubic feet in 2010 (EIA 2011b).

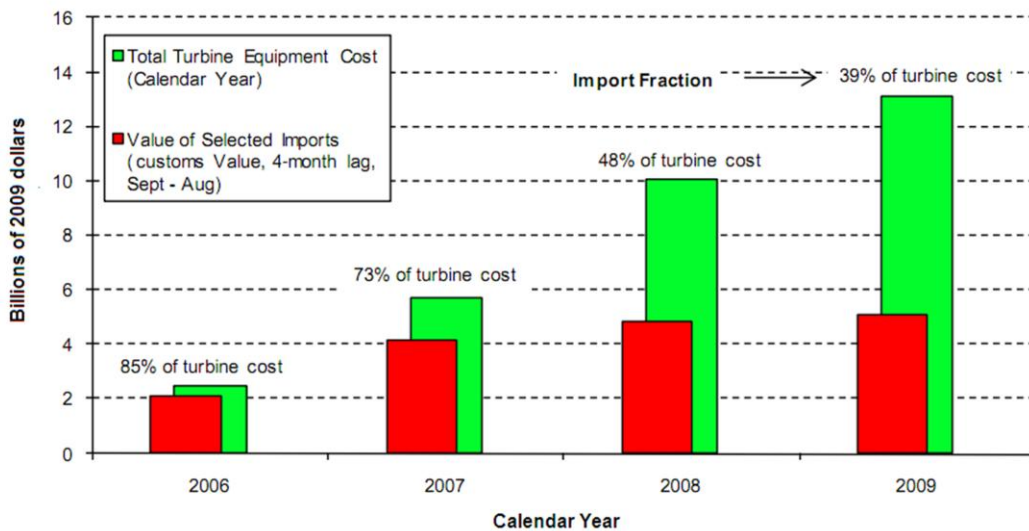
price stability of wind can allow utilities and their customers to hedge the price volatility associated with natural gas and other fossil fuels (Bolinger, Wiser, and Golove 2002).

Economic Benefits

Beyond its cost-competitiveness, wind power offers significant economic benefits for big cities and rural communities. For example, the wind industry has been a job creator even amid the recent struggles of the U.S. economy. According to the American Wind Energy Association, the industry employed roughly 85,000 full-time workers at the end of 2009—up from 35,000 in 2007. Those jobs included more than 18,000 in manufacturing, and many others in project development, construction, operations, maintenance, and financial, legal, and consulting services. In 2009, Midwest states had 30,000 to 50,000 jobs in the wind industry (AWEA 2011c).

Figure 2.2. Imports of Wind Power Equipment as a Fraction of Total Turbine Cost

U.S. investment in wind has increased over the last few years, and a growing percentage of the cost of this equipment is being built domestically.



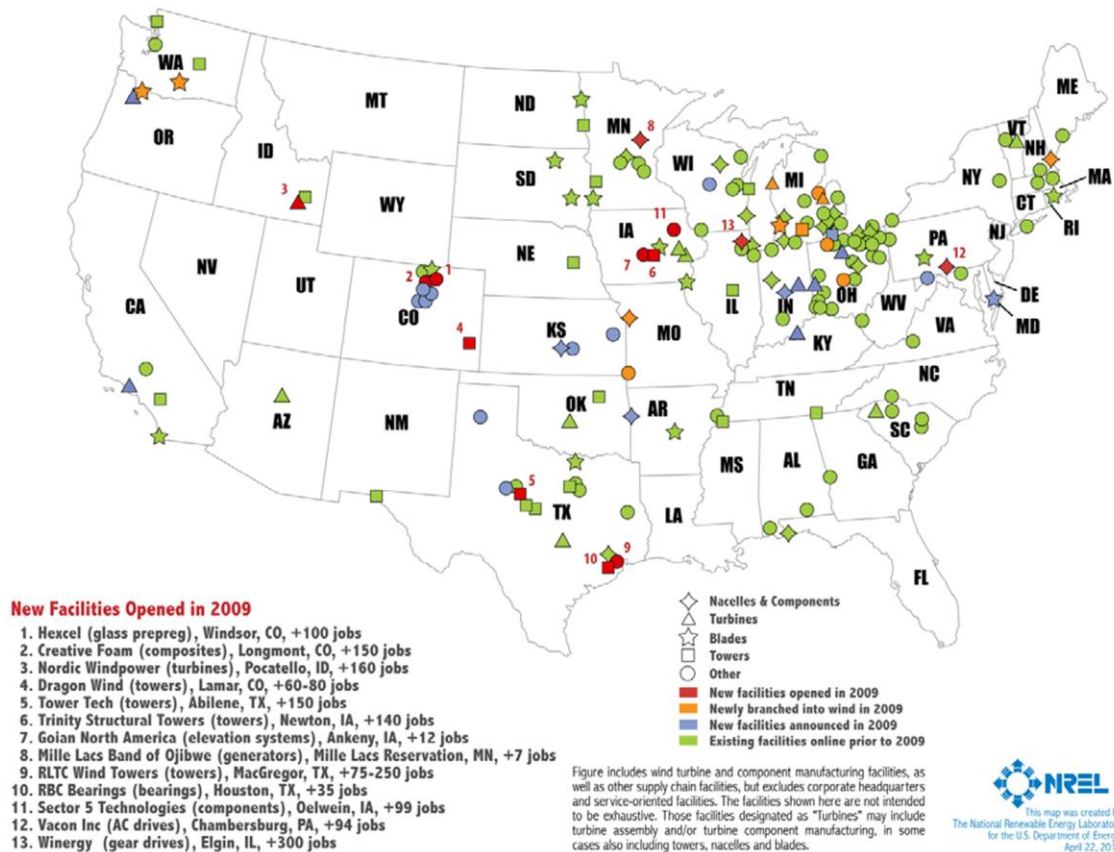
Source: NREL 2009.

As the U.S. wind industry grows, Midwest states can see continued job growth in wind equipment manufacturing. A single large-scale wind turbine includes more than 8,000 parts, ranging from small mechanical, structural, and electrical pieces to large components such as blades, towers, and gearboxes. A growing percentage of the cost of this equipment is being built domestically: about 60 percent in 2009, up from less than 20 percent in 2006 (Figure 2.2) (Wiser and Bolinger 2010). Total U.S. investment power project installation grew from \$3.8 billion to \$20 billion during that period (Wiser and

Bolinger 2010, 2007).⁷ More than 150 U.S. facilities now manufacture wind turbine equipment—many in the Midwest (Figure 2.3) (Wiser and Bolinger 2010).

Figure 2.3. Companies Participating in the Wind Industry Supply Chain, 2009

More than 150 U.S. facilities now manufacture wind turbine equipment—many of them in the Midwest.



Source: NREL 2009.

Wind power projects can also generate significant economic benefits to local communities where they are sited. Local governments gain property and income tax revenues and other payments from the owners of wind projects. And individual property owners such as farmers and ranchers often receive lease payments ranging from \$3,000 to \$6,000 per megawatt of wind capacity installed on their land, as well as payments for power line easements and road rights-of-way. In 2009, wind capacity in the Midwest contributed more than \$68 million in property taxes and \$35 million in annual land-lease payments (AWEA 2011c).

⁷ Converted to real 2007 dollars for comparison

Property owners may also earn production royalties based on a project's annual revenues. And landowners and other rural residents are increasingly becoming wind power owners and developers themselves, in an effort to maximize the investments and economic benefits that stay within the local community. Regardless of their form, these payments can provide a stable supplement to farmers' income, helping to offset swings in commodity prices (GAO 2004).

Key Challenges for Wind Power

Wind power has the potential to play a major role in meeting the renewable energy targets of the Energy Roadmap and helping the Midwest transition to a clean energy economy. To fully achieve that potential, several key challenges need to be addressed, including developing fair rules for siting wind facilities, addressing concerns about wind's effects on wildlife, integrating wind into the power grid, expanding the transmission system, and improving access to transmission (explored in Chapter 3).

Siting

As with any large project, the permitting process for siting a new wind power facility should review its impact on the local environment, community, economy, and public safety. The process should be transparent, taking into account the interests and rights of all stakeholders.

The process should also be consistent with permitting processes for comparable projects. Often, however, the process for obtaining the required approvals for wind power projects can be overly complex, costly, burdensome, and time consuming, which can deter investors and prevent high-quality projects from moving forward. Jurisdiction over the siting of energy facilities also varies greatly from state to state, in some cases involving numerous agencies in multiple levels of government.

Efforts are under way to streamline the approval process for wind energy and improve cooperation between local, state, and federal agencies while ensuring responsible development. In the meantime, wind developers must also take responsibility for being "good neighbors" when they seek to build in a community. State governments should also play an active role in ensuring that projects take into account the latest research on the technology and its impact on neighbors, and that best practices become the norm.

Wildlife

A wind project's ability to produce electricity without creating air or water pollution or global warming emissions offers significant benefits to the natural world, especially when compared with the use of fossil fuel. However, like all energy sources, wind power can have local effects on birds, bats, and other wildlife.

A recent review by the National Wind Coordinating Collaborative (NWCC) of peer-reviewed research found evidence of bird and bat deaths from collisions with wind towers, as well as habitat loss and disruption (NWCC 2010). Bats can also be killed by barotrauma, a phenomenon caused by rapid pressure changes as they fly close to turning blades. However, the NWCC concluded that the impact on birds and bats is relatively modest at the vast majority of locations, and does not pose a threat to species populations.

Over the last several decades, the wind industry has made great strides in reducing its impact on wildlife thanks to better research, technological advances, and lessons learned in siting. To help wind developers site and maintain wind farms with minimal impact on wildlife, the American Wind Wildlife Institute funds research on risk assessment and mitigation, and communicates significant advances. An advisory committee created by the U.S. Fish and Wildlife Service, composed of representatives from industry, state and tribal governments, and nonprofit organizations, has published recommendations for land-based wind projects, including a multistage decision-making framework for developers (FWS 2010).

Integrating Wind into the Power Grid

Wind power can play a substantial role in providing reliable electric service to consumers. The fact that the wind does not blow all the time does pose some challenges to integrating this source of power into the electricity grid, but they are not insurmountable.

Operators of our nation's electricity grid must continually adjust to changing consumer demand, ramping power plants up and down and varying their output as electricity use rises and falls. Operators always need to keep power plants in reserve to meet unexpected surges or drops in demand, as well as to respond to power plant outages and downed power lines.

Wind energy adds to the variability of electricity supply, but it can be well integrated through careful and effective management of power reserves. New tools are helping to improve that process. For example, significant improvements in short-term forecasting allow grid operators to plan more accurately for the availability of wind power. Most newer wind projects also use sophisticated electronic controls that allow operators to continually adjust their output, giving them greater flexibility to respond to changing events elsewhere in the power system.

Distributing wind turbines across a broad geographic area can also help smooth out the variability of the resource. While the variability of wind generation may be significant at a single wind turbine, each turbine is in a different location, and receives a different amount of wind at different times. As the number of interconnected wind turbines grows—first within a wind farm, and then across the regional transmission grid—variability diminishes.

The costs of integrating wind energy into the electric grid are manageable. Extensive engineering studies by U.S. utilities, and actual operating experience, show that the costs of integrating wind increase along with its share of the electricity mix. However, even at 20 percent penetration, integration costs add 10 percent or less of the wholesale cost of wind generation (EERE 2008).

Our economic analysis includes those costs. However, because wind power has low operating costs given that there is no fuel to purchase, it can reduce the overall costs of operating the power system by displacing output from more expensive units. Our model accounts for this by ensuring that there is enough capacity to meet minimum reliability requirements in each electricity supply region.

Many utilities are already showing that wind can make a significant contribution to their electricity supply without reliability problems. Xcel Energy, which serves nearly 3.5 million customers in eight states, now obtains 11 percent of its electricity from wind, and plans to increase that amount to about 20 percent by 2020.

In 2009, installed wind capacity in Iowa generated 19.7 percent of the electricity used in the state, on average. Three other Midwest states also rely on wind to generate more than 10 percent of their power: South Dakota (13.3 percent), North Dakota (11.9 percent), and Minnesota (10.7 percent) (Wiser and Bolinger 2010).

Promising developments in the technology for storing electric power could also improve the reliability of wind power, though there is plenty of room to greatly expand wind use without storage for at least the next few decades (EERE 2008).

Biopower

Biomass—plant material and animal manure—is the oldest source of renewable energy: humans have been burning it to make heat ever since we first learned how to build fire. Until recently, biomass has also supplied far more renewable electricity—or biopower—than wind and solar power combined (EIA 2008). With careful management, biomass could supply a growing share of the region’s electricity. The Midwest is particularly rich in biomass resources, making it the region’s most abundant renewable energy resource after wind (Figure 2.4).

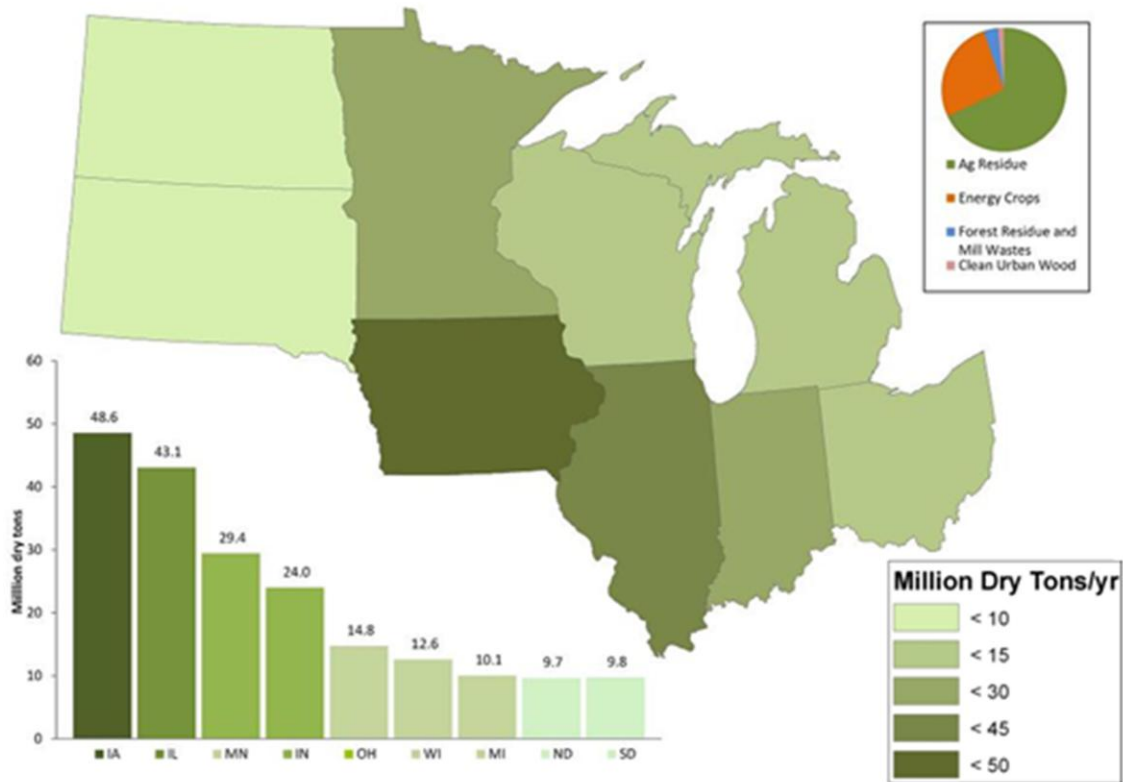
Our analysis considers a wide variety of biopower resources. These include biomass residues from forests, crops, and urban areas; unused mill residues; and landfill gas, which is mostly methane from decomposing organic matter. We also include crops grown primarily for use in producing energy, such as fast-growing poplars and native grasses (switchgrass, for example).

These resources can be used for large-scale production of electricity based on several technologies: power plants that run solely on biomass; coal plants that co-fire biomass along with coal; and combined heat and power (CHP), which use biomass to produce both electricity and steam. We assume that electricity production from landfill gas—a cost-effective but limited resource in the Midwest—is eligible to meet the Energy Roadmap targets (EPA 2010).⁸

⁸ The EPA estimates the potential of landfill gas in the Midwest at about 250 MW, which would generate less than 2 billion kilowatt-hours of electricity per year (EPA 2010).

Figure 2.4. Potential Biomass Resources for Producing Power in the Midwest, 2025

The Midwest has vast potential to use biomass resources in energy production—mostly agricultural residues and energy crops, owing to its large agricultural base.



Note: See the technical appendix for sources and details on how we developed our biomass supply curves.

Investments in biomass co-firing are relatively small compared with those of dedicated biomass plants, because the technology uses much of the existing infrastructure at coal plants. Plants with co-firing capability can also take advantage of fuel flexibility to better deal with variability in the supply and price of both coal and biomass. The economics of electricity production at CHP plants in the biofuels industry are also attractive because they can burn biomass that is unused or a byproduct of biofuel production, and can make efficient use of waste heat from the electricity production process.

Biomass supplied more than 1,500 megawatts of generating capacity in the Midwest in 2009. That capacity produced about 0.9 percent of the region's electricity, and accounted for more than 25 percent of the non-hydro renewable energy supply. The growth of biopower will depend on the availability of biomass resources; land-use and harvesting practices; and the amount of biomass used to make fuel for transportation and other uses.

Analysts have produced widely varying estimates of the potential for electricity from biomass. For example, a 2005 DOE study found that the nation has the technical potential to produce more than 1 billion tons of biomass for energy use (Perlack et al. 2005). In a study of implementing a 25 percent renewable electricity standard by 2025, the Energy Information Agency (EIA) found that biomass could supply 12 percent of the nation's electricity needs by 2025 (EIA 2007). That study assumed that 598 million tons of biomass would be available, with 40 percent of that amount from the Midwest.

