Energy Sector
Midwest Technical Input Report
National Climate Assessment

CLIMATE CHANGE AND ENERGY

WHITE PAPER PREPARED FOR THE U.S. GLOBAL CHANGE RESEARCH PROGRAM
NATIONAL CLIMATE ASSESSMENT
MIDWEST TECHNICAL INPUT REPORT

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At the request of the U.S. Global Change Research Program, the Great Lakes Integrated Sciences and Assessments Center (GLISA) and the National Laboratory for Agriculture and the Environment formed a Midwest regional team to provide technical input to the National Climate Assessment (NCA). In March 2012, the team submitted their report to the NCA Development and Advisory Committee. This whitepaper is one chapter from the report, focusing on potential impacts, vulnerabilities, and adaptation options to climate variability and change for the energy sector.

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Summary

Both climate change and climate change policy are salient to the energy sector. Climate change policies adopted by the states are already affecting planning and investment decisions as utilities respond to emergent policy requirements under the Clean Air Act and state laws as well as anticipate eventual federal greenhouse gas and other climate and air regulations. The transition away from fossil fuels (particularly coal) to renewable resources, such as wind, photovoltaic, geothermal, hydroelectric, and bioenergy, has significant implications for the tradeoffs among goals of clean, reliable, and affordable energy and the respective institutions and agencies responsible for achieving those goals. Over time, the Midwest region may be comparatively advantaged with respect to climate change impacts by its northern latitude and abundant water resources.

Introduction

Both climate change and climate change policy are intrinsically important to the energy sector. The sector bears considerable, yet not exclusive, responsibility for climate change associated with greenhouse gas (GHG) emissions from fossil-fuel-based production facilities, namely electric power plants. Activity within the energy sector can thus be understood in the context of both problem and solution, where the sector's heavy reliance on fossil fuels makes the sector a target of remedial policies designed to limit and mitigate greenhouse gas emissions. These include rigorous permit processes, emissions targets, scrubbing technologies, and carbon capture methods as well as renewable portfolio standards. Consequently, the pattern of response and adaptation within the sector may be driven as much by climate change policy as by actual and anticipated climate change attributable to energy demand and production.

This review, drawing from both the academic and applied literature, focuses on climate and climate change policy with respect to both the supply-side (production) and the demand-side (consumption) of the sector. Federal and state policy developments are summarized. A number of emerging and critical policy issues are also considered.

While climate change will affect the energy sector, the effects of climate change policy are more immediate and potentially more far-reaching. Climate change considerations permeate modern energy policy, along with concerns about energy security, resource renewability, and economic development. Energy providers are subject to increasingly stringent environmental regulations that require significant investment in emissions reduction, alternative energy resources, transmission facilities, and grid modernization. Simultaneously, replacing and modernizing the aging generation, transmission, and distribution infrastructure (including "smart grid" investments) are adding to cost pressures (American Society of Civil Engineers, 2011). Efficiency gains from standards, conservation programs, and load-management tools will help offset some costs. Even so, utility ratepayers can be expected to bear the cumulative burden of infrastructure investments and environmental mandates as the controversy over costs and their allocation is inevitable.

Structure and Regulation of the Energy Sector

Public utility companies that provide energy services comprise a significant share of the U.S. economy in terms of gross domestic product and employment (Beecher, 2012c) . Utility expenditures also constitute a significant share of household expenditures. Over the last decade, the average percentage change in Consumer Price Index for electricity was approximately 4%, although this rate of change is less than the change for the entire index (Beecher, 2012b).

Publicly and privately owned utilities are subject to federal environmental regulation pursuant to the Federal Clean Air Act (CAA) and Environmental Protection Agency (EPA) rules as well as other environmental mandates (including the National Environmental Policy Act, the Clean Water Act and Toxic Substance Control Acts). Federal and state laws and regulations are implemented through state environmental agencies.

Most electricity and natural gas utilities are privately owned and subject to economic regulation by the Federal Energy Regulatory Commission (FERC) and state public utility commissions. Federal authority is pursuant to the interstate commerce clause. Over the last two decades, energy markets have been substantially restructured, which, in turn, affects how they are regulated. The natural gas industry was restructured in the 1980s, when wellhead production was deregulated; interstate pipeline transmission is subject to federal jurisdiction and local distribution is regulated by the states.

Oversight of the electricity sector varies by state depending on market structure (U.S. Energy Information Administration, 2010). In the past, generation, transmission, and distribution functions were provided by vertically integrated utilities. Vertical integration remains in about half of the states today, including Indiana, Iowa, Minnesota, Missouri, and Wisconsin, and state regulators continued to have comprehensive authority. Illinois and Ohio are considered restructured states, where vertical separation resulted in deregulated (competitive) generation companies and federally regulated transmission providers. In Michigan, transmission was separated but generation and distribution remains integrated and regulated. The federal government oversees bulk power markets through Regional Transmission Organizations (RTOs). Restructuring limits state jurisdiction for the sector to intrastate activities and retail distribution.[1]

Thus, much federal economic regulation focuses on wholesale operations while retail oversight belongs to the states. The prices and profits of vertically integrated and distribution utilities are regulated because they are organized as state-sanctioned monopolies. Various technical and economic characteristics distinguish utilities from other enterprises and contribute to their monopolistic character. Economic regulation is designed to prevent abuse of monopoly power while balancing the interests of utility investors and ratepayers. Regulators review the prudence of utility investments and expenditures in a quasi-

[1] For more on state regulatory jurisdiction, see Institute of Public Utilities jurisdiction survey at ipu.msu.edu/research/pdfs/IPU-Jurisdiction-Survey-2011.xls.