Our analysis assumes that 367 million tons of biomass would be available nationally to produce both electricity and biofuels—with 47 percent of that amount from the Midwest. This estimate includes limits for removal rates for crop residues to prevent increased soil erosion and loss of soil carbon, and for potential land-use conflicts that could affect the sustainable production and use of biomass.

Nearly three-quarters of the available biomass in the Midwest comes from agricultural residues, which we estimate based on grain yield, crop rotation, field management, climate, and physical characteristics of the soil (Walsh 2007). Our calculations included algorithms to control for water erosion⁹ and wind erosion.¹⁰

We included estimates for the quantities of residues that must remain on the field to maintain levels of soil organic matter.¹¹ We also accounted for the cost of collecting and harvesting the available residue. Thus we considered many of the factors described in the primary literature as driving residue availability, and our estimates of economically feasible biomass account for the need to maintain soil retention and productivity (Walsh 2007).

To minimize direct and indirect changes in land use to produce biomass, we excluded 50 percent of the energy crop supply assumed by the EIA. That allows for farmers to grow most energy crops without decreasing food production or converting natural ecosystems to agricultural systems—which also leads to much greater cuts in carbon emissions. The biomass available for U.S. energy production in our analysis is therefore just one-third of that identified in the DOE study, and 60 percent of that in the EIA study. Our model includes biomass used for electricity production, combined heat and power, and cellulosic ethanol.

Justifiable concern has arisen that greater use of cellulosic energy crops could drive up the cost of food or compete for land. If we simply extrapolate today's trends and practices, then bioenergy could undermine food production and security, prove lacking in quantity and land availability, and contribute to environmental degradation.

⁹ To control for water erosion, we used the Revised Universal Soil Loss Equation (RUSLE) (Walsh 2007; Renard et al. 1996)

¹⁰ To control for wind erosion, we used the Wind Erosion Equation (WEQ) (Walsh 2007; Skidmore 1988; Skidmore and Kumar 1979; Skidmore and Fisher 1970).

¹¹ To account for soil carbon, we used the Soil Conditioning Index (SCI) (Walsh 2007; Lightle and Argabright 1999; Lightle 1997).

Yet a growing body of literature suggests that innovative management practices—such as pasture intensification, nitrogen recovery, and animal feed rations—can integrate energy crops into our food system without triggering these concerns (Dale et al. 2010a; Coppock et al. 2009; Anex et al. 2007; Stewart et al. 2007). By limiting energy crops to 50 percent of their potential and considering these management practices, we are reducing the potential for land-use change from the energy crops developed under our analysis.

Local Benefits of Biopower

Greater reliance on biomass energy can bring substantial benefits to local communities. For example, biomass resources used to generate electricity—whether at a dedicated biomass plant or co-fired at a coal plant—tend to come from relatively nearby areas, to minimize transportation costs. Fuel expenditures therefore stay in the local economy, adding valuable new markets for farm products. Because the Midwest is primarily a net coal importing region, dollars spent on biopower resources that directly displace coal remain in the local economy rather than leaving the area to pay for imports.

The use of agricultural residues for biopower can provide an additional revenue stream for growers. However, to ensure sustainability, a fraction of crop residues must be left on fields to maintain soil characteristics that control erosion, and to maintain soil organic matter and moisture.

Determining a sustainable rate for removing agricultural residues must take into account crop yields and rotation, management practices (such as tillage), field topography, climate, and physical characteristics of the soil. Our analysis includes a detailed assessment of water and wind erosion, and an approximation of the amount of biomass needed to maintain soil organic matter, to determine the residues that must remain on fields. We did not adjust for other factors, such as soil fertility and soil moisture (Walsh 2007).

Growing perennial grasses for energy can help improve soil quality on overused land and potentially reduce the prevalence of monocultures, diversify crop rotations, and increase grassland coverage. Perennial plants used for biopower can also be grown on marginal lands and need considerably less fertilizer, pesticide, herbicide, and fungicide than annual row crops (Tilman et al. 2006a).

Reduced chemical use helps protect groundwater and surface water from poisons and excessive growth of aquatic plants. Perennial energy crops can also create more diverse habitats, attracting a wider variety of birds, pollinators, and other beneficial insects, and supporting larger populations of various species (Tilman et al. 2006b). Perennial energy crops can build and conserve soil, capture and store carbon, hold and filter water, and cycle nutrients more efficiently (Anex et al. 2007). The net impact of energy crops will be site specific, but they can grow in nutrient-depleted, compacted, poorly drained, acidic, and eroded soils, improving these overused or marginal lands (Blanco-Canqui 2010).

Biopower can also help landowners maintain forest health by creating a market for ecologically required treatments for forests. For example, to reduce the risk of catastrophic forest fires, landowners often remove and burn biomass, at considerable cost, or do not remove it, leading to greater risk of more intense forest fires. Harnessing this resource may help cover some of the costs of preventive maintenance, and in some cases turn an activity required for healthy forest management from a net cost to a net profit for landowners.

Key Challenges for Biopower

Ensuring the Sustainability of Biopower and Wise Land Use

Though the environmental risks of biopower are much lower than those of conventional energy sources, it does pose risks that need to be mitigated. If not managed carefully, biomass for energy can be harvested at unsustainable rates, damage ecosystems, pollute the air, consume large amounts of water, and produce net increases in global warming emissions.

However, many scientists believe a wide range of biomass resources can be produced sustainably and with minimal harm while reducing the overall impacts and risks of our power supply (Dale et al. 2010b; Tilman et al. 2009). Implementing policies that properly integrate bioenergy feedstock production with agriculture is essential to securing the benefits of biomass and avoiding its risks.

Biomass is a renewable resource not only because the energy it contains comes from the sun, but also because it can be regrown over a relatively short period of time. The CO₂ released when biomass is burned for energy is reabsorbed through photosynthesis as more biomass is grown to replace the original resource.

In this way, biomass functions as a sort of natural battery for storing solar energy, as photosynthesis converts carbon dioxide from the air and water from the ground into carbohydrates. As long as biomass is produced sustainably—meeting current needs without diminishing resources or the land’s capacity to regrow biomass and recapture carbon—the battery will last indefinitely and provide sources of low-carbon energy.

Many scientists believe that a wide range of biomass resources are “beneficial” because their use will clearly reduce overall carbon emissions and provide other benefits (Dale et al. 2010b; Tilman et al. 2009). Beneficial biomass includes energy crops that do not compete with food crops for land, portions of crop residues such as corn stover or wheat straw, sustainably harvested thinnings and forest residues, and clean municipal and industrial wastes (Tilman et al. 2009).

Beneficial biomass sources generally maintain or even increase carbon stocks stored in soil or plants. They also displace the use of coal, oil and natural gas, the burning of which adds new carbon to the atmosphere and causes global warming. Unsustainably planting and harvesting biomass, on the other hand, results in net carbon emissions, degraded soils, increased erosion, and loss of habitat.

The long-term impact of residue removal on soil structure, composition, functioning, erosion, and soil carbon dynamics across management types and climate needs further

study (Blano-Canqui 2010; Johnson et al. 2010). We have tried to include the effects of topography, tillage, crops, and climate in our model. However, we did not include site- and soil-specific factors such as soil texture and drainage, because of limitations in the model.

Some recent research has raised important questions regarding the timing of the biomass carbon cycle (Manomet 2010). Because biomass contains more water than fossil fuels do, it burns less efficiently, so stack emissions are higher, creating a “carbon debt.” In the Northeast, for example, emissions from burning whole trees may remain higher than those from fossil fuels for decades before the carbon debt is repaid during tree regrowth—making whole trees less desirable than other biomass resources. These same studies have found that forest residues and other waste biomass have rapid carbon paybacks and strong carbon reduction benefits. More research is needed to determine the applicability of these findings to other regions such as the Midwest, and to determine detailed criteria for sustainable biomass. To be conservative though, our analysis does not consider whole trees as eligible fuels.

The carbon debt of treetops and tree limbs is much lower than that of large, mature trees, partly because the residues would decay and release carbon dioxide after trees are harvested for saw timber or pulp. If trees are cut only as a source for biopower, then the resulting carbon debt will take much longer to pay back, because these trees would normally be growing rather than decomposing, or the harvested timber or pulp would be put to alternative uses, such as in structures, where decay and carbon dioxide release would normally not occur for a long time. Researchers at the Manomet Center for Conservation Sciences have estimated that logging residues will have a payback time of about 5 to 30 years, depending on the fossil fuel they replace (Manomet 2010). Whole trees, in contrast, would have a payback of 15 to more than 90 years (Walker 2011). Carbon dynamics vary based on different feedstocks, and these differences need to be considered when evaluating supply pathways for biomass.

It is also important to consider potential carbon emissions created by changes in land use. Some forms of biomass—such as native perennials grown on land that would not be used for food, and biomass from waste products such as agricultural residues—do not change the way we use our land, and can therefore significantly reduce global warming emissions. However, changing the way we use land to produce biomass for energy may indirectly affect land use in other locations, and thus carbon emissions.

For example, replacing traditional crops with energy crops can shrink food production, which can spur the conversion of forests and natural habitat to agriculture in other locations, to make up the shortfall. This conversion releases carbon sequestered in the ecosystem, and can create more emissions than biopower prevents (Fargione 2008). Both direct and indirect land-use conversions should be taken into account when assessing potential cuts in carbon emissions from the use of biomass (Searchinger et al. 2011, 2008).

Biomass Distribution and Transport

The distribution and transportation of biomass pose another challenge for its widespread

deployment. While many types of biomass are available throughout the Midwest, they need to be collected from a wide area and delivered to where the resource will be used.

As the distance from source to power plant increases, the cost also rises, as do the emissions from burning diesel used in transport. This is less of an issue for new biomass power or biofuel plants, which can be located close to where the resource is readily available. However, in the case of co-firing at existing coal plants, the biomass must come from nearby if it is to yield the maximum environmental benefits and be cost-effective. In locations where several coal plants are clustered together, it becomes increasingly difficult for all plants to engage in high levels of co-firing using local biomass supplies. Biomass then would have to come from greater distances, the plants would have to use less desirable sources, or the co-fire rate would be limited.

Possible exceptions may occur when plants are located on waterways, allowing biomass to be delivered by barges or ships, which can be much more efficient and less expensive than shipping by land. Some wood pellets are now shipped from the U.S. Northeast and Southeast to European markets, because of the higher value they place on renewable energy. The process of torrefaction, which dries biomass to better approximate the consistency of coal, can also reduce shipping costs. Torrefaction could play an important role in the transition to a clean energy economy, but because it is not fully commercialized, we do not consider it in our analysis.

Other Technical Challenges of Co-Firing

Though not insurmountable, technical challenges can also diminish the attractiveness of biomass co-firing. Altering the fuel mix in a coal plant can affect slagging, fouling,¹² the plant's emissions profile, and reduce plant efficiency (KEMA 2009). These problems can generally be minimized through close monitoring and control, and the installation of handling systems that can adjust to one or more types of biomass in addition to coal.

Co-firing designs are plant specific, and must take into account the different constraints at each facility depending on the type and availability of biomass, furnace and boiler type, space limitations, and other factors to optimize power production and limit emissions. The costs of retrofitting a plant for co-firing can therefore range substantially, making it attractive in some locations and prohibitive in others. To account for these challenges, our analysis examines a range of co-fire rates: up to 5 percent under our core policy case, and up to 15 percent under our alternative technology pathway (see Chapter 3).

Emissions of pollutants other than carbon dioxide are also affected by biomass co-firing. The concentrations of elements in biomass are different from those in coal, even after accounting for differences in heat content. Biomass generally has lower concentrations of sulfur, nitrogen, and mercury, which can lead to lower emissions of sulfur dioxide and mercury. Experiments have shown both higher and lower nitrous oxide emissions from co-firing than from coal alone. Emissions of other heavy metals and chlorine can increase

¹² Slagging and fouling refer to the accumulation of unwanted material on the surfaces of boilers and heat transfers, and can affect operation of the equipment.

if contaminated urban and demolition waste is used (KEMA 2009), so we excluded this potential source from our analysis.

Solar Power

Photovoltaics (PV), or solar cells, use semiconducting materials to convert direct sunlight to electricity. Historically, most PV panels were used for off-grid purposes, powering homes in remote locations, cellular phone transmitters, road signs, water pumps, among other uses. But thanks to large declines in costs, strong incentives, and net metering policies, the PV industry has placed more focus on home, business, and utility-scale systems attached to the power grid.

In 2005, for the first time ever, the installation of PV systems connected to the electricity grid outpaced off-grid PV systems in the United States (Prometheus Institute 2006). From 1998 to 2009, the cost of solar power declined more than 30 percent (Wiser et al. 2009), and in 2010 system prices dropped 20 percent (SEIA 2010). As the PV market continues to expand, the trend toward grid-connected applications will continue, with power producers developing multi-megawatt PV projects such as the new 10-MW project in Illinois, and the proposed 50-MW Turning Point project in Ohio (SEIA 2011).

The technical potential of U.S. solar power is huge: PV panels installed on less than one percent of the U.S. land area could generate the equivalent of the country's entire annual electricity needs. PV panels could make a significant contribution in the Midwest, even though solar radiation levels are somewhat lower than in other regions. Given solar radiation levels in Wisconsin, for example, the electricity needs of the entire Midwest could be met with less than 0.04 percent of the region's total land area.

Solar PV is still relatively costly compared with other Midwest renewable resources such as wind and biomass, but that could change as costs continue to drop owing to technological advances and growing economies of scale in manufacturing. To accelerate the industry's growth in the region as well as attract jobs and investments, Illinois, Missouri, and Ohio have created separate requirements for deploying solar PV as part of their renewable electricity standards. And some solar PV manufacturers have already established facilities in the Midwest, hoping to take advantage of the region's infrastructure, skilled labor force, and large market. For example, Toledo, Ohio, is home to First Solar and Xunlight Corp., both producers of thin-film solar cells.

Distributed Energy and Combined Heat and Power

Because some renewable technologies—including solar PV installations, small wind turbines, and combined-heat-and-power facilities—can be small and modular, they can be sited in or near buildings where energy is used. These distributed technologies offer some benefits that utilities have usually not considered, including the avoidance of costly expenditures on transmitting and distributing electricity. For example, a utility installing distributed generation in a new neighborhood might be able to use smaller transformers, or reduce the size or number of power lines to that location.

Distributed generation reduces wear and tear on existing equipment, delaying the need for replacement or upgrades, reduces marginal distribution losses (so less electricity

needs to be produced in the first place), and can lead to improvements in power factor and voltage support in the distribution system. Distributed generation can also provide "premium power" to customers, improving its quality and system reliability. Companies with critical electricity needs, such as hospitals, airports, and computer-dependent firms, pay a premium to ensure reliable power, as the cost of outages can be huge. Onsite generation, with small generators based on renewable resources, is one way to meet those needs.

Placing generating facilities in or near where energy is used may also allow more efficient use of fuels. Much of the thermal energy created at large power plants is not converted into electricity. A typical coal-fired power plant, for example, converts only about one-third of the energy in the coal to electricity—the rest is lost as “waste” heat. CHP systems, also known as cogeneration, offer a much more efficient option for energy consumers, as they capture waste heat for use in space heating and cooling and other purposes.

CHP systems have allowed industrial facilities and building owners to save money on energy costs and reduce their fossil fuel use. Such systems use more of the energy in fossil fuels, reducing emissions by displacing less efficient forms of power generation. And CHP systems can use renewable fuels such as biomass to replace part or all of the fossil fuels they use. Businesses, government, and consumers have much to gain if CHP is adopted on a larger scale. In 2006, CHP produced 506 billion kWh of electricity in the United States—more than 12 percent of total power generation.

Transmission and Other Infrastructure Challenges

Lack of transmission capacity is one of the primary barriers to building more utility-scale renewable energy in the Midwest. Meeting the Energy Roadmap targets for renewable energy will therefore require a major effort to modernize and expand the electricity grid.

Key near-term needs include reforming the management and operation of the grid, creating new mechanisms for financing and recovering the costs of an expanded grid, and creating processes for siting new transmission lines. Coupled with these efforts must be initiatives that encourage energy efficiency, demand-side management, and smart-grid improvements, while discouraging access to new transmission lines for coal and other fossil fuel plants that lack carbon capture and sequestration.

Our analysis assumes that new policies facilitate new transmission lines and upgrades of existing lines to enable power producers to meet the renewable electricity targets in the Energy Roadmap. While we did not explicitly model these policies, we did include the cost of building transmission lines for new renewable, fossil-fueled, and nuclear power plants, and we allocated those costs to all electricity users based on EIA assumptions. (For more information, see the Technical Appendix, online at www.ucsusa.org/brightfuture.) Our analysis also includes the costs of siting and connecting wind projects and transmitting the power they produce as the use of wind increases, based on an analysis by the National Renewable Energy Laboratory (NREL) for the EIA (PERI 2007).

Overall, the cost of transmission represents a relatively small fraction of the cost of deploying renewable energy. Permitting, siting, and constructing new lines, however, can be a lengthy and complicated process. While most renewable energy technologies can be deployed quickly, obtaining the approvals to site and construct new transmission lines typically takes several years or more.

For example, 95,000 MW of wind projects are now in the interconnection queue in the Midwest (65,000 in Midwest ISO and 30,000 in PJM)—equivalent to roughly half of the Midwest’s total electric generating capacity. While some of these projects are less certain and may not be built, most are stalled because of inadequate transmission capacity.

Successful implementation of the Energy Roadmap targets will require new policies to facilitate and speed the permitting, siting, and construction of transmission lines. These policies need to bring all stakeholders into the process in a fair and equitable manner. They must also take into account the rights of landowners and communities where transmission is sited and ensure that they are treated fairly.