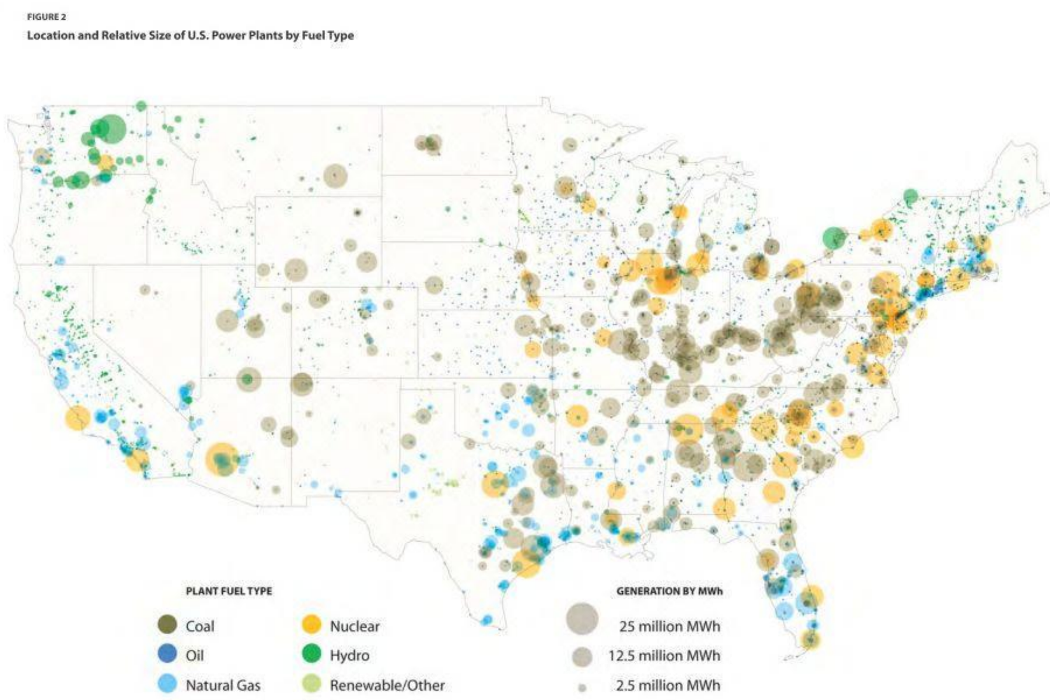

Exhibit 1. *Electricity power plants in the United States and Midwest region. Source: Ceres (2010).*

judicial process prior to their inclusion in rates. Rate-making, or the determination and allocation of a utility's revenue requirements, is controversial, particularly in the contemporary context of rising costs.

In addition to environmental and economic regulation, energy utilities are subject to financial regulation (by the Securities and Exchange Commission), accounting rules (by the Federal Accounting Standards Board), and reliability standards (by the North American Electric Reliability Corporation). Bulk power transmission for various regions is managed by independent system operators such as MISO (Midwest) and PJM (Pennsylvania New Jersey Maryland), which impose planning and operational requirements on market participants, including congestion management and real-time pricing. As a result of extensive oversight, including market monitoring, the transmission sector is considered relatively accountable to regulators and transparent to stakeholders.

Energy Profile for the Midwest

The Midwest region is home to numerous powerplants (Exhibit 1) and continues to rely heavily on coal for generating electricity (Exhibit 2). The region, however, is also home to 25 nuclear power plants, about a quarter of the nation's aging fleet. Among states in the region, Illinois is highest in both production and sales of electricity (Exhibit 3). Traditionally, large central power production has been favored due to substantial and persistent scale economies (declining unit costs) in both construction and operation. Powerplants are owned by regulated utilities or competitive providers, including independent power producers. The power production fleet is aging and much of the recent capital investment has been in peaking facilities as compared to baseload capacity. Between 2000 and 2010, the slight shift toward natural gas and wind energy is attributable to favorable natural gas prices and policy support for renewable energy development. Low market prices for natural gas, spurred by shale development, continue to shape investment decisions in the electricity sector with regard to both fossil and renewable energy (EIA, 2012).

Growth in retail electricity sales in the Midwest actually began to slow prior to the recent recession (Exhibit 4). Socioeconomic trends and efficiency gains will continue to shape demand, which has slowly risen over the last two decades (Exhibit 4). In the short term, recessionary influences are apparent. Loss of manufacturing base and population for some of the region's legacy cities, however, will likely affect demand over a longer horizon. Higher prices, driven by higher costs, will continue to influence price sensitive (elastic) demand. Price engineering (dynamic pricing enabled by smart grid technologies) will likely be used to shape demand deliberately. Average electricity prices in the region for 2010 are comparable or below the national average (Exhibit 5), reflecting the cost of infrastructure, resources, and, increasingly, environmental mandates.

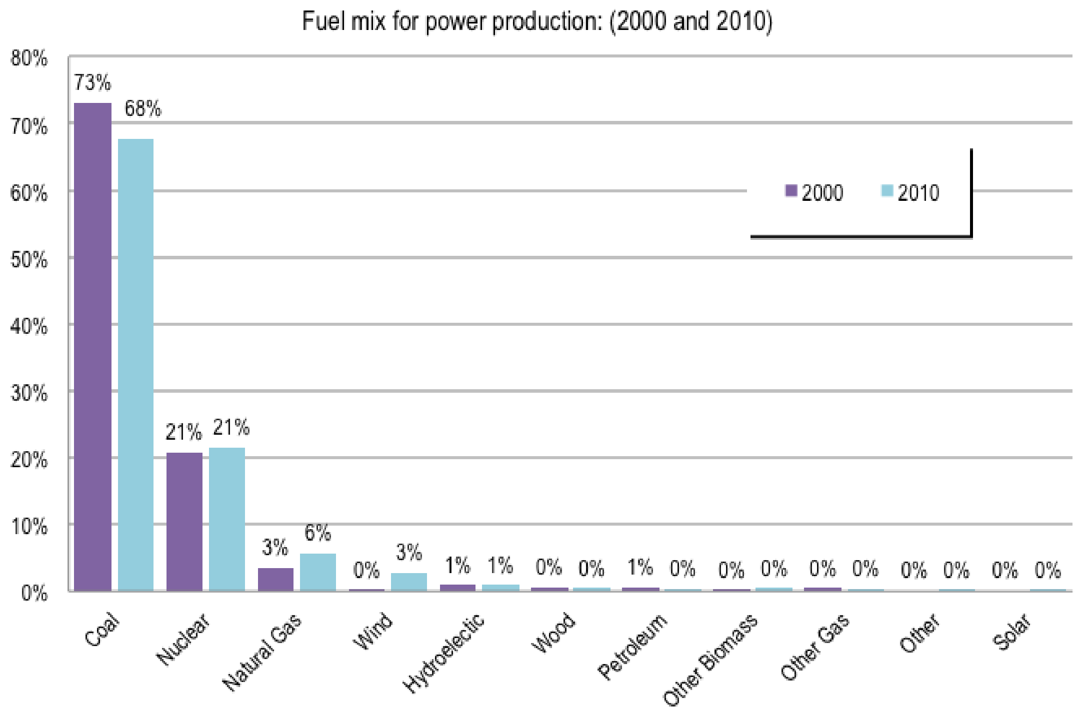

Exhibit 2. *Fuel mix for power production in the Midwest region Source: Authors' construct from EIA, "Electricity" (2010).*

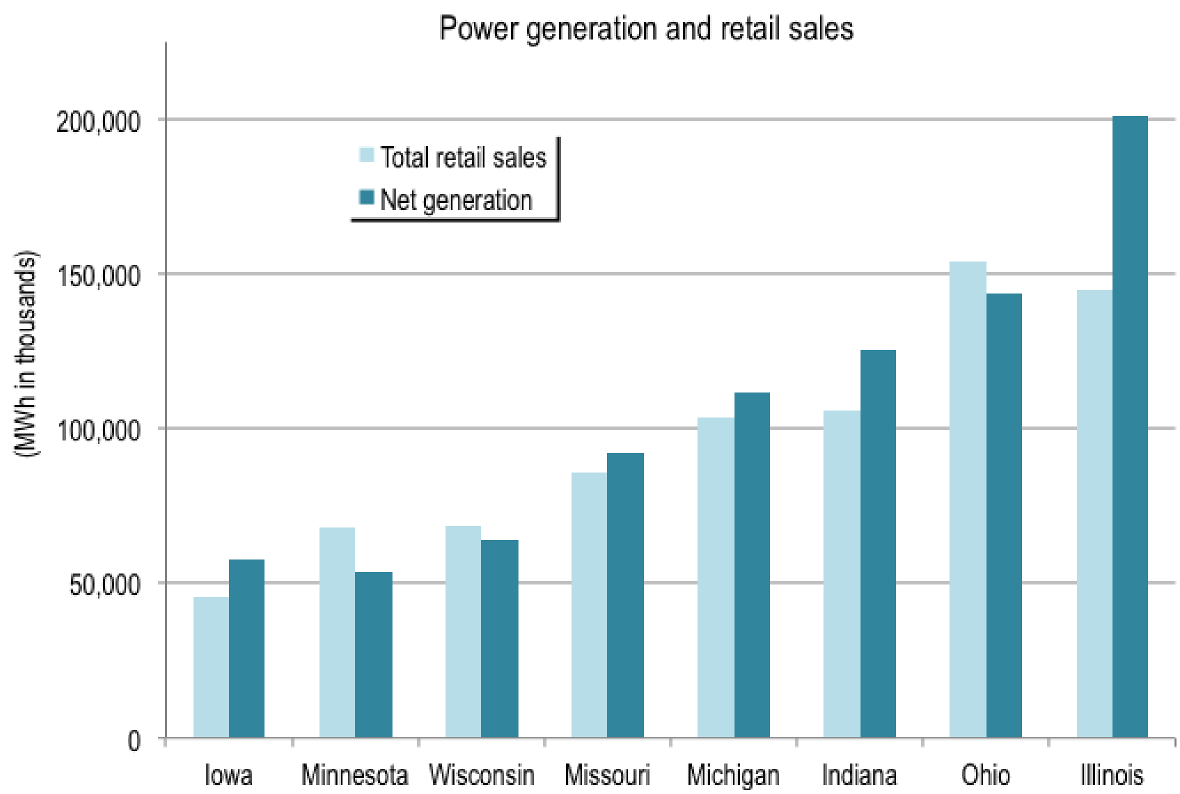

Exhibit 3. *Power generation and retail sales in the Midwest region. Source: Authors' construct from EIA, "Electricity" (2010).*

Impacts on the Energy Sector

The impacts of climate change and climate change policy on the energy sector can be organized into demand-side and supply-side issues, as represented by the framework in Exhibit 6. The demand side considers effects on how and when energy is used by consumers. The supply side considers effects on the production of energy as well as its transmission and distribution. Demand and supply are dynamic and intersecting, so changes in one will affect the other.