Several renewable energy technologies could share transmission lines. In fact, combining biopower, landfill gas, and sustainable hydro projects—which provide baseload power—with wind and solar projects, which provide variable power, can allow more cost-effective use of new transmission lines and upgrades. To capture these benefits, state, regional, and national agencies are now considering how to increase the capacity of the grid to transmit power from “renewable energy zones” to areas with high demand.

Several transmission planning efforts are under way in the Midwest. Both Midwest ISO and PJM are pursuing system planning and cost allocation processes. Midwest ISO released the *Regional Generator Outlet Study* in November 2010, focusing on the transmission needed to bring 23,000 MW of renewable energy capacity online in the region by 2027, to serve existing state renewable electricity standards (MISO 2010). Our analysis is consistent with this effort, and we used it as guidance as we examined the transmission capacity needed to meet the Energy Roadmap targets, and to understand where renewable energy development is likely to happen.

Fragmented jurisdiction over the existing transmission system allows any single state to effectively veto the construction of new multistate transmission lines by refusing to grant required permits. The transmission planning of regional transmission organizations (RTOs) does not yet adequately examine energy efficiency, demand response, and retirement of fossil fuel–based facilities. Federal land-use agencies also lack a consistent policy for siting transmission lines.

These challenges could be overcome with significantly improved subregional and multistate coordination that better integrates state and regional processes for approving new transmission lines. This would help plan for and integrate new renewable energy sources and distributed power plants into the grid, while taking into account options for managing demand. Such an approach could also allocate costs fairly among all users of the transmission system, and ensure the protection of sensitive environmental and cultural resources.

New federal policies are also needed to increase the reliability and efficiency of the electricity grid and maximize the integration of renewable energy sources. Because some of the best renewable energy potential is located away from population centers, “green energy superhighways” will be needed to expand the use of clean, renewable electricity and reduce carbon emissions from the electricity sector, even after taking into account opportunities for energy efficiency, reducing demand, and distributed generation. The federal government should provide a framework, guidelines, timelines, and a backstop decision-making authority, particularly for cases where agreement at the state level cannot be reached.

As part of DOE planning grants funded by the 2009 American Recovery and Reinvestment Act, each of the major electricity interconnects (Western, Eastern, and Texas) are attempting to address several grid planning problems that RTO processes have been unable to address effectively, including substantial integration of renewable generation. The Midwest is part of the Eastern Interconnect, which accounts for 75 percent of the nation’s electricity demand.

The Eastern Interconnection Planning Collaborative is drawing together stakeholders to plan the future of the electricity grid, specifically to include state renewable energy requirements. This effort will model transmission needs under various generation scenarios. This consensus-based planning process includes participation by nongovernmental organizations, and is a pivotal opportunity to move away from business as usual, wherein owners and operators of transmission and generation facilities plan the system solely to address reliability, pricing, and congestion concerns. The new process can shift the process toward interconnect-wide comprehensive grid planning that also considers regional and national goals for energy efficiency, clean energy, and climate change.

Energy Efficiency Technologies and Their Potential in the Midwest

Energy efficiency technologies allow the use of less energy to get the same—or higher—level of production, service, and comfort. We can still light a room, keep produce fresh, and use a high-speed computer, but we can do it with less energy. Energy efficiency is less expensive than any form of electricity generation, and does not require transmission lines (Friedrich et al. 2009; Lazard 2008).

Measures such as more building insulation, improved lighting systems, more efficient air-conditioning, and improved water-heating systems also dominate the list of cost-saving solutions for reducing demand for coal-based power and cutting global warming emissions (Pers-Anders, Naucner, and Rosander 2007). Creating a highly energy-efficient economy requires the deployment of these technologies, as well as policies and programs

to overcome the entrenched barriers that prevent businesses and consumers from using energy wisely and efficiently.¹³

The Midwest has made strides in adopting energy efficiency policies over the last six years. Seven of the Midwest states examined in this report have energy efficiency resources standards in place: Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Missouri has adopted an integrated resource planning process that incorporates energy efficiency into the utility planning process.

While utilities and regulators are just beginning to implement these policies, they are already saving consumers money and creating jobs. As a result, states are gaining momentum toward the Energy Roadmap target of 2 percent annual savings for electric utilities by 2015 and each year thereafter. In the Midwest, budgets for ratepayer-funded energy efficiency programs reached \$443 million in 2009 (Molina et al. 2010), and are projected to increase to \$1.2 billion in 2011 (MEEA 2011).

Potential for Greater Energy Efficiency in the Midwest

Analysis from the Energy Center of Wisconsin, performed with the American Council for an Energy-Efficient Economy (ACEEE), found that the Energy Roadmap's 2 percent annual energy efficiency target is aggressive but achievable (Stratton and York 2009). In fact, a majority of the studies reviewed in the analysis showed the potential for achievable efficiency gains of 1.9 percent or more each year.

A review of utility- and state-level efficiency programs found that the cost of implementing energy efficiency measures ranged from about 1.5 cents to nearly 7 cents per kilowatt-hour saved (¢/kWh), with a median of 3.0¢/kWh (Figure 2.5) (Hurley et al. 2008). That review also found that implementation costs are lower the greater the efficiency gains a program produces.

Another ACEEE review examined the costs of ratepayer-funded energy efficiency programs in 14 states, and found a range of 1.6 to 3.3¢/kWh. The analysis included three Midwest states: Iowa (1.7¢/kWh), Minnesota (2.1¢/kWh) and Wisconsin (3.3¢/kWh) (Friedrich et al. 2009). Those costs are lower than the average Midwest retail price for electricity in 2009 (7.57 to 8.91¢/kWh) (EIA 2010b), suggesting that an aggressive, comprehensive plan to boost energy efficiency is a cost-effective approach to reducing coal dependence. Our analysis assumed a cost of 3.0¢/kWh as a conservative estimate, based on these analyses.

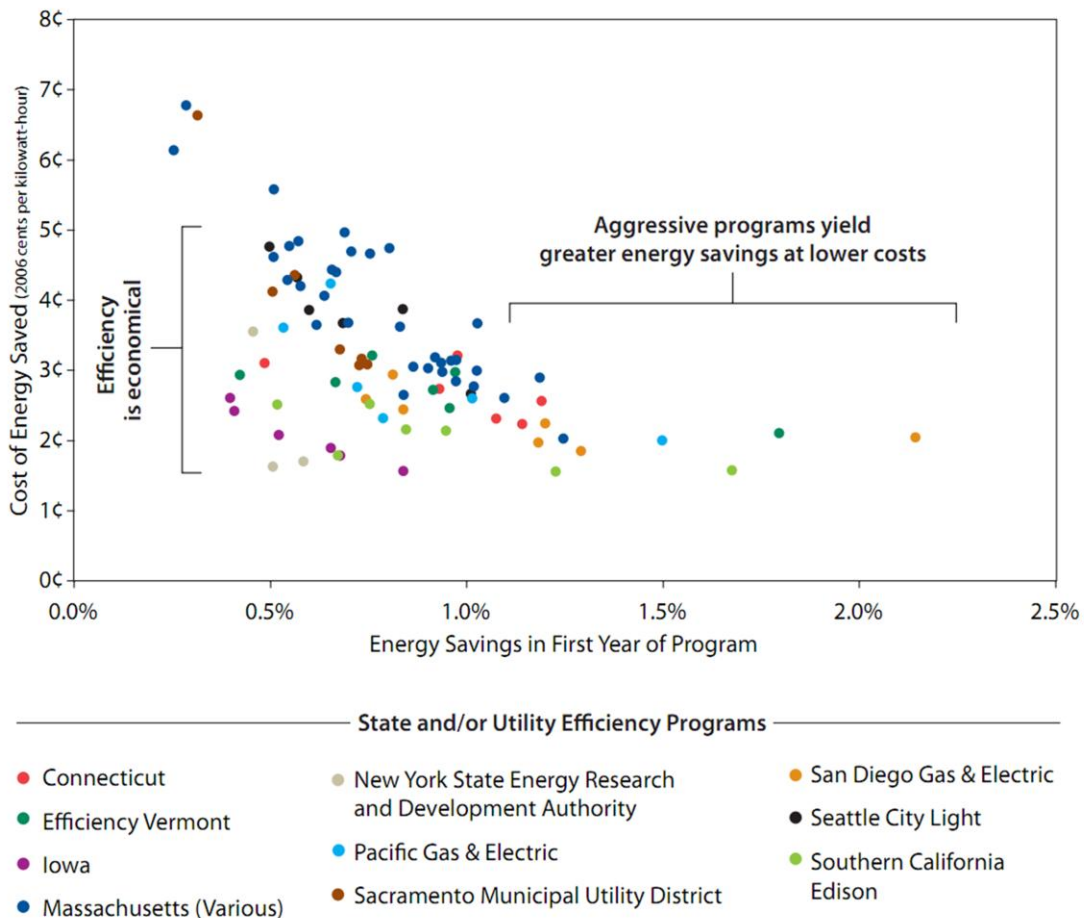
In 2008, energy efficiency programs in five states reduced energy use by more than 1 percent that year, including Vermont, where reductions reached 2.59 percent. Three Midwest states—Iowa, Minnesota, and Wisconsin—reduced electricity demand by more than 0.7 percent that year (Molina et al. 2010). An analysis concluded that the Energy Roadmap energy efficiency targets are realistic for two key reasons: “Existing program activity levels have not targeted this level of savings,” and “existing energy efficiency

¹³ For a discussion of market barriers to energy efficiency by customer class, see the EPA's National Action Plan for Energy Efficiency (2010). Online at <http://www.epa.gov/eeactionplan>.

potential studies are very conservative (Stratton and York 2009).” What’s more, studies of the potential for energy efficiency measures have not accounted for many programs that can be used to meet the MGA targets.

Figure 2.5. Energy Savings and Costs of Energy Efficiency Programs

A review of utility- and state-level efficiency programs found that the cost of implementing energy efficiency measures ranged from about 1.5 cents to nearly 7 cents per kilowatt-hour saved, with a median of 3.0 cents per kilowatt-hour. Those costs are lower than the average Midwest retail price of electricity in 2009.



Source: Adapted from Hurley et al 2008.

Key Challenges for Energy Efficiency in the Midwest

The advancement of energy efficiency policies in the Midwest faces three key challenges. First, the region’s economic slowdown has reduced the willingness and ability of residential, commercial, and industrial electricity customers to invest in energy efficiency improvements, even when they produce long-term financial benefits.

High initial cost is a primary barrier to installing new energy efficiency technologies and retrofitting existing buildings (National Action Plan for Energy Efficiency 2010). While federal stimulus funding has provided resources to retrofit buildings and develop smart electricity grids, better state and regional coordination is needed to attract private capital to continue the pace of these activities after those funds are expended. For example, AFC First Financial Corporation, a national financial services company, offers residential energy efficiency and renewable lending and rebate programs in partnership with states, utilities, manufacturers, and municipalities.

Second, opposition to energy efficiency policies comes from several sources. Utilities, for example, may be reluctant to expand their energy efficiency efforts if their revenues are linked inextricably to increasing electricity and natural gas sales. Regulators can break this link, spurring utilities to promote energy efficiency. For example, regulatory incentives can turn energy efficiency programs that exceed mandatory targets into profit centers for utilities (National Action Plan for Energy Efficiency 2007).

Third, efforts to increase energy efficiency resource standards in some states have suffered from lingering misperceptions that such investments raise utility bills. Better communication, and the expansion of existing energy efficiency programs, can show policy makers and consumers that energy efficiency lowers total utility bills, both directly, by reducing the amount of energy used, and indirectly, by providing downward pressure on electricity prices. Together those measures allow electricity providers to reduce fuel costs at existing plants and avoid new investments in generation and transmission facilities.

Other Non-Renewable Low-Carbon Technologies

Carbon Capture and Sequestration

Beyond renewable energy and energy efficiency, carbon capture and sequestration and advanced nuclear power plants are low-carbon technologies that have significant potential to help achieve the deep reductions in heat-trapping emissions needed to avoid the most dangerous effects of global warming. At present, neither of these technologies is cost-competitive with energy efficiency, many renewable energy technologies, or new natural gas power plants—partly because significant technical hurdles continue to limit their widespread deployment. Nevertheless, as these technologies improve and costs drop, they could become important options in helping to reduce global warming emissions.

Carbon capture and storage (CCS) could allow electricity producers to capture a significant fraction of CO₂ emissions from power plants, pressurize it, and pump it into underground formations, where it would ideally remain stored safely and permanently. This approach is being investigated today primarily to reduce carbon emissions from coal-fired power plants, but it could also be applied to natural gas-fired power plants or industrial sources of CO₂. CCS also has the potential—if coupled with the sustainable use of biomass to produce electricity—to provide carbon-negative power, as the carbon absorbed by the biomass during growth would be stored underground as it burned, rather than being released back into the atmosphere.

Our analysis includes only pre-combustion carbon capture in new coal integrated gasification combined-cycle (IGCC) and natural gas combined-cycle plants, because the 2009 version of NEMS does not have the capacity to model post-combustion CCS technologies. Both pre- and post-combustion technologies are expected to capture 85–95 percent of a coal plant’s carbon emissions. However, the actual rate of carbon emissions avoided per unit of electricity could fall to 80–90 percent, after the fuel used to power the pre-combustion CO₂ capture process is factored in (IPCC 2005).

No coal-fired power plants are now using CCS on a commercial scale. This makes accurate projections of the cost of CCS highly uncertain and difficult to validate. Design estimates indicate that CCS could increase the cost of energy from a new pulverized coal plant by 78 percent, and that adding pre-combustion capture to a new IGCC plant would increase its levelized costs by 36 percent. Cost increases would be even greater if CCS were added as a retrofit (ITF CCS 2010).

Future advances in CCS technology could drive down such costs substantially (Al-Juaied and Whitmore 2009). However, significant research and development will be required before we know if any of these approaches can be successfully commercialized. Several CCS projects under development today—including three recent projects in the Midwest—have faced serious cost overruns and delays.

A cost review of a proposed Tenaska Energy IGCC plant in Illinois found that the project would cost more than \$210 per MWh (or 21¢/kWh), and that uncertainties could push costs higher (ICC 2010). The FutureGen CCS project, also in Illinois, has already been canceled once for cost overruns and then revived. Finally, Duke Energy’s IGCC plant in Edwardsport, Indiana, was approved in 2008 by the state utility regulatory commission at a cost of \$1.9 billion. The latest cost reported by Duke Energy is \$2.9 billion (Downey 2011).

Nuclear Power Plants

Nuclear power plants could play a role in reducing global warming emissions because they emit almost no carbon when they operate. Other parts of the nuclear fuel cycle do emit CO₂, though some studies have found those emissions to be roughly comparable to emissions from manufacturing and installing wind power and hydropower facilities (UCS 2003).

With no recent domestic experience to draw on, reliably projecting construction costs for new U.S. nuclear plants is challenging. Experience with reactors under construction in Europe and Asia, however—and recent trends in the overall cost of commodities and construction—show the same vulnerability to cost escalation that plagued the last generation of nuclear plants.

Based on a review of estimates of construction costs for a range of nuclear power plants, we assumed modest cost escalation of 2.4 percent per year through 2015, and then a 4.2 percent drop in costs by 2030 owing to learning. We also included 300 MW of uprates (modifications to an existing nuclear power plant that allow it to increase its power

output) in the Midwest, based on projections using survey data from the Nuclear Regulatory Commission (NRC).

Current applications to the NRC to build and operate new nuclear power plants reference five plant designs—of which the NRC has certified only two. And one of those, the AP1000, has undergone significant changes since it was certified. The five designs offer evolutionary improvements to existing plants: they are somewhat simpler, relying more on “passive” safety systems and less on pumps and valves.

The industry and the NRC had hoped that these upgrades—along with a streamlined licensing process and greater standardization of reactor designs—would improve the safety of nuclear power plants and reduce their costs. However, standardization has so far proved elusive, and the licensing process has not yet been fully tested. Given the effects of the March 11, 2011, earthquake and tsunami on the Fukushima Daiichi nuclear power plant in Japan, proposals for new plants will likely be subject to additional reviews and changes, potentially causing delays and adding costs to their construction and operation.

Potential Impact of Electric Vehicles

Automobile manufacturing in the United States started in the Midwest, and it was midwestern ingenuity that transformed transportation for an entire continent. Now, in the search for new and better ways to power vehicles while reducing heat-trapping emissions, Detroit can lead the charge once again by investing in low-emissions cars. One of the more promising developments is using more electricity to power vehicles.

Electric vehicles—which use electricity stored in on-board batteries for part or all of their power needs—have the potential to reduce CO₂ emissions from the transportation sector. However, cuts in emissions can vary significantly with the source of the electricity used to charge the batteries for these vehicles.

If a significant fraction of the electricity used to charge the electric vehicle’s batteries comes from plants that burn a lot of fossil fuels, electric cars can have lower lifecycle CO₂ emissions than conventional vehicles but offer little global warming advantage over an efficient hybrid-electric vehicle. However, CO₂ emissions from the electric vehicle fleet can drop significantly—to levels below those of efficient hybrid vehicles—as more power from low-carbon sources is used to charge the batteries.

Assessing the lifecycle emissions of plug-in hybrid-electric vehicles is more complex because the total emissions are a combination of the emissions coming from the on-board internal combustion engine and those from the electricity from the grid used to charge the batteries. Driving habits and vehicle design have a significant effect on how much the two sources contribute. The emissions of these vehicles will fall between those of all-electric vehicles and non-plug-in hybrids.

Previous analyses have suggested—based on the current Midwest electricity mix, which is dominated by coal—that an all-electric vehicle would account for slightly more CO₂ emissions than an efficient hybrid, but far less than a typical conventional vehicle.

Reducing coal and fossil fuel use, and replacing it with renewable energy, can therefore improve the carbon benefits of both all-electric vehicles and plug-in hybrids.

A number of car companies are now starting to sell all-electric vehicles and plug-in hybrids, or have announced plans to do so. However, there are uncertainties as to how quickly the market for such vehicles will grow. Our analysis does not specifically explore the effect that various penetration rates of electric vehicles could have on the electricity system in the Midwest. However, our model contains the same assumptions used by the EIA in its *Annual Energy Outlook 2009* (AEO). The AEO includes projections for demand for the electricity used for electric and plug-in hybrid vehicles, which accounts for only a small fraction of total electricity consumption.

Chapter 3. Our Modeling Approach

To analyze the impact of the Energy Roadmap targets in the Midwest, we relied primarily on a modified version of the National Energy Modeling System (NEMS), developed by the EIA, an independent division of the U.S. Department of Energy. NEMS is a comprehensive model that forecasts U.S. energy use and emissions from the electricity, transportation, industrial, and buildings (residential and commercial) sectors. The model relies on a variety of assumptions about technological progress as well as household and business behavior. Using these assumptions, it selects the technologies that can best enable the nation to meet its projected energy needs.

The EIA uses NEMS each year to provide a long-term forecast of U.S. energy production, demand, imports, prices, expenditures, and emissions. The resulting report, the *Annual Energy Outlook (AEO)*, includes a scenario based on policies in place at the time, called a reference case, and numerous “sensitivity” cases based on changes to key assumptions. The EIA also receives numerous requests from Congress to use NEMS to assess the effects of proposed climate and energy legislation. The NEMS model allows users to capture the dynamic interplay between energy use, energy prices, energy investments, the environment, and the economy, as well as competition for limited resources under different policy scenarios.

Our approach is similar, in that we used a modified version of NEMS (which we call UCS-NEMS) to create a forecast under existing policy conditions, which we call the existing policies case, or base case. We modified EIA’s assumptions for the costs, performance, and supply of several energy technologies based on more recent information, and we also updated the model to include the latest relevant state and federal policy changes.

We then modeled several policy cases that apply new measures to promote renewable energy, energy efficiency, and cuts in carbon emissions. We compared these policy cases with the existing policies case to evaluate their effect on consumers, the economy, and the environment. The forecast period for our analysis runs through 2030. Although our analysis focuses on the electricity sector, NEMS models multiple sectors of the economy, which allows us to capture the dynamic relationships between the electricity sector and all other sectors. (For more information on how we modified the model, see the Technical Appendix, online at www.ucsusa.org/brightfuture.)

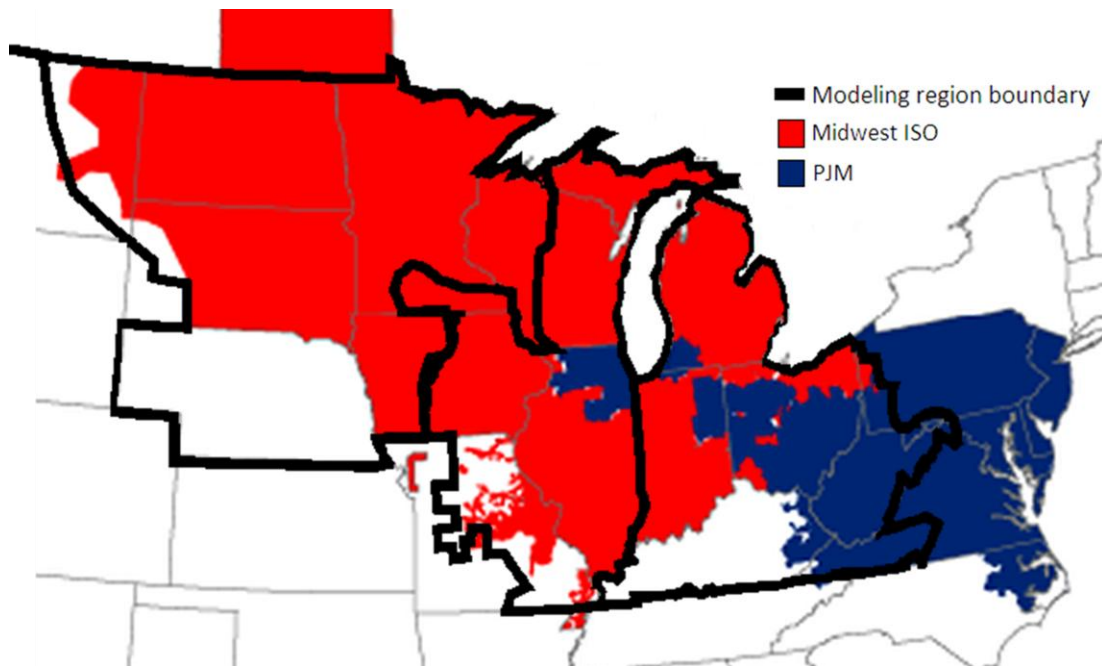
As noted, our analysis focused on the nine Midwest states (Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota, and Wisconsin) that are part of the Midwest ISO and PJM—the two independent transmission system operators in the region. The 2009 version of the NEMS model we used for this analysis divides the United States into 13 North American Electric Reliability Council (NERC) regions—performing calculations and reporting results for the electricity sector in these regions before aggregating to the national level (EIA 2009).

Three of the NERC regions correspond roughly to the Midwest ISO and PJM footprint (Figure 3.1). We then used Midwest-specific information on existing energy use and production, renewable resource potential, transmission planning analyses, and other

analyses of renewable energy and energy efficiency to estimate where renewable energy deployment and fossil fuel displacement were more likely to occur at the state level. (We describe state-level results in a series of fact sheets available online at www.ucsusa.org/brightfuture.)

Figure 3.1. Midwest Regional Transmission Organizations, and Their Overlap with NERC Regions in NEMS

Our analysis focused on the nine Midwest states that are part of the Midwest ISO and PJM—the two independent transmission system operators in the region. Three of the North American Electric Reliability Corporation (NERC) regions in our model correspond roughly to the Midwest ISO and PJM footprint.



Source: PJM 2011a, 2011b.

Note: Two electric utilities serving customers in Ohio—FirstEnergy Service Co. in northern Ohio, and Duke Energy in southern Ohio—have filed with the Federal Energy Regulatory Commission to withdraw from the Midwest ISO and join PJM.

Energy Efficiency Analysis

Our study included a supplemental analysis to account for the costs and energy savings of implementing the Energy Roadmap energy efficiency targets. The analysis used the resulting calculations of annual, regional-level energy savings to reduce electricity demand by sector in the NEMS model, distributing the energy savings proportionally across the relevant NERC regions.

In the residential sector, the model also distributed energy savings proportionally across different end-use categories, such as lighting, home appliances, space heating and water heating. The model then determined the effects of the reductions in energy demand on electricity generation, fossil fuel use for electricity production, CO₂ emissions, energy prices, and energy bills. To determine net consumer energy expenditures, we accounted for the investments and costs of implementing the energy efficiency targets as well as the savings on consumer energy bills from NEMS.

Jobs Analysis

To derive the impact on employment of meeting the Energy Roadmap targets, we began with changes in expenditures brought about by the manufacturing, construction, installation, and operation of renewable energy and energy efficiency technologies, and the savings on consumer energy bills that result from the deployment of these technologies. We also examined the avoided capital costs, operation and maintenance costs, and fuel costs associated with the displacement of conventional power plants.

After determining both the gains and losses for specific industries, we evaluated the net benefits to the Midwest overall economy. The macroeconomic impacts include direct, indirect, and induced jobs, personal income, and gross state product. We evaluated these effects using state-specific data derived from IMPLAN (Impact Analysis for Planning), an input-output model that identifies interactions between all sectors of the economy.¹⁴ IMPLAN allowed us to obtain state-level results, and to incorporate some of the positive effects on gross state product and jobs of investments in energy efficiency, renewable energy, and other low-carbon technologies, and of savings on consumers' energy bills.

Our analysis assumed that only a portion of the jobs created or displaced from changes in expenditures in the Midwest would occur within the region: the remainder would be reflected in changes in employment in other regions. We adjusted coefficients in the model that estimate the proportion of new equipment supplied by producers within each state and the region (as a percent of the total dollars spent), based on industry data whenever it was available. While some expenditures, such as those related to construction and biomass feedstocks, stay largely within the region, others, such as for PV components, rely heavily on imports from outside the Midwest. Our analysis reports only jobs created within the region. (For more information on the modeling and assumptions underlying our jobs analysis, see the Technical Appendix, available online at www.ucsusa.org/brightfuture.)

Analysis of the Biomass Supply Curve

To determine the amount of biomass from plant cellulose that is potentially available for use in producing electricity and liquid fuel for transportation at different prices, we relied on a separate analysis prepared by Marie Walsh, an agricultural economist with the University of Tennessee, and formerly of Oak Ridge National Laboratory (ORNL). Walsh and her colleagues at ORNL developed the original supply curves used by the EIA

¹⁴ For more information on the IMPLAN model, see <http://implan.com>.

for each of the main biomass feedstocks: energy crops (switchgrass), agricultural residues (corn stover and wheat straw), forestry residues, urban wood waste, and mill residues. The EIA model included an annual supply curve for each biomass feedstock through 2030, separated into 14 U.S. subregions. The model summed the data from those curves to get a total biomass supply curve for each region, and for the nation as a whole.

Walsh and her colleagues at the University of Tennessee updated the supply curves for energy crops, agricultural residues, and corn for a 2007 EIA analysis that examined a national policy requiring 25 percent of the electricity and energy used for transportation to come from renewable sources by 2025 (EIA 2007). The report based the supply curves on new runs of an economic forecasting model for agriculture called POLYSYS. Starting with a 2006 baseline forecast by the U.S. Department of Agriculture, POLYSYS projected the tonnage of all major crops and calculated changes in land use, based on the price of biomass and corn in each of 305 agricultural statistical districts.

Our analysis used those supply curves, but we reduced the amount of biomass available from energy crops by 50 percent, to account for potential indirect effects on land use that would increase carbon emissions, and for potential downward pressure on the biomass supply from concerns over sustainability and carbon accounting. Indirect land-use effects occur when energy crops are grown on lands that could otherwise be used to grow food crops. That shift drives up the price of food crops and spurs the conversion of forests and other lands to cropland in the United States and other countries. We also assumed that the costs of transporting the biomass to coal plants that can burn it start at \$12 per dry ton, and increase up to \$35 per dry ton, based on the level of co-firing at each facility.

Scenarios

Base Cases

To establish our base case, we applied a variety of modifications and updates to the *Annual Energy Outlook 2009* version of the NEMS model, including the tax credits and incentives in the American Recovery and Reinvestment Act of 2009 (EIA 2009). For example, we modified the EIA's assumptions about the costs and performance of several energy technologies based on data from actual projects, information from more recent studies, power plant cost indices, and input from experts. We further updated the model to include new state renewable electricity standards, the existing \$18.5 billion nuclear loan guarantee program, and, as noted, the revised biomass supply curves. Neither the base case nor our policy cases, however, include more recent changes in power plant regulations under the EPA's enforcement of the Clean Air Act.

We also modeled a second base case—different from the first case only in that it includes lower cost assumptions for the biomass supply curve—for comparison with two policy cases.

Policy Cases

For our policy cases, we modeled the regional targets for renewable energy and energy efficiency in the MGA's Energy Roadmap. We assumed that the region could meet those

targets if the nine Midwest states that are part of the Midwest ISO and PJM implement a mandatory renewable electricity standard (RES) and an energy efficiency resource standard (EERS) that would extend to all electric utilities in those states.

The RES would require Midwest utilities to use wind, sustainable biopower, solar, and other renewable energy sources to generate 10 percent of their electricity by 2015, ramping up to 30 percent by 2030. The EERS would require utilities to use energy efficiency improvements to meet at least 2 percent of annual retail sales of electricity in the region by 2015 and thereafter.¹⁵

The RES and EERS have proven to be effective and popular market-based tools at the state level for encouraging deployment of the least-cost renewable energy and energy efficiency technologies (Molina et al. 2010; Wiser 2010). We assumed that the Energy Roadmap targets build on the eight existing state-level RES and seven EERS policies in the Midwest, incorporating the commitments that have already been made. Other policies will also be needed to remove key market barriers and maximize economic benefits, but we did not model them for this analysis. (See Chapter 5 for more on policy recommendations.)

The NEMS model implements an RES by assuming that power producers install the least-cost renewable energy technologies, including wind, biopower, solar, landfill gas, and incremental hydro. Though the Midwest has significant potential to develop all these resources, wind and biopower are the most abundant and economically competitive in the region.¹⁶

Small changes in the cost and performance assumptions used to evaluate wind and biomass resources can have a large effect on the mix of technologies that are deployed. UCS modeled two policy scenarios to evaluate a reasonable range of possible technology pathways for meeting the renewable energy targets in the Energy Roadmap. We call these scenarios our *core policy case* and our *alternative technology pathway*. Both cases model regional RES and EERS policies. They differ only in the relative cost of biomass available to produce electricity, and the amount of biomass that can be co-fired at existing coal plants.

Our core policy case includes additional biomass fuel costs (\$15 per dry ton) to reflect the significant uncertainties and constraints facing biomass development, both today and into the future. We added those costs because there is still no mature market for energy crops and agricultural residues that we could use as a reference point. The higher costs are associated with additional storage, transportation, and premiums paid to biomass producers, as well as uncertainty about available levels of sustainably harvested, low-carbon supplies.

¹⁵ The MGA's Energy Roadmap recommendations also include an energy efficiency target for natural gas utilities. Our analysis did not consider this policy as our focus is the electricity sector.

¹⁶ Large-scale models such as NEMS do not value all the benefits that small-scale solar and community-scale wind can provide to the transmission and distribution system, or higher levels of public acceptance. The model likely underestimates the level of such resources that would be desirable to help achieve the Energy Roadmap targets.

Our core policy case also reflects a future in which the economic feasibility of co-firing biomass in coal plants is limited to 5 percent of the capacity of those plants, on average, across the Midwest. Although higher levels of co-firing have been achieved in practice, biomass availability and site-specific constraints can limit co-firing rates.

Model limitations could also overstate the amount of co-firing that is economically feasible. For example, NEMS varies the costs of transporting biomass to coal plants based on the level of co-firing, to account for larger distances as biomass requirements increase. However, coal plants are often located in clusters around transportation and transmission infrastructure, increasing the potential for overlapping demands on the same local biomass resource from several plants. The transportation costs in the model may not always account properly for this overlapping demand.

Under the alternative technology pathway, we assumed that biomass co-firing can represent up to 15 percent of coal capacity, and that biomass supplies are available at lower price points. This is consistent with EIA assumptions for the *Annual Energy Outlook 2009*, as well as previous UCS analyses (Cleatus, Clemmer, and Friedman 2009; EIA 2009; UCS 2009b). Experience in Europe also suggests that under the right conditions, higher levels of co-firing are feasible.

We also modeled a third scenario that includes a stand-alone federal policy to reduce carbon emissions in all sectors of the economy, in combination with the Energy Roadmap renewable energy and energy efficiency targets. While the Energy Roadmap targets hasten the transition to a low-carbon electricity sector in the Midwest, they do not reflect a comprehensive national (or even regional) strategy to address global warming. Federal policies or regulations to reduce carbon emissions are needed to bring about the swift and deep reductions that can head off the most dangerous effects of climate change.

The third policy scenario reflects that need, and evaluates the effect of a federal climate policy on the Midwest. As a proxy for a federal carbon reduction policy, we modeled the climate legislation passed by the U.S. House of Representatives in 2009 (H.R. 2454), which required carbon dioxide emission reductions of 17 percent below 2005 levels by 2020, and 42 percent by 2030. We opted to model this proposal because it garnered bipartisan support in the House, and has been modeled by both the EIA and the EPA.

Key Technology Assumptions

Our technology assumptions start with those used by the EIA in the *Annual Energy Outlook 2009* (EIA 2009). We conducted a thorough review of the cost and performance assumptions for technologies in the electricity sector, and compared them with data from actual projects, input from experts, historical trends, and cost indices. This section summarizes several of the key changes we made to the cost and performance assumptions for various technologies. (For a more detailed discussion of the modifications, see our Technical Appendix, online at www.ucsusa.org/brightfuture.)

Escalation of construction costs. We adjusted escalation rates of construction and commodity costs for all technologies, based on data from actual projects, input from experts, and power plant cost indices. Whenever we used data from actual projects, we

applied an escalation rate that reflected reported costs. For all other technologies, we assumed that costs would continue to rise 2.5 percent per year (after accounting for inflation) until 2015, but not afterward. Our escalation rates were based on information published prior to the economic recession. Commodity and construction costs for different technologies have since remained relatively constant or declined.

Wind. We included land-based, offshore, and small wind technologies. We based our capital costs for land-based wind on a large sample of actual projects from a database at Lawrence Berkeley National Laboratory. We used an analysis from the National Renewable Energy Laboratory, conducted for the EIA, to develop regional wind supply curves that include added costs for siting, transmitting, and integrating wind power as its use grows. We also assumed increases in wind capacity factors (a measure of power production) and a 10 percent reduction in capital costs by 2030 from technological learning, based on assumptions from a DOE report on producing 20 percent of U.S. electricity from wind power by 2030 (EERE 2008).

Solar. We assumed expanded use of distributed (small-scale) and utility-scale photovoltaics through 2020, based on actual proposals and state policies. We also assumed faster learning and larger cost reductions for PV than the EIA did, to match the EIA's assumptions for other emerging technologies, and based on historical trends.

Biopower. Key technologies included co-firing biomass in existing coal plants, dedicated biomass gasification plants, the use of biomass to produce combined heat and power in the industrial and biofuels sectors, and the use of methane gas from landfills.

Hydropower. We included hydropower from upgrades and new capacity at existing dams, and counted both new sources of power as contributing to the regional renewable electricity standard.

Carbon capture and storage. We included carbon capture and storage as an option for advanced coal gasification and natural gas combined-cycle plants, with costs and performance based on recent studies and a small number of proposed projects.