Like other markets, many of the impacts described here, and the evidence that support those changes, are not unique or confined to the Midwest region. While the effects of climate change are already being felt, they may be more gradual than some of the more immediate effects of climate policy.

Climate Change and Energy Demand

The influence of climate change on energy usage is relatively well understood, at least in terms of consumer response to changes in weather (Cline, 1992; Smith and Tirpak, 1989). Energy is used for heating and cooling to maintain safety, comfort, and lifestyle. Individuals with the means to adapt to more extreme weather are likely to utilize technologies to these ends; individuals without the means may suffer adverse health effects. Warmer weather will induce more cooling (generally from electricity) while cooler weather will induce more heating (generally from natural gas, fuel oil, or propane) (Gotham, et al., 2012). Increased cooling needs would increase summer-peaking electricity loads based not only on temperature but also on humidity levels. If climate change increases the duration and frequency of heat waves, as has been suggested, then electrical demands are likely to rise during summer periods (Hayhoe, et al., 2010). In terms of energy demand, climate change may correlate with both overall trends in total usage and usage variability, as seen in patterns of average and peak demand. Changes in consumer demand are, in fact, well known by utilities, which routinely must "adapt" operations and management to weather variation and use "heating-degree days" and "cooling-degree days" for modeling and forecasting purposes. Climate change is expected to accentuate existing weather-related seasonal demand variability. The most vexing implication is that increased energy demand, particularly peak demand, would result in increased GHG emissions if fossil fuels remain the primary fuel source for supply.

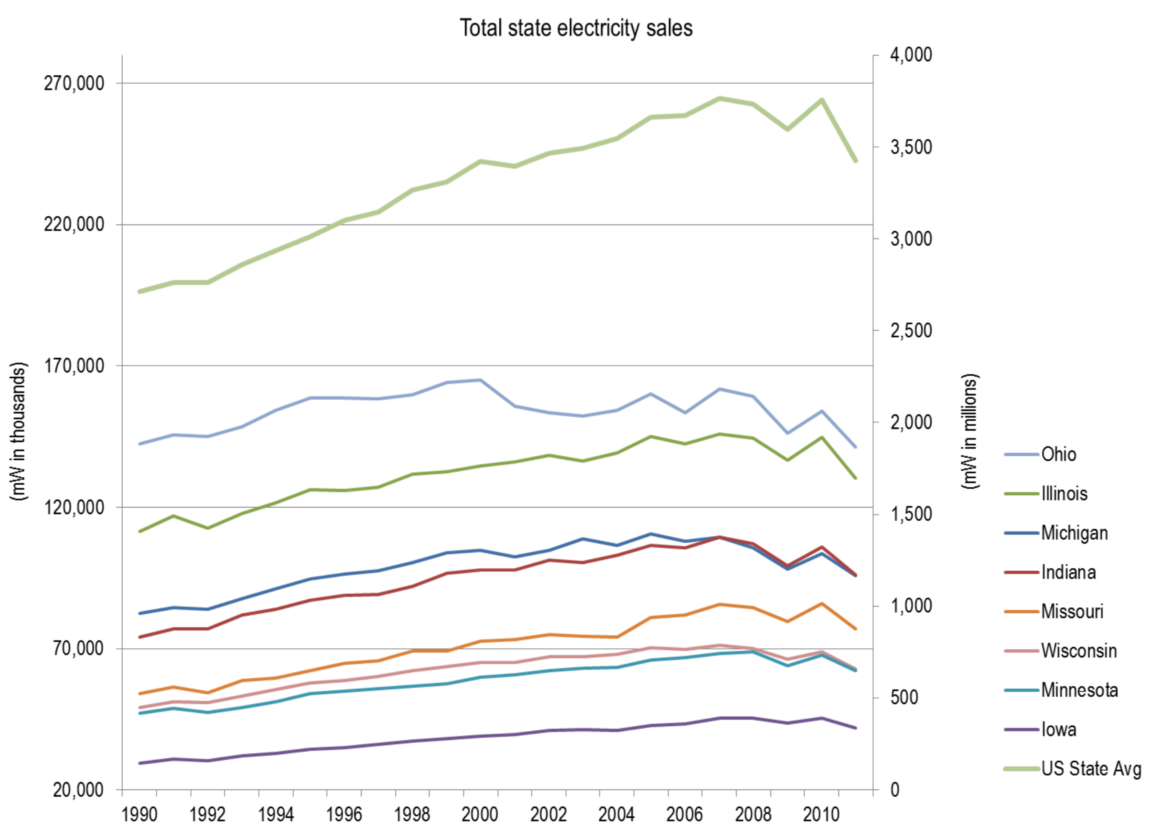

Exhibit 4. *Trends in retail electricity sales in the Midwest region. Source: Authors' construct from EIA, "Electricity" (2010).*

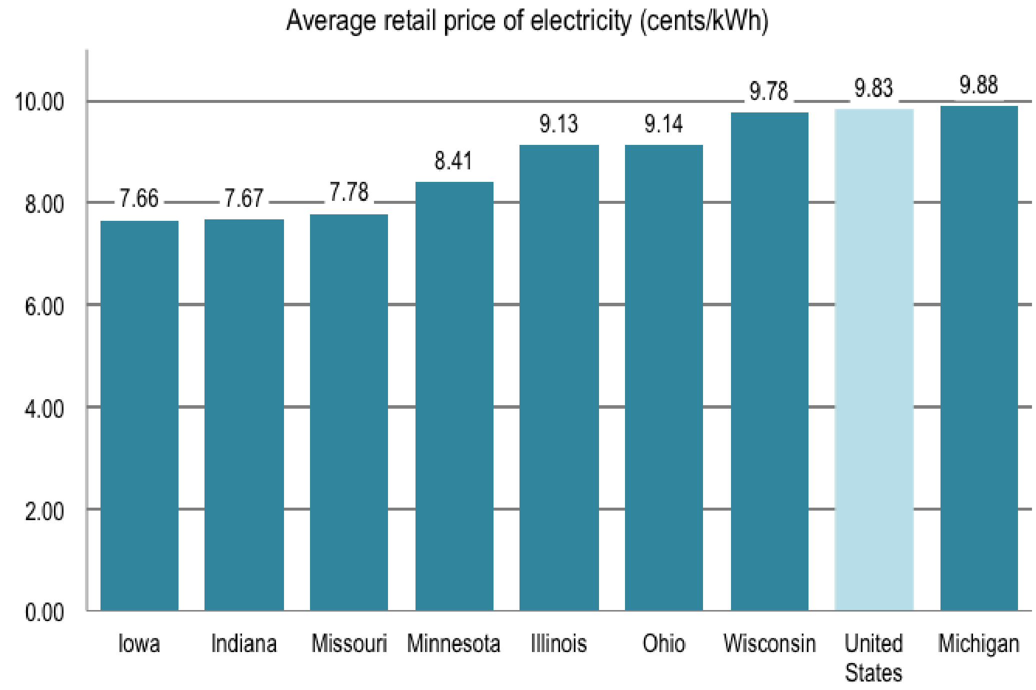

***Exhibit** 5. Average retail price of electricity in the Midwest region. Source: Authors' construct from EIA, "Electricity" (2010).*

Exhibit 6. Climate Change Impacts on the Energy Sector

	Climate change	Climate change policy
Demand-side issues	• Changes to energy usage patterns (heating and cooling) • Health effects of heat and cold (including death) due to access and affordability • Peaking demand due to extreme weather events • Changing energy needs of other sectors, including water supply	• Demand-management mandates (standards, programs) • Load-management practices (shifting load to off-peak periods) • Energy needs of electric vehicles • Higher utility prices and price elasticity effects on demand
Supply-side issues	• Renewable energy availability (wind, photovoltaic, geothermal, hydroelectric, and bioenergy, etc.) • Water availability and shift to power plant thermal cooling alternatives • Potential supply disruptions (reliability) • Stress on physical infrastructure from variable and extreme weather • Impact of variable demand on utility revenues and risks	• Changes to supply portfolio, including fuel switching from coal to natural gas and investment in alternative supplies, transmission facilities, energy storage, grid modernization, and back-up capacity • Financial incentives, including taxation, rates of return, and carbon tax or trade • Environmental impacts of renewable energy development (land, aesthetics) Effect of variable resources on reliability Complex energy supply markets • Higher energy and water utility costs

Source: Authors' construct.

Analysts have applied different methodologies to model consumer response to changes in climate (see Mansur et al., 2008, Sailor and Munoz 1997; Rosenberg and Crosson, 1991) and considerable regional variation is recognized (Sailor 2001). Several of these studies have focused on California or the United States in general (see Baxter and Calandri, 1992; Franco and Sanstad, 2008; Aroonruengsawat and Auffhammer, 2009), although a few speak specifically to the Midwest region. As noted, models of consumer electricity demand in the context of climate change should consider not just temperature but humidity. A combined heat index that considers temperature and humidity is the best indicator for human (residential) demand for electricity (Gotham, et al., 2012).

Regional latitude is likely relevant to assessing climate change's effect on energy usage. An early study (Rosenberg and Crosson, 1991) focused on Missouri, Iowa, Nebraska, and Kansas and suggested that climate change would lead to a small increase in consumer demand for energy. Another study, however, suggested that Midwestern states may actually experience a drop in energy demand (Hadley, et al. (n.d.). The West North Central zone (including Minnesota, Iowa, and Missouri) and the East North Central zone (including Wisconsin, Illinois, Michigan, Indiana, and Ohio) could experience more cooling demand in the summer but less heating demand in the winter. At the aggregate level, energy usage was predicted to decline up until 2014 but rise thereafter. Rosenthal and Gruenspecht (1995) also anticipated a drop in energy demand, estimating that a 1 degree Celsius increase in temperature could also translate to substantial energy savings.