Nuclear. We assumed that existing plants are relicensed and continue to operate through their 20-year license extension, and that they are then retired, as the EIA also assumes. We based assumptions on the costs and performance of new advanced nuclear plants primarily on recent project proposals and studies. We included planned builds and accounted for existing incentives to develop and build advanced nuclear and coal plants. These include tax credits for both technologies as well as a range of risk-shifting and regulatory subsidies for nuclear plants, such as loan guarantees, insurance against licensing delays, and limits on liability.

Transmission. We included the costs of new capacity for transmitting electricity for all renewable, fossil fuel, and nuclear technologies. We also added costs for growing amounts of wind power, based on the NREL analysis conducted for the EIA (PERI 2007). We allowed the model to build more transmission lines between NERC regions than the EIA currently models. Our transmission assumptions are consistent with the

Midwest ISO's *Regional Generator Outlet Study*, which informed our understanding of where new transmission to support additional renewable energy development was more likely to occur (MISO 2010).

Limitations, Uncertainties, and Opportunities for Future Research

Projections of long-term changes in the supply, use, and price of energy are subject to uncertainty. Modeling the impacts of energy and climate policies that will require significant changes in the way we produce and use energy adds to this uncertainty. Our model results are therefore not statements of what will happen but of what might happen, given the assumptions and methodologies used in the model.

One limitation of our analysis is that we analyzed only two potential scenarios for meeting the Energy Roadmap targets. These scenarios are intended to reflect uncertainties in the cost of biomass available for energy production, and in the ability to co-fire biomass in existing coal power plants. Other scenarios with different policy, economic, and technology assumptions could also achieve the Energy Roadmap targets, with different effects in the Midwest.

Besides our biomass assumptions, the most important types of assumptions we made include:

- energy demand and prices
- the cost and performance of technologies
- policies for energy efficiency and renewable energy
- the proportion of new equipment supplied by producers within each state and the region (as a percent of total dollars spent).

Assumptions about energy prices and the cost and performance of technologies are informed, in part, by data from recent projects and historical trends. However, cost escalation, economic growth, and fuel prices have not always followed historical trends, and have some inherent volatility. Natural gas prices, for example, have proven particularly challenging to forecast, spiking to near-record levels in 2008, only to decline dramatically by 2010 owing to increased supplies and lower energy demand (Bolinger and Wiser 2010).

Continued uncertainty around natural gas prices,¹⁷ and cost competition between natural gas and wind power, mean that assumptions about fuel prices will have a significant effect on model results. If natural gas prices remain at or near 2010 levels for an extended period, electricity from natural gas could play a substantially larger role in the Midwest than our base cases and policy scenarios project, likely resulting in less coal-based power (Kaplan 2010; Casten 2009).

¹⁷ For example, U.S. environmental regulators issued a draft plan on February 8, 2011, outlining how they will determine whether a hydraulic fracking technique for drilling natural gas harms drinking water supplies. Their findings, expected by the end of 2012, may lead to additional regulations of this industry.

Other assumptions, such as the costs of biomass available for energy, are based on expert knowledge and analysis, but will remain untested until a mature market for biopower develops. The rates at which the costs of energy technologies drop and their performance improves are also subject to changes in input costs and advances in technology.

The details of policy design can also significantly influence the results of modeling. For example, the regional RES and EERS we modeled assume that all electric utilities must comply with the annual targets. Exemptions for certain classes of utilities, such as municipal utilities and rural cooperatives, which several state-level RESs and EERSs now allow, can substantially reduce the deployment of renewable energy and energy efficiency.

Future legislation and regulations could also affect outcomes significantly. For example, limits on pollution from coal-based power plants, or overly strict regulations on wind siting or biopower sustainability, could significantly alter the viability of existing coal plants, and of new biopower co-firing and wind energy.

We were also unable to address a variety of limitations of NEMS, despite incorporating information from other analyses and modifying the model. Examples include:

Allocating changes in generating capacity across regions. As noted, NEMS organizes the United States into regions, and the model selects the technologies that can best enable each region to meet its projected energy needs at the lowest cost, given the assumed constraints. However, the model's geographic resolution is limited, and this approach cannot fully capture site-specific constraints or the complexities of power plants that are sensitive to geographical location. The model deals with issues such as the proximity of wind resources to transmission lines and demand centers—and the availability of local biopower resources to facilities that could use them—indirectly, by adjusting assumptions about the cost and supply of wind energy and biopower.

Modeling energy efficiency. The model includes specific technologies used to boost the energy efficiency of vehicles, industry, and buildings. However, analyzing the impact of proposed efficiency policies in the residential, commercial, and industry sectors is difficult without significantly modifying the model and its assumptions. The model also attempts to capture some reductions in energy use owing to higher prices, but this approach is limited.

We conducted an offline analysis of the efficiency targets in the Energy Roadmap to quantify the effects of investments in energy efficiency. However, this type of analysis does not fully capture the dynamic interplay between reductions in electricity demand from energy efficiency and its effect on electricity prices. We also did not model the efficiency targets for natural gas in the Energy Roadmap, as they were beyond the scope of this analysis. However, efficiency investments in natural gas in the industrial, commercial, and residential sectors will have indirect effects in the electricity sector, because of downward pressure on natural gas prices from reduced demand.

Analyzing effects on the economy and jobs. NEMS has significant limitations in how it quantifies the macroeconomic effects of energy and climate policies. For example, it

cannot fully account for the positive effects on GDP and jobs of investments in energy efficiency, renewable energy, and other low-carbon technologies, and of savings on consumers' energy bills. Nor does NEMS value other productivity gains and non-energy benefits that would both accelerate adoption of more advanced technologies and improve economic performance (Worrell et al. 2003). The model also treats reductions in energy consumption and increases in energy prices as exerting a negative impact on the economy, even if overall energy bills are lower. And NEMS does not account for the loss of GDP that may result from unchecked climate change in the base case.

We addressed some of these limitations by using IMPLAN, which identifies interactions between all sectors of the economy to assess effects at the state and regional level. This model also reflects some of the positive effects on GDP and employment of investments in energy efficiency, renewable energy, and other low-carbon technologies, and of savings on consumers' energy bills. However, input-output models have several known shortcomings when analyzing long periods of time, industries that are changing rapidly, and industries with international trade spillovers.

Our analysis assumes that a portion of the jobs created from investments in the region would occur outside the region, and our assumptions about that impact vary with the technologies. We report only jobs created inside the region. However, uncertainties exist with respect to the amount of new renewable energy and energy efficiency equipment that would be supplied by producers within each state and the Midwest as a whole. Over time, variables such as global competition and government-supported manufacturing incentives can alter the share of total dollars spent on these investments that remains inside the region, and play an important role in determining local job creation.

Sources of electricity with variable power output. The model does not fully capture the impact of high levels of variable-output wind and solar on the electricity grid. NEMS does capture variations in the output of these technologies during nine different time periods throughout the year for 13 different U.S. regions.¹⁸ It also includes the costs of ramping up and down other sources of power, and building any new facilities needed to meet demand for electricity and provide a reserve margin. However, the model does not capture all the fluctuations that can occur over much shorter time periods (such as by the second, minute, or hour), and at the subregional level.

Capturing the impact of these fluctuations would require modeling of additional ramping up and down of electricity sources over shorter periods. However, we included additional costs to account for this. Several studies of wind integration by U.S. and European utilities and government agencies have found that wind can provide as much as 20–25 percent of electricity generation at the regional or utility level without adverse effects on the power system's reliability or the need to store power, at a modest cost of 10 percent or less of the wholesale cost of wind generation (EERE 2008; Holttinen et al. 2007). Our results for the core policy case show that wind and PV generate less than 20 percent of the electricity in each of the three electricity reliability regions that cover the Midwest

¹⁸ The model meets electricity demand and provides a reserve margin during three seasons (summer, winter, and spring/fall), and three time periods during a typical day.

(and other) states by 2030. However, the penetration level of these technologies would exceed 25 percent in some subregions with extensive wind or solar resources.

Modeling transmission. The ability of NEMS to model electricity transmission is limited. While the EIA does include a cost for adding new transmission capacity to support new electricity generation in the model, it does not capture the full technical complexity of planning for new transmission capacity, or potential siting constraints. These technical issues could have important implications for the timing and location of new and upgraded transmission lines.

Accounting for plant-specific variations in cost. Some technological alternatives, such as retrofits of coal plants to allow co-firing with biomass, are subject to plant-specific constraints that can alter costs significantly. The model accommodates some variation in costs depending on plant size and type. It also includes the costs of transporting biomass resources from farther away to accommodate higher levels of co-firing. However, greater detail would increase the accuracy of the model's projections.

Accounting for the costs of inaction on climate change. The NEMS model cannot account for the economic, health, and environmental costs associated with inaction on climate change, which numerous studies found would be widespread, and greatly exceed the cost of reducing emissions (ASP 2011; UCS 2009a; Ackerman and Stanton 2008; Ruth, Coelho, and Karetnikov 2007; Stern 2006). Incorporating these costs into NEMS would be particularly challenging because they depend on actions at the global as well as regional level.

These limitations of the model, and the uncertainties surrounding some of our key assumptions, present important opportunities for future research. Other research could also model different combinations of technologies and policies.

Chapter 4. Results: Implementing the Energy Roadmap Targets

This chapter presents results from implementing a regional renewable electricity standard (RES) and an energy efficiency resource standard (EERS) to meet the goals in the Midwestern Governors Association's Energy Roadmap. Using the UCS-NEMS model and other analyses, we compared the impact of achieving the regional clean energy targets to that of an existing policy case (or base case). We modeled several policy scenarios to evaluate a range of possible technology pathways for meeting the Energy Roadmap regional renewable energy targets, and to examine the impacts on the Midwest from a federal policy to reduce carbon emissions.

Our core policy case models the effects of implementing an RES and EERS to meet the Energy Roadmap targets, and we present results showing changes in the electricity generation mix, electricity and fuel prices, consumer energy bills, job creation and other economic development benefits, and carbon emissions. This case includes higher biopower technology and fuel cost assumptions than assumed by EIA to reflect the significant uncertainties and constraints facing biomass development both today and into the future.

Our second scenario, referred to as the "alternative technology pathway," also examines the impacts of implementing an RES and EERS to meet the Energy Roadmap targets, but with biopower technology and fuel cost assumptions that are more in line with those used by the EIA in the *Annual Energy Outlook 2009*. Specifically, the relative costs of biomass available for energy production is lower, the amount of biomass that can be co-fired at existing coal plants is higher: 15 percent of fuel used vs. 5 percent in our core policy case (see Chapter 3 for more information). Like our core policy case, this alternative technology pathway scenario implements the RES by building the least-cost renewable energy technologies first, taken from a supply of all economically available eligible resources.

Evaluating both policy scenarios together provides valuable insights into the economic and environmental effects of achieving the Energy Roadmap targets using a different mix of renewable energy technologies. They can also provide valuable information on the uncertainties around biomass development constraints.

Our third scenario models the impacts on the Midwest from a federal policy to reduce carbon emissions in the electricity sector, with and without the Energy Roadmap targets. For this scenario, we present results on renewable energy development, consumer energy bills, and carbon emissions.

Our existing policies scenario includes only those state and federal policies which were adopted through March 2010, such as state-level RES and EERS and the federal renewable energy tax credits and incentives in the American Recovery and Reinvestment Act of 2009. It does not include, for example, more recent changes in power plant regulations that the U.S. Environmental Protection Agency (EPA) is developing to implement existing statutory standards of the Clean Air Act. Accounting for these regulatory changes in our base case modeling would likely have made coal use more

expensive for many power plants, and the relative economics of greater use of renewable energy and energy efficiency more attractive.¹⁹

Overall, our analysis shows that the region can meet the Energy Roadmap targets affordably with a range of technologies that would capitalize on the region's tremendous renewable energy and efficiency resources. Doing so would spur investment and innovation, create jobs, save consumers money, cut coal dependence, and reduce global warming emissions. Our results also show that the Energy Roadmap targets would serve as a strong complement to a federal carbon policy, spurring greater investments in renewable energy technologies and saving consumers more money than a federal policy alone.

Detailed Results: Core Policy Case

Changes in the Electricity Mix

In 2010, the Midwest relied on coal for nearly 68 percent of its power needs. As Midwest states pursued the Energy Roadmap targets, the region would diversify its electricity supply using a mix of homegrown renewable energy sources, and significantly reduce demand for electricity by investing in more energy efficiency technologies in buildings and industry.

Under the core policy case, non-hydro renewable energy capacity would grow to 63,000 MW by 2030—a nearly fivefold increase above 2010 levels (13,300 MW), and enough power to serve the equivalent of more than 40 million typical homes. By 2030, gains in energy efficiency would also reduce annual electricity demand in the region by the equivalent output of more than 33 new typical-size (600-MW) coal-fired power plants.

The strong growth in renewable energy capacity would allow renewables to account for 35.1 percent of total retail electricity sales in 2030, after gains in energy efficiency—up from around five percent in 2010. About 10 percent of this capacity would be used for electricity exported to states within the PJM transmission system but outside the Midwest.²⁰ Under the existing policies case in contrast, renewable energy would account for only about 20 percent of electricity sales by 2030, mostly because of existing state renewable electricity standards.

Achieving the Energy Roadmap targets for renewable energy would spur a diverse mix of renewable energy sources, led primarily by wind and biopower (Figure 4.1). Wind energy capacity would grow from 12,000 MW in 2010 to 50,740 MW in 2030—2.3 times the

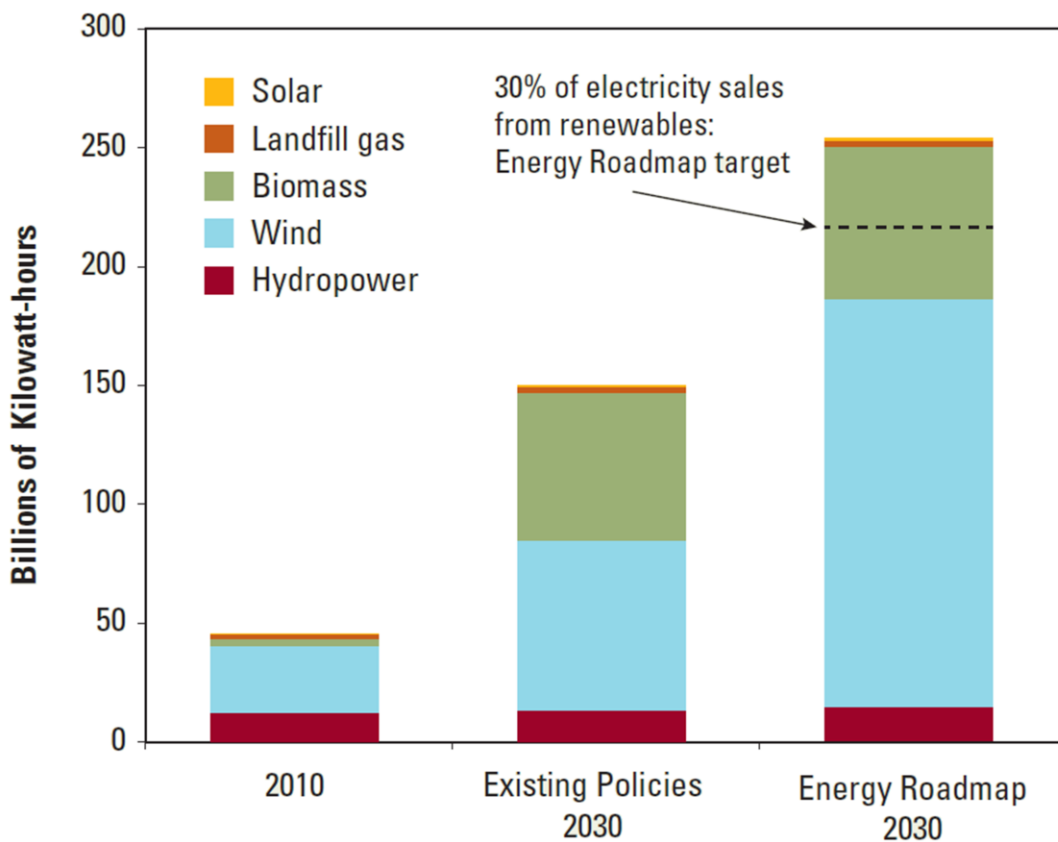
¹⁹ We focused on analyzing the effects of the Energy Roadmap targets compared with existing policies, and the EPA regulations have not been finalized. For a more detailed discussion of how current economic, technological, and policy trends could affect prospects for coal generation, see *A Risky Proposition, The Financial Hazards of New Investments in Coal Plants*, online at http://www.ucsusa.org/clean_energy/technology_and_impacts/impacts/financial-hazards-of-coal-plant-investments.html.

²⁰ Unless otherwise noted, our results include renewable energy serving other regions since these investments will provide economic benefits in the Midwest.

level of development that would occur under our existing policies case.²¹ Wind power would account for more than two-thirds of all electricity based on renewable energy in the Midwest in 2030.

**Figure 4.1. Electricity from Renewable Resources in the Midwest:
Existing Policies vs. Energy Roadmap**

Achieving the Energy Roadmap targets for renewable energy would spur development a diverse mix of renewable energy sources, led primarily by wind and biopower. Wind power would account for more than two-thirds of all electricity based on renewable energy in the Midwest in 2030.



Note: The information includes electricity produced to serve other regions.

The suite of biopower technologies—dedicated facilities, co-firing at existing coal plants, and combined heat and power—would account for 25 percent of the renewable energy mix: 15 percent from CHP, and 10 percent from biomass co-firing. Biomass co-firing at

²¹ Although the UCS-NEMS model includes offshore wind as an eligible technology for RES compliance, no offshore wind on the Great Lakes was determined to be economically viable during the forecast period.

existing coal plants would rise by the equivalent of 4,000 MW of capacity from 2010 to 2030—800 MW more than under existing policies. By 2030, this level of co-firing would annually consume nearly 15 million dry tons of biomass, and generate 25 billion kilowatt-hours of electricity.