Forecasting energy demand has become particularly challenging given a host of exogenous influences, including economic and technological factors that could alter consumer behavior beyond climate change alone. Hekkenberg, et al. (2009) asserted that future energy demand may be underestimated by existing models because it is influenced not just by weather but also by socioeconomic trends. Population growth, economic development, and income correlate positively with energy demand. Going forward, prices will also affect demand, both intrinsically and by design. While demand for utility services is *relatively* price inelastic, it is not perfectly so; in other words, some electricity demand is more discretionary and price sensitive. Demand response to prices can be anticipated and modeled. Higher prices are likely to induce interest in energy curtailment and efficiency, but also interest in self-supply options (such as home solar devices).

Many new technologies associated with grid modernization are aimed directly at peak-demand management (that is, load shifting) in order to mitigate these effects. Some "smart grid" technologies essentially add two-way, real-time communications capabilities. With "smart meters," customers can receive detailed information about home energy usage and costs (Giordano, 2012). Utilities can also adopt dynamic pricing for load-management purposes, although long-term efficacy must be studied. Perhaps more importantly, smart technologies can enable automation that does not rely on significant alterations either to consumer behavior or lifestyle. Although benefits to utilities are well known, much is yet to be learned about the benefits of smart technologies to utility customers and society relative to costs. Consumer acceptance remains a considerable challenge.

In addition, the effects of climate change on other sectors may change their patterns of demand, which, in turn, will affect the energy sector. For example, the water sector is highly energy intensive and changes in water demand could have positive or negative effects on the energy sector.

Climate Change and Energy Supply

Because electricity is an "on-demand" service and supply and demand must be balanced on a real-time basis, changes to demand have a direct and immediate bearing on supply. Compared to other drivers, including climate and price uncertainty, population trends are a more significant determinant of electricity demand (Aroonruengsawat and Auffhammer, 2009). As noted earlier, to the extent that climate change affects weather, it will affect consumer demand for electricity, which, in turn, will shape energy supply. In effect, climate change policy is already exerting a significant influence on energy supply portfolios and the delivery infrastructure, particularly for electricity. If energy demand grows, so will production capacity needs. In the Midwest region, increased demand associated with climate change could potentially exceed 10 GW, which would require more than $6 billion in infrastructure investments (Gotham, et al., 2012).

Extreme weather associated with climate change, such as stronger, more frequent hurricanes, tornadoes, floods, and droughts, would place further burdens on the supply of electricity. Major weather events are directly related to power disruptions and outages, with damage to utility and customer equipment alike, in addition to economic opportunity costs. In recent years, the number of outages affecting the bulk power grid has increased mostly due to weather-related events, arguing for modernization strategies that consider weather resilience.[2] As of 2008, 65% of all disturbances are related to severe weather – up from 20% in the early 1990s (Karl, et al., 2009). Loss of power is a life-threatening event and more people die of extreme heat than any other weather event (DOC, NOAA). Recovery can be costly, labor-intensive, and time-consuming and may raise significant liabilities. As such, the

[2] Detailed annual "Events Analysis" and "System Disturbance Reports" can be found at the North American Electricity Reliability Corporation (NERC) website (www.nerc.com).

loss of power, or power reliability, has dire economic consequences. The cost of recovery is generally passed along to all utility customers, and the increased cost of planning for, mitigating the effects of, and recovering from catastrophe can exacerbate affordability concerns. Climate-induced weather variation can stress infrastructure and add to the cost of initial investment as well as system operation and maintenance (Gotham, et al., 2012). Low temperatures can increase icing on overhead power lines and nearby trees. High temperatures cause metal to expand, increasing power-line sag; lack of wind worsens the problem as it prevents natural cooling of the distribution infrastructure. Excessive sag (beyond design specifications) can bring lines into contact with vegetation or even cause an arc to form within the line. Additional investment by utilities may be needed in power line monitoring (including robotic sensors), preemptive vegetation management, and even underground relocation of power lines.

Exhibit 7. Generation of Hydropower in the Midwest

State	Conventional Hydro MWh	Total MWh	Total Renewables MWh	Hydro as a % of total	Hydro as a % of renewable	Powered & Non-powered Dams
Illinois	136,380	193,864,357	3,666,132	0.10%	3.70%	1,504
Indiana	503,470	116,670,280	2,209,306	0.40%	22.80%	1,142
Iowa	971,165	51,860,063	8,559,766	1.90%	11.30%	3,374
Michigan	1,371,926	101,202,605	3,995,111	1.40%	34.30%	927
Minnesota	809,088	52,491,849	7,545,745	1.50%	10.70%	1,021
Missouri	1,816,693	88,354,272	2,391,498	2.10%	76%	5,099
Ohio	527,746	136,090,225	1,161,156	0.40%	45.50%	1,577
Wisconsin	1,393,988	59,959,060	3,734,283	2.30%	37.30%	1,163

Source: National Hydopower Association. http://hydro.org/why-hydro/available/hydro-in-the-states/midwest/

Climate change also influences the performance of generation equipment (Gotham, et al., 2012; Al-Ohaly, 2003). Higher temperatures result in decreased efficiency in combustion turbines that are primarily used to generate electricity in the Midwest regions. Normally, the combustion of fossil fuels produces steam, which, in turn, moves the turbines used to generate electricity. Higher ambient temperatures lower the density of the air flowing within the system. Thus, it takes both more fuel to generate energy and more generating capacity to meet demand. In the Midwest, approximately 95% of the electrical generating infrastructure is susceptible to decreased efficiency due to ambient temperature change. As long as generators rely on steam to produce electricity, these vulnerabilities will persist (Gotham, et al.,2012).