While biomass CHP would provide 15 percent of renewable energy generation in 2030, the development of this sector would be driven largely by the need to build cellulosic ethanol plants to meet the existing federal renewable fuel standard for transportation. That is because cellulosic biomass can be economically used to produce heat and power for biofuel refineries while generating enough excess power to sell to the grid.²²

However, our results show that there is little incentive to build biomass CHP plants beyond what is economical for meeting the renewables fuel standard. As a result, there is very little difference in the amount of biomass CHP used to generate electricity between the existing policies case and either of our Energy Roadmap policy scenarios. Similarly, landfill gas and incremental hydropower—resources with fairly limited potential in the Midwest compared with wind and biopower—show little growth over existing policies case levels in 2030 under the renewable energy targets in the Energy Roadmap.

Our analysis shows that while the Midwest does experience significant growth in solar generation from rooftop PV compared with today's levels, this increase is not driven by the renewable energy targets in the Energy Roadmap. Rather, growth in solar power within the region is spurred largely by technology-specific requirements that are part of existing RES policies in several states.²³

The Energy Roadmap targets do not contain technology-specific requirements, and do not provide any solar incentives beyond existing policies. More than 90 percent of the growth in solar energy occurs by 2016, when the federal investment tax credit for solar is set to expire. This suggests that in the Midwest, solar energy may struggle to compete with wind and biopower through 2030 without additional financial incentives, technology-specific requirements, or cost reductions beyond those assumed in our analysis.²⁴ To foster the development of solar energy, Midwest states could consider complementary policies that spur the use of more solar to achieve the Energy Roadmap targets.

Greater reliance on renewable energy and energy efficiency reduces the need to generate power from coal and other fossil fuels in the Midwest (Figure 4.2). Under the Energy Roadmap targets, coal-based generation in 2030 drops by nearly 9 percent from 2010 levels, and by 16 percent compared with existing policies.

²² In the UCS-NEMS model, these plants are assumed to use clean, cellulosic biomass residues and energy crops to produce ethanol as well as electricity, heat, and other byproducts. The model also includes some CHP from the forest products industry. We assume the electricity from these facilities will be used to meet the regional renewable electricity targets.

²³ Three Midwest states have solar set-aside requirements: 1.5 percent solar PV by 2025 in Illinois, 0.3 percent solar electric by 2021 in Missouri, and 0.5 percent solar electric by 2024 in Ohio.

²⁴ Solar photovoltaics have shown substantial cost reductions since our analysis was completed. In 2010 weighted average system prices declined 20.5 percent (SEIA 2010), a substantially higher rate than our estimate.

Our analysis takes into account electricity produced from natural gas needed to meet peak demand. Still, the amount of natural gas generation—which now plays a much smaller role than coal in the Midwest electricity mix—declines under our core policy case, as the region deploys more renewable energy. However, the recent drop in natural gas prices, combined with the growing list of announced coal plant retirements, could lead to a much larger role for gas generation in the Midwest than projected under our base case or policy scenarios (Bradley et al. 2010; Smith 2010). Ramping up natural gas-based electricity in the Midwest (and elsewhere) would likely result in further cuts in coal-based power (Kaplan 2010; Casten 2009).²⁵

Nuclear power generation remains unchanged by the Midwest’s pursuit of the Energy Roadmap targets. No new nuclear facilities would be brought online in the region during the forecast period, either in the base case or policy scenarios. As a result, nuclear generation remains relatively flat from 2010 to 2029 and declines by 3 percent in 2030, owing to a few expected retirements of reactors at the end of their operating license.²⁶

The regional EERS makes the largest contribution to displacing existing fossil fuel-based electricity while meeting new demand for power. After accounting for efficiency gains stemming from existing state policies, other efficiency measures—such as advanced buildings and industrial processes, and high-efficiency appliances, lighting, and motors—reduce power demand in the Midwest by the equivalent of 20 percent of sales by 2030.

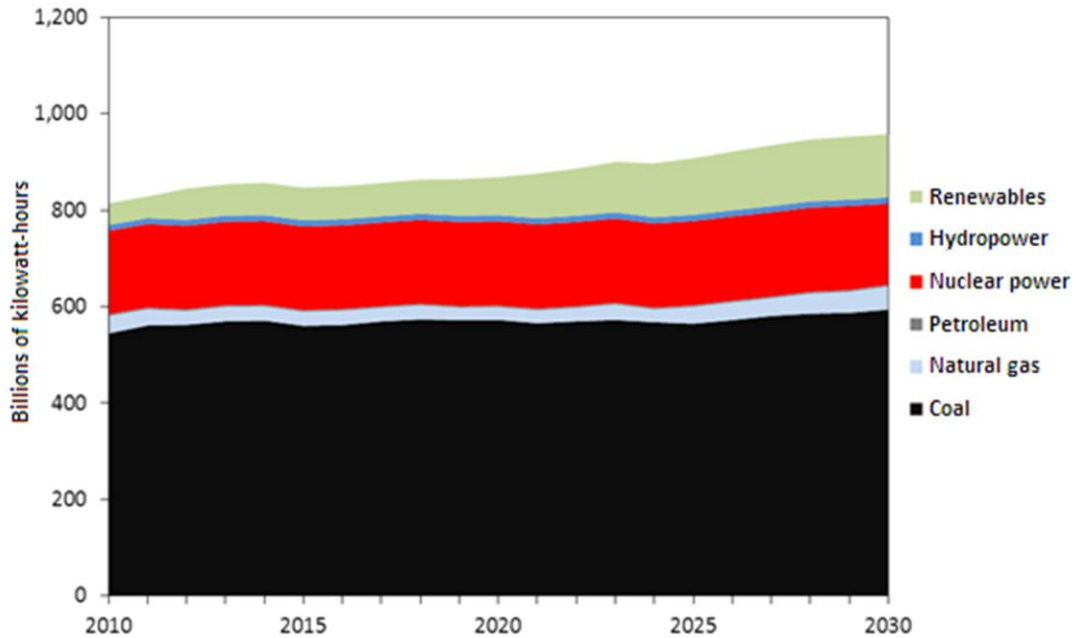
²⁵ Current natural gas prices—and long-term price projections—have fallen significantly from record highs in 2008, partly as a result of increased domestic production capacity due to technological breakthroughs in drilling. For a more detailed discussion of how current economic, technological, and policy trends could affect the role of natural gas in displacing coal generation, see B. Freese et al. 2011 (*A Risky Proposition: The Financial Hazards of New Investments in Coal Plants*), online at http://www.ucsusa.org/clean_energy/technology_and_impacts/impacts/financial-hazards-of-coal-plant-investments.html.

²⁶ We adopted the EIA’s assumption that all existing nuclear plants will be relicensed for 20 years, and then retired after operating for 60 years.

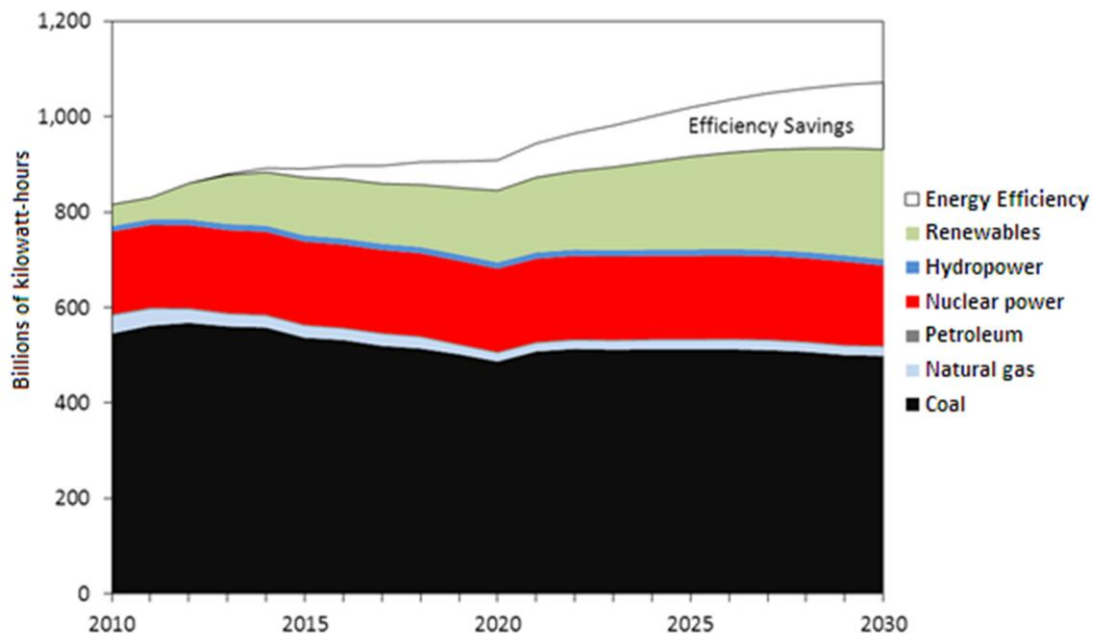
Figure 4.2. Sources of Electricity under Two Scenarios

Greater reliance on renewable energy and energy efficiency reduces the need to generate power from coal and other fossil fuels in the Midwest. Under the Energy Roadmap targets, coal-based generation would drop by nearly 9 percent from 2010 levels by 2030, and by 16 percent compared with existing policies.

Existing Policies Case



Energy Roadmap: Core Policy Case



Changes in Consumer Energy Prices and Bills

Consumers across the Midwest stand to realize big savings on their energy bills if the region implements the Energy Roadmap targets for renewable energy and energy efficiency, compared with existing policies. Investments in energy efficiency deliver much of these savings by reducing power demand in homes, businesses, and industry. Greater use of renewable energy and energy efficiency reduces demand for fossil fuel and creates more competition in the regional energy market. This leads to slightly lower prices for the coal and natural gas used to generate electricity, as well as that used to provide heat for buildings and industrial uses.

Consumer electricity prices in the Midwest would be 0.7 percent lower beginning in 2012, 2.2 percent lower in 2020, and 11.6 percent lower by 2030, under the Energy Roadmap targets, compared with existing policies. Annual consumer electricity prices would be 4.4 percent lower, on average, from 2010 to 2030. Annual consumer natural gas prices would be 0.8 percent lower, on average, starting with a 0.2 percent savings in 2011, and increasing to 0.6 percent in 2020, and 1.6 percent in 2030.

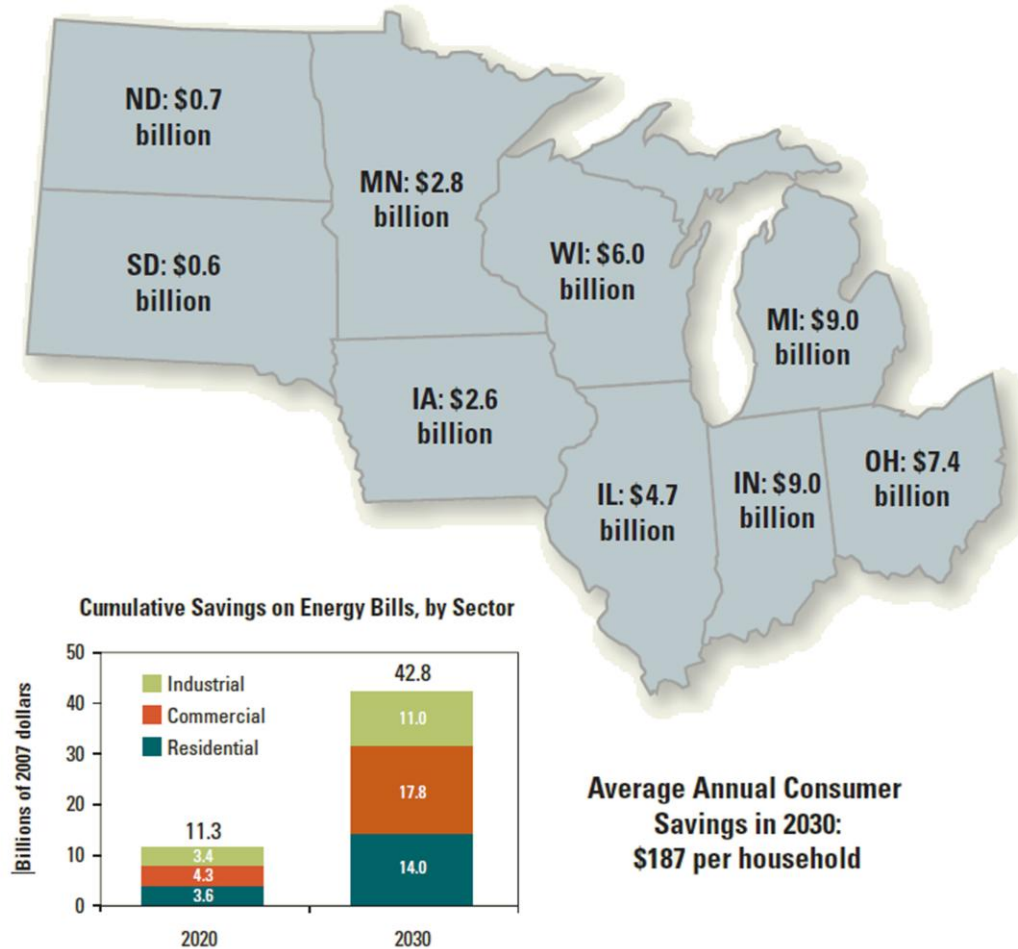
Savings from reduced energy consumption and lower prices for natural gas and other fossil fuels more than offset the costs of investing in renewables and efficiency. Cumulative savings for Midwest consumers on their electricity and natural gas bills would reach \$11.3 billion by 2020, and \$42.8 billion by 2030, with all sectors of the economy and all Midwest states sharing in those savings (Figure 4.3).²⁷

The typical Midwest family would begin to see small savings in annual gas and electricity costs in 2011, with annual electricity savings reaching \$61 by 2020 and \$179 by 2030, and annual natural gas savings reaching \$3 by 2020 and \$8 by 2030. A typical household would save \$78 annually on electricity and natural gas bills from 2010 to 2030.

²⁷ All cumulative figures are discounted using a real discount rate of 7 percent.

Figure 4.3. Cumulative Consumer Savings on Energy Bills, 2010–2030

Savings from reduced energy consumption and lower prices for natural gas and other fossil fuels more than offset the costs of investing in renewables and efficiency. Consumers across the Midwest stand to realize big savings on their energy bills if states implement the Energy Roadmap targets for renewable energy and energy efficiency.



Note: Results are in 2007 dollars and rely on a 7 percent real discount rate.

Job Creation and Other Economic Development Benefits

The renewable energy sector has been one of the few bright spots for struggling job markets in many Midwest states. In Ohio, one recent estimate cites 169 Ohio-based companies as contributing to the manufacturing supply chains of the wind and solar

industries.²⁸ Toledo has become a national hub for thin-film solar cell research and manufacturing (Craig, Learner, and Gray 2011a).

As a hub of wind development in the region, Iowa has attracted major facilities for manufacturing towers and blades and assembling turbine components (AWEA 2011b). Illinois boasts more than 100 companies participating in the wind energy supply chain, supporting 15,000 employees (Craig, Learner, and Gray 2010). And Michigan has more than 240 manufacturing firms in the wind and solar supply chain (Craig, Learner, and Gray 2011b).

In fact, just about every Midwest state now has a facility used to manufacture or assemble wind turbine equipment (Wiser and Bolinger 2010). Midwest states have attracted clean energy companies because of their strong renewable energy resources, skilled labor force, manufacturing infrastructure, access to transportation, and state laws and incentives that support investment in renewable energy.

Further investments in renewable energy and energy efficiency spurred by the clean energy targets would lead to significant new job opportunities and other local benefits throughout the region. By 2030, the new clean energy investments needed to achieve the RES and EERS in the Energy Roadmap would result in a net increase of 85,000 jobs in Midwest states. These jobs would produce an additional \$4.1 billion in income and \$2.7 billion in gross state product in 2030, compared with existing policies. The benefits would span numerous sectors of the regional economy, including manufacturing, construction, operations, maintenance, agriculture, forestry, finance, and retail.

Beyond jobs related directly to the renewable energy and energy efficiency industries, our analysis includes indirect jobs created in industries that support the renewable energy and energy efficiency sectors, as well as “induced” jobs added when income from these direct and indirect jobs and savings on consumer energy bills are spent in the local economy. As noted, our results include only net new jobs in the Midwest stemming from the Energy Roadmap targets. They do not include effects on jobs outside the region (both jobs gained to support Midwest investments and jobs lost from displaced fossil fuels), or jobs created in the Midwest from new export opportunities from expanded manufacturing facilities.

Transitioning to a cleaner, safer energy system would curb job opportunities in the fossil fuel sector, and our analysis takes this into account. However, those job losses are far outweighed by job gains from investments in renewable energy and energy efficiency. Investments in clean energy typically deliver more jobs than electricity based on fossil fuel generation because a larger share of the money is spent in the regional economy, and on labor-intensive sectors such as component manufacturing, installation, and maintenance. By contrast, much of the expenditures on power production from coal and natural gas plants flow to states outside the region, and support less labor-intensive fuel extraction and transportation.

²⁸ Other estimates, which include more links in the supply chain as well as emerging companies, report a much higher number of companies (OH DOD 2010).

The Midwest spends a significant amount of money importing fossil fuels from outside the region. In 2008, for example, the Midwest imported 63 percent of the coal used in its power plants from as far away as Wyoming, sending \$7.5 billion out of the region (Deyette and Freese 2010). Almost all the natural gas used to produce electricity and fulfill other energy needs is also imported into the region. Substituting local clean energy for fossil fuels can help reduce out-of-state fossil fuel purchases and keep more money circulating in local economies across the Midwest. Meeting the Energy Roadmap targets would cut the region's coal and other fossil fuel expenditures \$2.1 billion per year in 2030.