The water-energy nexus is also important in terms of energy supply. The water industry depends on energy and the energy industry depends on water. Home to the Great Lakes, the Midwest enjoys relatively plentiful water resources. The region is also home to numerous power plants at significant scale (Exhibit 3). Most energy production processes, traditional and alternative, are water intensive. Thermoelectric power generation accounts for about half of total water withdrawals in the U.S., more than any other discrete function (USGS, 2009). In 2007, droughts in the Southeast jeopardized power plant operations due to their reliance on water for both steam and cooling (Manuel, 2008). The unpredictable nature of water conditions presents an operational challenge to plant operators (Rice et al., 2009). With limited water for cooling, power plants operate at reduced capacity, which results in severe economic impacts in prolonged droughts. Given variability in water supply, even relatively water-rich regions are not immune from these effects; reuse and storage technologies for cooling purposes may become more important.

Although the Midwest is not highly dependent on hydropower (Exhibit 7), fluctuations in flows will directly affect supply availability from that source (Rosenberg and Crosson, 1991). The use of pumped storage for energy adds to aggregate demand on water resources. For conventional resources, additional water storage or non-water cooling technologies may be needed. Climate change may also affect the availability and intermittency of some forms of renewable energy, particularly wind and photovoltaic sources. A significant consequence is the need for backup capacity to ensure reliability and resilience (see Prescott and Van Kotten, 2009).

In sum, climate change has the potential to affect power production, as well as distribution, with implications for reliability and cost. However, these effects are relatively well known to the sector, and both mitigative and adaptive strategies are being planned and deployed, in some cases in accordance with policy mandates (see Neumann, 2009).

Climate Change Policy

Most climate policy action in the United States has been implemented at the state or local level, in the absence of comprehensive federal policy (see Cohen and Miller, 2012). The federal government has focused much attention on subsidizing the development of clean energy sources, along with research and education in such areas as energy efficiency and "smart grid" applications. Federal regulators have promoted investment in and modernization of the high-voltage transmission grid, in part to accommodate power generation from renewable resources.

Not surprisingly, a considerable amount of state and regional climate change policy targets the energy sector with the goal of reducing emissions, particularly carbon. The considerable activity in the realm of climate change policy is already shaping demand and supply in the energy sector. States in the Midwest have joined states across the nation in adopting both climate action and energy sector policies toward this end as well as in anticipation of regional or national policies (Exhibit 8).

Demand-side policies for the sector are focused on reducing energy load through end-use efficiency (load reduction) as well as shifting load to off-peak periods for more efficient utilization of power plant capacity (thus avoiding or postponing the need for extra capacity to meet peak demand and associated capital and operating costs). Price plays a critical role in cost recovery as well as an incentive-based tool of demand management. Real-time prices and demand-response programs take advantage of price elasticity to encourage load shifting by consumers. Demand-side programs are designed to accelerate development and deployment of efficiency practices in areas such as heating, cooling, and lighting across, the residential, commercial, and industrial sectors. National standards for appliance and fixture efficiency are important to this effort.

Climate change policy looks to the supply side with the intention of shifting away from reliance on greenhouse gas-emitting fossil fuels and toward clean and renewable energy alternatives. Efficiency on the supply side can be achieved through loss reduction and heat capture strategies, including cogeneration. Leading policies include state-level renewable portfolio standards (RPS), with various specifications and timetables, which in many respects are an alternative to carbon taxes or markets (also known as cap and trade). These changes will affect resource and labor markets as well as land-management practices. For example, wind and biomass facility siting and development have significant implications for the agricultural sector. The effects of renewable energy development are likely to vary across and within states, depending on resource availability, land and water characteristics, economic profile, and state and local policies.

Much policy attention has also focused on utility incentives and compensation for developing cleaner generation options and promoting energy efficiency. Carbon capture and storage solutions or "clean coal" have received some attention although significant technical challenges remain (see Graus, et al., 2011). Net metering laws allow consumers to sell excess power produced by renewable technologies back to the power company. Grid modernization and "smart" technologies (including smart meters) are regarded as enabling supply-side resource integration as well as demand management. Any large-scale use of electricity or natural gas for transportation will have a significant impact on energy markets.

Future Considerations & Issues

A perennial issue in the energy sector concerns the true cost of electricity. Direct and indirect subsidies, and environmental externalities, distort prices. When true costs are not accurately reflected in price, production and consumption are inefficient. In the past, fossil fuels enjoyed preferential policies whereas renewable resources are favored today. To many economists, putting a price on carbon via a tradable market or tax would promote more efficient choices among competing technologies for lowering greenhouse gas emissions (see Parry and Williams, 2010; Burtraw, 2011).

Instead, state renewable portfolio standards (RPSs) have become the centerpiece of climate policy. RPSs require providers to use renewable technologies for a specified portion of the energy they produce by a target date. Many states allow the providers to purchase credits from other utilities in order to meet the mandated threshold. Considerable variability in the standards is found among the states, including differences in what constitutes renewable energy resources. Today, almost half (46%) of the electricity sold in the United States is covered by a state RPS program. More than half of the growth of renewable capacity between 1998 and 2007 occurred in states that have adopted a renewable portfolio standard; most of the growth is in the wind sector. While some states have achieved high rates of compliance, others have had to adjust their implementation time frames due primarily to a lack of