An important benefit of the new clean energy job opportunities is their distribution across the region. Large-scale renewable energy facilities can be sited in rural areas with the best wind resources and capacity to produce biomass feedstocks. Solar panels and energy efficiency technologies can be installed anywhere, from homes, businesses, and public buildings in major cities and suburbs to small farms and remote locations. From machine shops to foundries to assembly facilities, the Midwest's strong industrial base can also be deployed to manufacture and build components for wind turbines, solar photovoltaic panels and films, and biomass facilities. Expanding the region's manufacturing base can also create promising export opportunities, given the rapidly growing commitment of other states and the rest of the world to improving energy efficiency and expanding renewable energy use.

Achieving the Energy Roadmap targets would also provide an important boost to the Midwest economy by spurring innovation and entrepreneurship, and injecting private-sector investment in the region. Through 2030, additional capital investment in renewable energy and energy efficiency would reach \$38 billion. When the investment driven by existing renewable energy and energy efficiency policies in the region is included, capital investment would total \$66.1 billion by 2030. Wind power and energy efficiency technologies represent the largest shares of new capital investment.

Investments in solar photovoltaics are driven primarily by technology-specific requirements under existing RES policies in several states, and by federal investment tax credits. Meeting the regional RES would not result in significant additional solar investments. Nevertheless, \$7.2 billion would be invested in the solar industry in the Midwest over the next two decades, largely to supply distributed residential and commercial PV.

Beyond jobs and capital investments benefiting local economies, farmers and other landowners in rural areas would gain income under the Energy Roadmap targets from the harvest and sale of biomass products, and from lease payments for wind turbines installed on their land. Cumulative biomass payments would reach \$4.3 billion by 2030—an increase of \$612 million compared with existing policies. Cumulative wind land-lease payments would total \$660 million—\$390 million more than under existing policies. If farmers and other landowners owned the wind turbines, revenues to them and local communities would be even higher.

Local communities would also receive some \$3.4 billion in cumulative new property taxes from investments in renewable energy by 2030—\$1.6 billion more than under

existing policies. These substantial increases in local coffers, especially in rural communities, could help fund schools and other vital public services.

Reducing CO₂ Emissions

If left unchecked, heat-trapping emissions such as CO₂ will worsen global warming, which already threatens our health and environment. Failure to reduce global emissions would have significant consequences for the Midwest, which would increase in severity throughout the century. A recent analysis found that unabated climate change will lead to scorching summers and related heat emergencies, dangerous storms and flooding, and more stress on agriculture throughout the Midwest (Hayhoe et al. 2009).

Fortunately, renewable energy and energy efficiency are smart and affordable global warming solutions that cut CO₂ emissions by reducing fossil fuel use. The Energy Roadmap targets would lower CO₂ emissions from Midwest power plants by more than 120 million metric tons annually by 2030 (16 percent below base-case levels)—equivalent to the annual emissions from 30 typical new coal plants. These reductions are greater than the energy-related CO₂ emissions of 183 nations in 2009 (EIA 2011a). The reductions are also on top of those that will occur because of existing renewable energy and energy efficiency policies in the Midwest.

Along with cutting global warming emissions, reduced fossil fuel use would curb other harmful air pollutants from power plants, such as mercury and sulfur dioxide, and limit damage to our water and land from the extraction, transport, and containment of wastes from fossil fuel.

In fact, the damage to public health and the environment caused by our dependence on fossil fuels exacts a major toll on the U.S. economy. Harvard Medical School researchers found that the total cost of damage caused by coal use alone approaches \$523 billion per year nationally, which would add as much as 27 cents per kilowatt-hour to the cost of coal if plant owners had to pay for it (Epstein et al. 2011). Our analysis does not account for reductions in harm to public health and the environment resulting from cuts in coal use under the Energy Roadmap targets. Our results therefore underestimate the economic benefits to the Midwest from clean energy investments.

Detailed Results: Alternative Technology Pathway

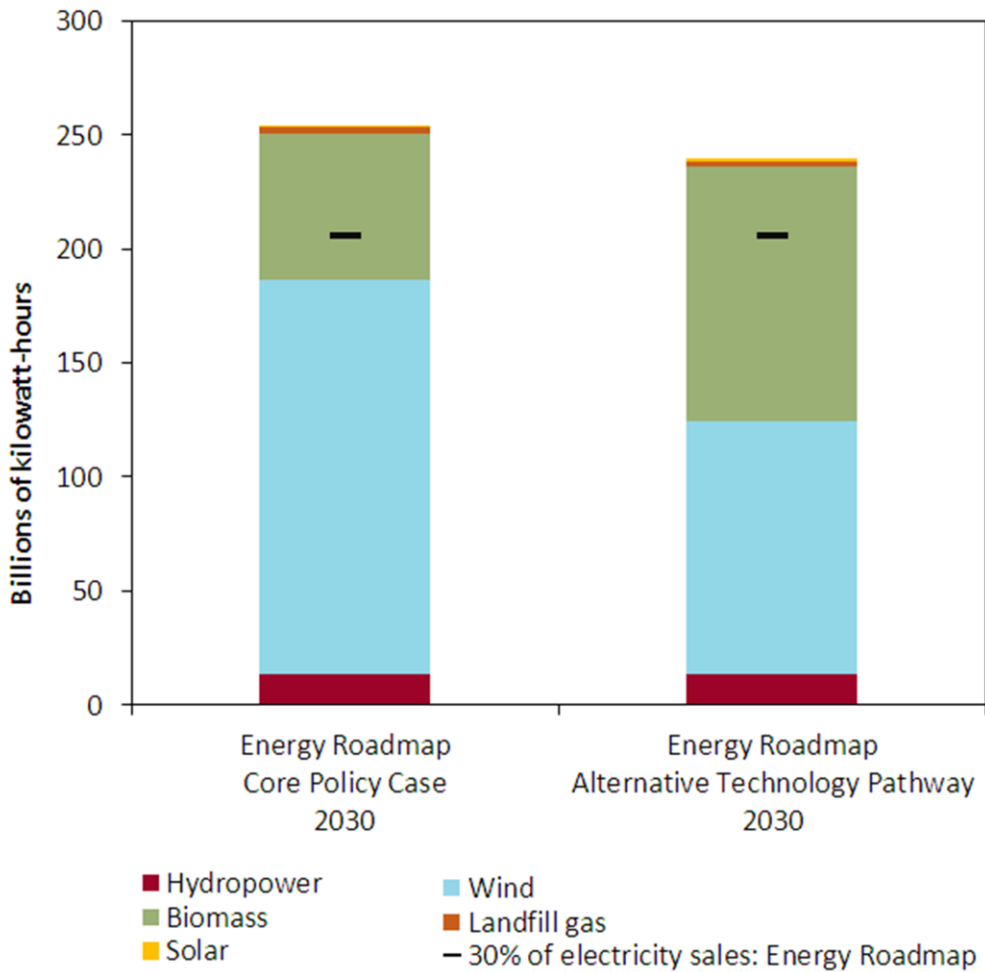
Given its abundant and diverse potential for renewable energy, the Midwest could rely on a range of technology mixes to meet the Energy Roadmap targets. Even small changes in assumptions about the cost, performance, and siting and supply constraints of each technology affect the resulting electricity mix.

Our alternative technology pathway assumes that some of the significant constraints facing biomass development can be overcome, leading to lower costs and better performance assumptions for the use of biopower. While these assumptions alter the mix of electricity generation based on renewable energy, the region can still achieve the Energy Roadmap targets affordably while reaping similar levels of job creation, economic development, and environmental benefits.

As with our core policy case, meeting the Energy Roadmap targets under our alternative technology pathway spurs the development of a diverse mix of renewable energy technologies. The biggest difference between the two cases is the relative contributions of wind power and biomass co-firing in existing coal plants (Figure 4.4).

**Figure 4.4. Electricity from Renewables in the Midwest, 2030:
Core Policy Case vs. Alternative Technology Pathway**

Under the alternative technology pathway, which assumes that some of the significant constraints facing biomass development can be overcome, the Midwest would use more biomass to meet the Energy Roadmap targets while reaping similar levels of job creation, economic development, and environmental benefits.



Under our alternative technology pathway, biopower technologies account for 47 percent of total Midwest renewable energy generation in 2030, nearly two-thirds of which comes from co-firing. The significant growth in co-firing generation compared with our core

policy case stems from more competitive biomass supply costs and a higher limit on co-firing. As a result, nearly 11,000 MW of coal capacity in the Midwest is converted to co-firing by 2030—up from less than 90 MW in 2010, and a 130 percent increase compared with existing policies.

Wind generation also plays a substantial role under this case, accounting for about 46 percent of the Midwest renewable energy mix in 2030. More than 21,000 MW of wind capacity is added in Midwest states by 2030, reaching 33,240 MW—a nearly 60 percent increase over the levels needed to meet existing renewable electricity standards.

Increasing renewable energy and energy efficiency under the alternative technology pathway provides consumer, employment, local economic, and environmental benefits similar to those under our core policy case (Table 4.1). Job creation and capital investments are somewhat lower under the alternative pathway, because a larger share of the renewable energy target is met by co-firing of biomass at existing coal plants, which is less capital intensive than building wind facilities. Conversely, the greater use of biomass under the alternative technology pathway puts more money into the pockets of rural landowners from the harvest and sale of biomass products.

**Table 4.1. Economic and Environmental Benefits:
Core Policy Case vs. Alternative Technology Pathway**

	Core Policy Case	Alternative Technology Pathway
Savings on Electricity and Natural Gas Bills (cumulative)		
2010–2020	\$11.3 billion	\$13.2 billion
2010–2030	\$42.8 billion	\$42.4 billion
Annual household savings, 2030	\$187	\$169
Net Job and Other Economic Benefits (in 2030)		
Net job creation	85,700	77,000
Income	\$4.2 billion	\$3.5 billion
Gains in gross state product	\$2.8 billion	\$2.3 billion
Other Net Economic Benefits (cumulative 2010–2030)		
New capital investment in renewable energy	\$26.4 billion	\$11.3 billion
New capital investment in energy efficiency	\$14.5 billion	\$14.5 billion
Biomass payments	\$610 million	\$3.2 billion
Wind land-lease payments	\$390 million	\$160 million
Property tax revenues	\$3.5 billion	\$1.5 billion
Reductions in CO ₂ Emissions from Power Plants (in 2030)		
Reduction in CO ₂ emissions and percent change from base case	130 million metric tons (16.7 percent)	120 million metric tons (15.5 percent)

Impact of a Federal Carbon Policy on the Midwest and the Energy Roadmap

Achieving the renewable energy and energy efficiency targets in the Energy Roadmap would be a responsible step toward reducing global warming emissions in the Midwest—which is among the nation’s largest sources. However, the targets in the Energy Roadmap are not substitutes for a comprehensive federal policy. To avoid the most dangerous effects of climate change, the United States must cut emissions deeply—by at least 80 percent below 2005 levels by 2050 (Gupta et al. 2007; Luers et al. 2007).

An important approach to making these cuts is a robust federal policy that achieves the needed reductions over time, puts a price on carbon through a compliance system that requires polluters to pay for their emissions, and invests the resulting funds in energy efficiency, renewable energy, and other promising low-carbon technologies.

Our analysis examined the effect of combining a strong federal carbon policy with our alternative technology pathway. We found that implementing the Energy Roadmap targets would help the Midwest achieve its share of federal cuts in carbon emissions, and would result in lower consumer costs than under a federal policy alone.

Combining a federal carbon policy with the Energy Roadmap targets makes the federal policy more affordable for Midwest consumers. Under this approach, cumulative electricity and natural gas bills would be 2 percent lower by 2030 than under our base case—and in contrast to a 3 percent increase in cumulative energy costs under a federal carbon policy alone.²⁹

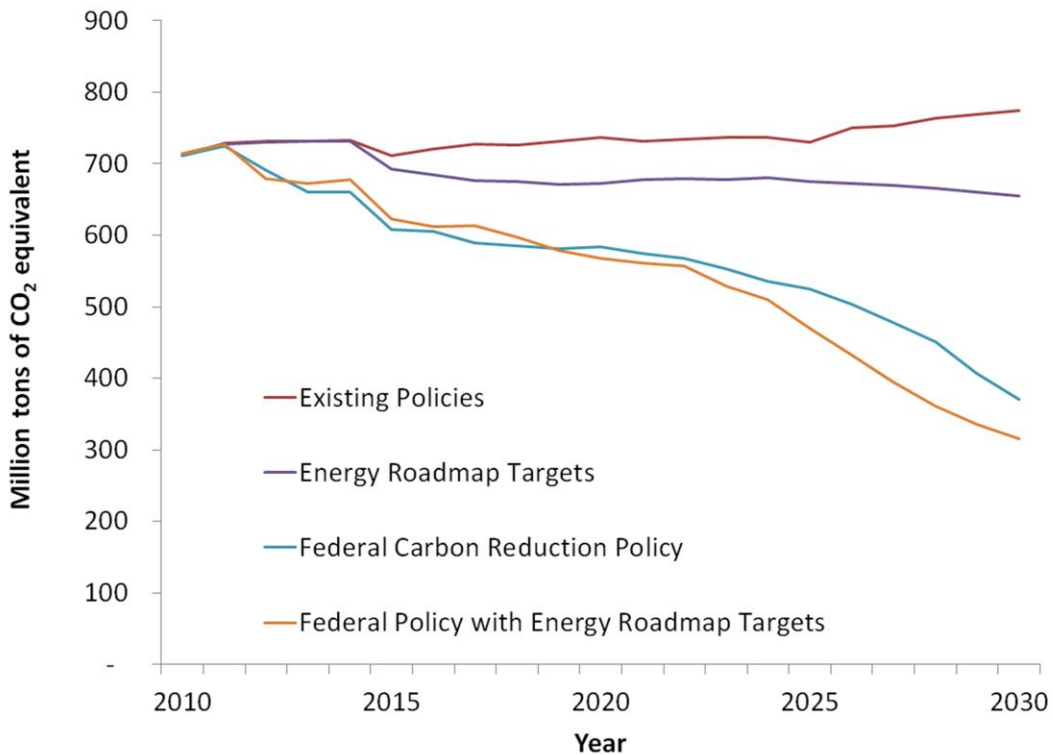
In other words, the savings that result from meeting the Energy Roadmap targets more than offset the added costs of a federal carbon policy, and make it affordable for consumers. Under a federal policy combined with the Energy Roadmap targets, renewable electricity generation in the Midwest would also be 10 percent higher than under the federal policy alone,³⁰ and 47 percent higher than under the Energy Roadmap alone, producing much greater local economic benefits.

²⁹ For comparative purposes, we evaluated energy prices and bills across two census regions: East North Central and West North Central. These regions include states other than the nine that are the primary focus of this report.

³⁰ We did not process regional results from the model to the state level for our federal carbon policy. Instead, we analyzed the NEMS regions that include Midwest states to compare the federal carbon policy case, the Energy Roadmap cases, and the existing policies case. Because these regions include states that are not part of the MGA and therefore would not implement the Energy Roadmap targets, this approach underestimates the percent increase in clean power in the MGA states, where more investments in renewables and energy efficiency would occur.

Figure 4.5. Comparison of CO₂ Emissions from Midwest Power Plants

While meeting the Energy Roadmap targets would reduce CO₂ emissions significantly, a comprehensive federal policy is essential if the United States hopes to avoid the most dangerous effects of climate change. The Energy Roadmap targets would help the Midwest achieve its share of federal cuts in carbon emissions, and would help make a federal policy more affordable by lowering costs to consumers in the Midwest.



A federal carbon policy would also significantly displace fossil fuel–based electricity throughout the region: coal generation would fall by 41 percent from 2010 to 2030, and by 49 percent under a federal policy combined with the Energy Roadmap targets. And while the Energy Roadmap targets reduce fossil fuel–based electricity and CO₂ emissions compared with existing policies, the decline would be much steeper under a federal carbon policy, and even deeper under a federal carbon policy combined with the Energy Roadmap targets (Figure 4.5).

A federal carbon policy alone would lower CO₂ emissions from Midwest power plants by 404 million metric tons annually by 2030—52 percent lower than under the base case.

Implementing the Energy Roadmap targets with a federal carbon policy would cut annual CO₂ emissions even further: by 459 million metric tons by 2030, or 59 percent below base case levels.

Chapter 5. Policy Recommendations: Setting a Course for a Midwest Clean Energy Future

Placing Midwest states on a sensible and attainable path toward a clean energy future can help solve several of the region's challenges: creating jobs, boosting the economy, cutting dependence on coal, and reducing the heat-trapping emissions that cause global warming.

Our analysis shows that meeting the renewable energy and energy efficiency targets in the Energy Roadmap would provide significant economic and environmental benefits for the Midwest. Investing in clean energy will spur innovation and entrepreneurship, help revitalize the manufacturing sector, and create tens of thousands of jobs. These investments will make energy more affordable for families and businesses, boost local economies, and help keep the region globally competitive. Tapping the region's ample renewable energy and energy efficiency resources will position the Midwest as a clean energy leader, and confer distinct advantages over other regions should the federal government implement policies that limit carbon emissions.

This chapter details some of the critical renewable energy, energy efficiency, and climate policies that would help the Midwest transition to a clean energy future.