Exhibit 8. Climate and Energy Policy Activities in the Midwest Region

Climate action	IL	IN	IA	MI	MN	MO	OH	WI
Greenhouse gas reduction targets.	Yes			Yes	Yes			
Standards limiting CO2 emissions from power plants.	Yes							
Climate change action plan with steps to mitigate emissions.	Yes		Yes	Yes	Yes	Yes		Yes
Legislative advisory commission on climate change policies.	Yes		Yes	Yes	Yes			Yes
Participates in regional initiatives to address climate change	Yes-1	Yes-2	Yes-1	Yes-1	Yes-1	Yes-3	Yes-1	Yes-1
Uniform standards for reporting GHG emissions.	Yes		Yes-4	Yes	Yes	Yes	Yes	Yes-4
Adaptation plans to preemptively prepare for climate change impacts.			Yes	Yes	Yes-5			Yes
Energy Policies	**IL**	**IN**	**IA**	**MI**	**MN**	**MO**	**OH**	**WI**
Public benefit funds for energy efficiency, renewable energy, or research.	RE			RE	R			RE
Renewable or alternative energy portfolio standards for utilities.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Net metering programs for end users that send surplus power to the grid.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green pricing programs providing an option to buy renewable energy.	Yes				Yes			
Decoupling policies to separate utility revenues and profits from sales.	G	G						EG
Renewable energy credit tracking systems for use in verification of state targets.	Yes		Yes		Yes			Yes
Energy efficiency resource standards to encourage reduction in energy use.	EG	E	EG	EG	EG		E	EG)
Financial Incentives for carbon capture and storage (CCS) technologies.	Yes	Yes			Yes			

(1) Midwest GHG Reduction Accord & Platform; (2) MGGRA Observer & Midwest Platform; (3) Midwest Platform; (4) Mandatory reporting also required; (5) In progress; (E) Electricity, (G) Gas, (EG) Electricity and Gas; (RE) Renewable energy and efficiency; (R) Renewable energy.
Source: Center for Climate and Energy Solutions, http://www.c2es.org/what_s_being_done/in_the_states/state_action_maps.cfm

transmission infrastructure (Wiser and Barbose, 2008). Successful RPS implementation has been attributed to the identification of cost-effective renewable resources and companion policies for transmission expansion and regional collaboration (Hurlbut, 2008).

Despite a favorable emissions profile, nuclear power has not found a secure place in portfolio policies. Nuclear power continues to suffer from persistent concerns about

cost overruns, fuel procurement, public safety, and waste disposal. As with thermoelectric plants, nuclear power plants require significant amounts of water for cooling and prolonged droughts could impact operations. Potential disruptions of service from severe weather, including storms and flooding, raise the specter of catastrophic failure. The Browns Ferry plant in Alabama escaped major damage during a 2011 tornado, but concerns Fukushima disaster in Japan has cast doubt on the future of the sector globally. Nonetheless, some advocates and utility companies are again considering nuclear power options, including large-scale and smaller scaled modular or package plants. Two large-scale reactors are under construction in South Carolina.

Without preferential policies and subsidies, development of alternative energy can be cost prohibitive. Many resource alternatives raise significant technical challenges in terms of supply chains, intermittent availability, and the lack of cost-effective means of energy storage. Long-distance transmission needs and costs are especially significant, particularly for wind energy (Yang, 2009). Some have argued, however, for development of lower-velocity local resources (Hoppock and Patino-Echeverri, 2010).

The potential for higher costs and lower reliability looms large, with significant economic and social implications, particularly affordability of an essential service (see Berger, 2009). The accurate comparison of resource alternatives requires a total life-cycle cost analysis. The regressive nature of utility prices argues further for awareness of the distributional consequences on households and attention to rate design (Beecher, 2012a).

Utility infrastructure is especially capital intensive and long-lasting. Changing the resource mix and operational profile is a formidable proposition, particularly given sunk costs and underlying concerns about meeting service obligations. Utilities also have a tradition of long-term capacity planning and their planning processes are already incorporating adaptive strategies, in part due to policy mandates. Utility investors and managers are not necessarily averse to responsible climate change policy, but it is widely understood that they prefer a context of more regulatory certainty to less, particularly with regard to cost recovery. Many have argued for policy and regulatory reforms, including special financial incentives for utilities. But the central role of economic regulation is the assurance of prudent compliance with policy mandates and the fair allocation of risks and costs among utilities and their customers.

A fair amount of consensus exists in the policy community about the relevance of climate change to the energy sector. Yet despite a large amount of attention and research, the sector suffers from limited evidence and contradictory speculation with regard to potential impacts and their extent. Logically, larger changes in climate are likely to present larger challenges and consequences.

The Midwest region will experience climate change and climate change policy in ways similar to the rest of the country. Resource profiles and endowments, however, are regionally distinct, with states facing divergent packages of renewable resources from which to draw generate energy (Wiser and Barbose, 2008). The Midwest region might be relatively disadvantaged in terms of wind and solar energy resources, which might argue for expanding development of bioenergy resources establishing markets for renewable energy credits. The region might be advantaged by its northern latitude and relatively abundant bioenergy and water resources. The challenges remain considerable but, in theory, they should be more manageable than in regions facing more stressful ecological and economic conditions.

Regardless of climate change, climate change policy, along with related energy policy mandates, will likely have an indelible impact on the provision and cost of essential energy services. Energy utilities are already anticipating and adapting, in part to manage regulatory uncertainties. The generational challenge of climate change policy will be to strike a workable balance among the goals of clean, reliable, and affordable energy.

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