Key Policies for Cleaner Electricity

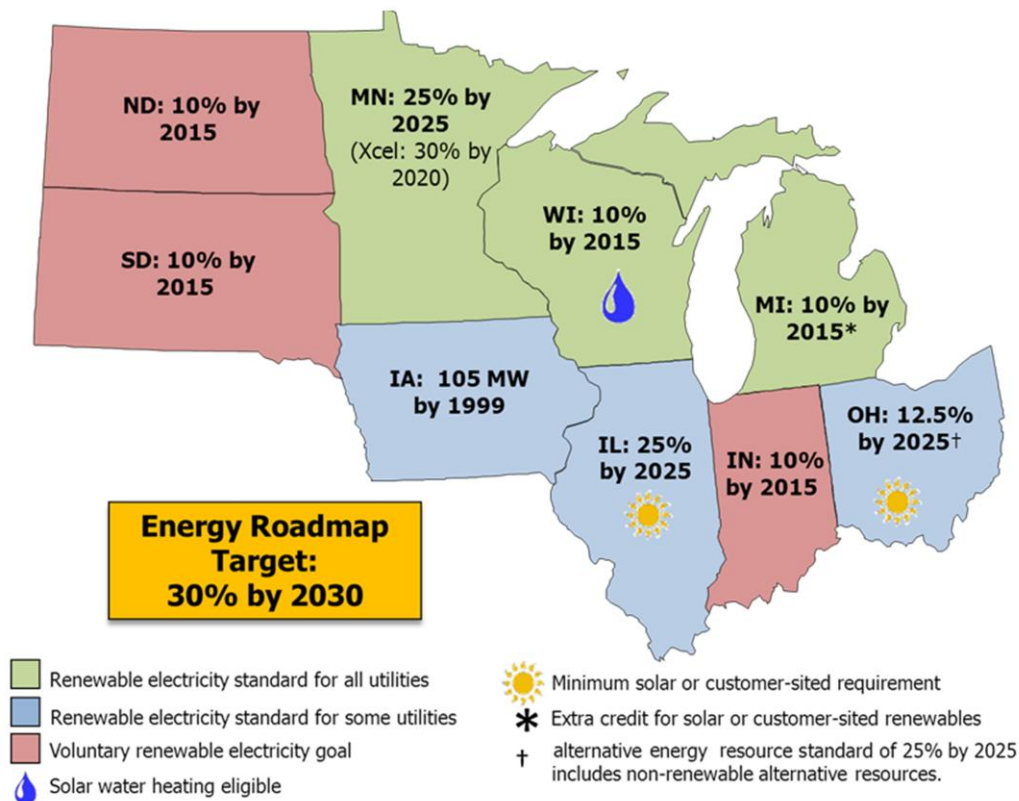
The Midwest is rich in renewable energy resources and the know-how to capitalize on them. However, taking full advantage of this opportunity requires smart and practical actions to give clean power solutions a strong foundation:

Enact or enhance state renewable electricity standards to match the Energy Roadmap targets. State RESs have been a key driver of record-breaking growth in electricity from renewables over the past decade, accounting for at least 60 percent of total non-hydro additions to that capacity from 1998 to 2009 (Wiser 2010). The Energy Roadmap targets must be implemented on a state-by-state basis, but the Midwest will benefit most when every state adopts the targets of 10 percent of electricity from renewables by 2015, and 30 percent by 2030, for all electric utilities.

Leading states, such as California, Colorado, and Hawaii, have made renewable energy commitments at or above the Energy Roadmap target. In the Midwest, Minnesota and Illinois are on track to meet the Energy Roadmap target, with RESs of 25 percent by 2025 for most utilities. In Minnesota, Xcel Energy must achieve a higher 30 percent RES by 2020. Other Midwest states have made significant progress in implementing RES policies, but none have committed to meeting the Energy Roadmap's 30 percent target (Figure 5.1).

Figure 5.1. Existing Renewable Electricity Standards and Voluntary Goals in the Midwest

Many Midwest states have established an RES, seeing it as an effective policy for deploying renewable energy technologies. Enacting or enhancing a renewable energy standard to match the Energy Roadmap target would produce additional benefits across the region.



Source: Adapted from DSIRE 2011.

Support a national renewable electricity standard of at least 25 percent by 2025. Congressional delegations from Midwest states should support a national RES of at least 25 percent by 2025, with a national credit-trading system as a means of compliance. Studies have shown that such an approach is feasible and affordable, and would significantly reduce carbon emissions from the electricity sector (UCS 2009b; Noguee, Deyette, and Clemmer 2007).

A national approach would also provide additional economic opportunities for the Midwest. For example, a national RES would spread responsibility for transitioning to a

clean energy economy across all states, and create a large market for the Midwest to export electricity based on renewables or credits. A federal standard would also create new markets for sending renewable energy equipment manufactured in the Midwest to other states.

Extend tax and other financial incentives for renewable energy. Short-term, on-again/off-again extensions of tax credits for renewable energy have produced a boom-and-bust cycle that injects needless uncertainty into the financing and construction of such projects and raises their cost. Congressional delegations from Midwest states should support a long-term extension of federal incentive programs such as the production tax credit, which is set to expire at the end of 2012 for wind and biopower. States should also consider adopting tax credits and other incentives to supplement federal policies.

Increase funding for research and development on energy efficiency and renewable energy. A significant increase in R&D funding for clean energy technologies is needed to lower their costs and spur widespread use. Midwest universities and research institutions have a world-class reputation for driving technological innovation, and should play a central role in finding and improving clean energy solutions. To ensure adequate R&D resources, states should support greater funding at both federal and state levels.

Resolve state and local conflicts around siting electricity transmission lines and renewable energy projects. It is critical that policy makers reduce the state-by-state balkanization that is crippling the creation of a nationwide grid for renewable energy. States should remove regulatory barriers to regional transmission planning, siting, and approval, and adopt model legislation that enhances the ability of utility regulatory commissions in each jurisdiction to consider and approve multi-jurisdictional transmission projects.

Policy makers should also support efforts now under way to plan and facilitate new capacity to transmit electricity in the Midwest, and allocate the costs of that capacity. These efforts include:

- The Midwest ISO's *Regional Generator Outlet Study* (MISO 2010).
- The Eastern Interconnection Planning Collaborative Transmission Study.
- Planning and development of renewable energy zones and the transmission needed to support them in each jurisdiction.
- Efforts to equitably and effectively allocate the costs of financing regional transmission. Collaboration among the Midwest ISO, the Cost Allocation and Regional Planning Work Group of the Organization of Midwest ISO States, and the Upper Midwest Transmission Development Initiative should continue.
- Other initiatives by the Midwest ISO and other regional transmission operators around grid integration.

Cooperation in enhancing and expediting transmission capacity in the Midwest and nationally will bring added benefits to the region: a stronger, more reliable grid, more opportunities for exporting renewable energy and equipment to other states, and new jobs associated with building and maintaining an enhanced grid. Delivering some of these

benefits will require giving the Federal Energy Regulatory Commission more authority to expedite new transmission capacity for renewable energy projects.

Besides resolving transmission bottlenecks, Midwest policy makers should streamline the approval process for siting renewable energy projects, and improve cooperation between local, state, and federal agencies while ensuring responsible development. Siting guidelines should be fair, equitable, and based on best practices informed by the latest research on transmission technology.

Ensure the sustainability of biopower. The region needs to promote the development of a sustainable and reliable biomass supply system. It could do so by developing sustainability guidelines and best management practices, funding research on inventories of biomass potential and effective biomass feedstocks, and coordinating regional strategies to develop the technology. Sustainability guidelines should include:

- Accounting for lifecycle global warming emissions—including those from growing and transporting biomass—for each type of feedstock, conversion technology, and location, based on scientific research.
- Protection for conservation land, natural ecosystems, and threatened or endangered species or unique ecosystems.
- Avoidance of air pollutants identified under the Clean Air Act, such as nitrous oxides, sulfur oxides, particulates, and volatile organic compounds.
- Measures that encourage the most energy-efficient use of biomass feedstocks, in line with local demand and infrastructure.
- Regional and local variations that affect sustainable feedstock management and procurement, with policies and programs tailored to regions or even localities.

Federal and regional policies should set minimum standards and rules that apply to all market players, while preserving rather than preempting the ability of states to implement more stringent rules. Practical and effective enforcement and certification of sustainable practices must also be part of any policy.

Key Policies for Energy Efficiency

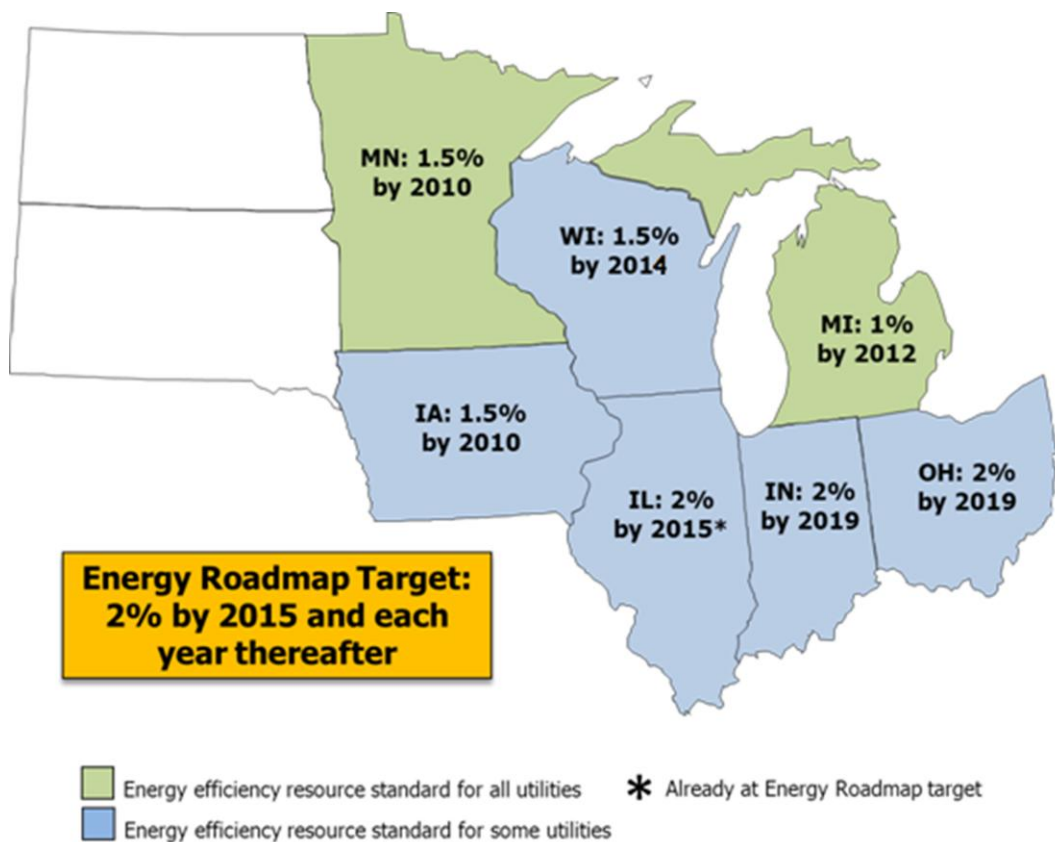
Making our industries and buildings more efficient must be a cornerstone of any comprehensive strategy for transitioning to a clean energy economy. Energy efficiency can quickly yield significant and sustained reductions in energy use, while providing substantial savings on energy bills for consumers and businesses. Creating a highly energy-efficient economy, however, requires policies and programs to help overcome significant and entrenched market barriers.

Enact or enhance an energy efficiency resource standard to match the Energy Roadmap targets. Many Midwest states have established an EERS, seeing it as an effective policy for deploying energy efficiency technologies. However, only one state in the region (Illinois) has committed to achieving the Energy Roadmap's target of 2 percent annual reductions in electricity sales by 2015 and thereafter (Figure 5.2).

The Energy Roadmap’s efficiency targets are consistent with actual efficiency gains and commitments by other leading states, including Arizona, Massachusetts, New York, and Vermont (Molina et al. 2010). In the Midwest, North Dakota and South Dakota should adopt EERS policies, while other states with EERSs should increase or accelerate their annual targets, and ensure that they apply to all electric utilities. To help meet their targets and remove key market barriers, states can also create new public benefits funds, which are furnished by a small charge on all electricity sold and support investments in efficiency technologies, or strengthen existing ones.

Figure 5.2. Existing Energy Efficiency Resource Standards in the Midwest

Many Midwest states have established an EERS, seeing it as an effective policy for deploying energy efficiency technologies. Enacting or enhancing an energy efficiency resource standard to match the Energy Roadmap target would produce additional benefits for consumers across the region.



Source: Adapted from DSIRE 2011.

Note: Numbers represent percent annual reduction in electricity sales.

Use regulatory mechanisms to change utility incentives. To complement mandatory energy efficiency programs for utilities, Midwest states should adopt regulatory mechanisms that remove utilities' traditional reluctance to sell less energy. These should include incentives for investments in energy efficiency, such as by allowing regulated utilities to recover the costs of such investments and earn profits by meeting efficiency targets. Several of these mechanisms are already in place in Illinois, Michigan, Ohio, and Wisconsin.

Adopt more stringent energy efficiency codes for buildings. All new buildings should comply with the most stringent minimum energy code in effect at the time of construction. Today this is the 2009 international energy conservation code (IEEC) and the 90.1-2010 code of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). These model codes are updated every three years, and every state in the Midwest except North Dakota, South Dakota, Kansas, and Missouri has adopted them, or is in the process of doing so.

States should adopt automatic review clauses to ensure that their codes reflect the latest standards. That approach ensures that builders deploy the most cost-effective technologies and best practices in all new residential and commercial construction. Midwest states should also encourage the use of above-code standards, such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system, and the U.S. Department of Energy's Energy Star program for new homes.

Set a high bar by adopting stringent energy efficiency codes for all government buildings. State governments can save taxpayer funds and provide case studies for owners of commercial buildings by requiring agencies to reduce energy use in their buildings by an annual percentage that is equal to or higher than the Energy Roadmap target.

Spur the deployment of combined-heat-and-power systems. By recovering and reusing the waste heat from producing electricity, CHP systems can achieve efficiencies of up to 80 percent (compared with about 33 percent for the average fossil-fueled power plant). That, in turn, reduces fuel use, emissions, and the need for new transmission capacity. Midwest states should enact standards (and support federal standards) for permitting CHP systems and connecting them to the local power grid, and establish equitable interconnection fees and tariffs for standby, supplemental, and buy-back power. More funding for federal and state programs that spur the use of CHP through education, coordination, and direct project support is also needed.

Accelerate adoption of energy efficiency technologies. Several additional measures are available to accelerate the growth of energy efficiency measures, including consumer education, smart grid technologies, electricity rates that promote energy efficiency, and financing incentives for energy efficiency investments. Every Midwest state has enacted at least one of these policies. However, wider adoption among all states is needed to ensure that the region achieves the 2 percent annual target for improving energy efficiency.

A Comprehensive Federal Policy for Reducing Carbon Emissions

Our analysis shows that meeting the Energy Roadmap targets will help the Midwest transform its economy by spurring investments and research in renewables and energy efficiency. However, that approach is not a substitute for reducing emissions to the levels that most scientists say are essential to prevent the world from warming another 2° F above today's temperatures, when far more serious consequences become inevitable. Efforts to transition to a clean energy economy will ultimately fall short unless we also tackle the central issue in addressing climate change: achieving deep cuts in emissions. The need to get started today is urgent.

A core element of our nation's response to climate change should be a federal carbon policy that moves swiftly to deliver deep cuts in carbon emissions, and charges polluters for their remaining emissions. Such a policy should create a clear market signal that rewards cuts in heat-trapping emissions and drives private investments in clean energy.

Such policies should include several critical features that provide certainty for investors: a mechanism for adjusting emissions targets to the latest science, incentives to support investments in renewables and efficiency, and consumer protections that do not diminish the effect of the policy.³¹ Any federal policy should also preserve the ability of states to implement more stringent climate, energy, and transportation policies.

Midwest states should support efforts to enact comprehensive federal climate policies, as they will spur investment and economic growth in the region. In the absence of federal leadership, Midwest states can help build momentum and experience by enacting their own state and regional programs.

Conclusion: A Vision for a Midwest Clean Electricity Future

From the strong winds of the Great Plains, to the agricultural lands of the Corn Belt, to the sun shining bright from Cleveland, Ohio, to Rapid City, South Dakota, the Midwest is home to some of the world's best renewable energy resources. The region is also endowed with a strong industrial base and leading research universities, where a tradition of hard work and innovation has long served as an economic engine for the entire nation. Few areas of the world have this ideal mix of resources, industrial capacity, and knowledge. These advantages give the Midwest the tools to turn the challenges of a stalled economy and an unsustainable, polluting energy system into an opportunity for economic prosperity, job growth, and a healthy environment.

Achieving the renewable energy and energy efficiency targets set forth in the Energy Roadmap would provide significant economic benefits to the Midwest. Meeting those goals would spur innovation and create tens of thousands of jobs in big cities and small towns across the Midwest. That effort would also provide much-needed savings for families and businesses on their energy bills, and a more diversified, reliable, and secure power supply. Such an endeavor would also move the Midwest away from its

³¹ For more information, see Cleetus, Clemmer, and Friedman 2009 (*Climate 2030: A National Blueprint for a Clean Energy Economy*), online at http://www.ucsusa.org/global_warming/solutions/big_picture_solutions/climate-2030-blueprint.html.

dependence on coal, improving public health and reducing the dangers of global warming and toxic emissions.

Fully capturing these important economic benefits and removing key market barriers will require smart policy solutions. Many Midwest states have already taken important steps to promote clean energy, and they must not retrench. Instead, each state can go further to strengthen or enact policies that at least match the Energy Roadmap targets, and that support local, regional, federal, and international efforts to promote renewable energy, energy efficiency, and cuts in carbon emissions.

States can benefit from enacting these policies individually, but they will benefit even more by acting together. With each state doing its part to promote renewable energy and energy efficiency, all Midwest states will collectively reap many important benefits today while building a clean and sustainable economy for future generations.

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