Climate Forward:

A New Road Map for Wisconsin's Climate and Energy Future

A Wisconsin Initiative Report of the Wisconsin Academy of Sciences, Arts & Letters

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About this Report

The Wisconsin Academy of Sciences, Arts, & Letters has a significant history of gathering thoughtful leaders from multiple perspectives to provide insight and shared wisdom on major challenges that affect our state and the world. In mid-2012, the Wisconsin Academy initiated a project to examine Wisconsin's climate and energy future. The fruit of this project is *Climate Forward: A New Road Map for Wisconsin's Climate and Energy Future*, a report that identifies five "pathways to progress" to reduce Wisconsin's dependence on fossil fuels, support sustainable energy sources, and create jobs and increase investment in the new 21st century economy. The report also profiles Wisconsin businesses, communities, and individuals in the vanguard of energy innovation and other sustainability practices, and outlines dozens of options for action at many scales, from establishing goals for incremental progress in improving energy efficiency across the state each year to expanding renewable energy sources such as solar, wind, and bioenergy to levels comparable to neighboring states.

About the Wisconsin Academy of Sciences, Arts & Letters

The nonprofit Wisconsin Academy brings people together at the intersection of the sciences, arts, and letters to inspire discovery, illuminate creative work, and foster civil dialogue on important issues. We connect Wisconsin people and ideas for a better world. Wisconsin Academy programs include the James Watrous Gallery in Overture Center for the Arts, a gallery by and for Wisconsin artists; *Wisconsin People & Ideas*, our quarterly magazine of Wisconsin thought and culture; Academy Evenings, our statewide series of public talks; and our Wisconsin Initiatives, which address water issues and climate change impacts in our state. For more information, please visit www.wisconsinacademy.org.

About Wisconsin Initiatives

The Wisconsin Academy's Initiatives bring Wisconsin residents together with a diverse array of experts and stakeholders to find solutions to statewide problems. Our current initiatives are: Waters of Wisconsin, developing a statewide leadership network to collaborate on strategies to protect our waters and to share recommendations and help state residents better understand water issues; and Wisconsin's Climate & Energy Future, developing a "road map" of specific recommendations for Wisconsin opportunities to address climate change and support clean, efficient energy choices to reduce Wisconsin's carbon footprint.

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Foreword

In mid-2012 the Wisconsin Academy of Sciences, Arts, and Letters initiated a project to examine Wisconsin's climate and energy future. The Wisconsin Academy has a significant history of gathering thoughtful leaders from multiple perspectives to provide insight and shared wisdom on major challenges that affect our state and the world.

Global climate change, driven by increased levels of atmospheric carbon dioxide (CO_2), is one of the most serious social, economic, and environmental challenges of our time; it is intimately coupled with the challenge of attaining clean and sustainable energy sources that minimize the release of CO_2. These are global, national, and Wisconsin challenges. Given Wisconsin's wealth of scientific and technical capacity in these areas, its rich conservation heritage, and the anticipated impacts of climate change on Wisconsin life, we wanted to stimulate more public dialogue on this topic and spark innovative solutions.

To this end, we developed a new tool to provide an assessment of where we are today and a practical vision for how we can build on Wisconsin values and our citizens' creativity and imagination to shape a future that is good for the environment, our economy, and all life on the planet. This tool is a report called *Climate Forward: A New Road Map for Wisconsin's Climate and Energy Future*. In the *Climate Forward* report we examine many facets of solutions for reducing both emissions and reliance on fossil fuels. These solutions focus on energy efficiency and conservation, renewable energy, improving transportation systems, carbon storage, and developing sustainable business models.

In our discussion of Pathways to Progress, we provide short profiles of Wisconsin organizations and communities that are demonstrating game-changing leadership in these energy-related arenas. In selecting these examples, we looked for actions and options that meet three criteria:

- They reduce Wisconsin's carbon dioxide and other greenhouse gas emissions (methane, nitrous oxide, and ozone) and/or support natural carbon storage.
- They embrace the foundations of sustainability—healthy and resilient people, environments, and economies.
- They are practical and effective in advancing clean, sustainable energy production and use, and they have minimal side effects.

These criteria include an ethical perspective in the sense that they are about choosing the right means to the right goals. Our primary goal is the well-being of Wisconsin's people and of what Aldo Leopold called "the land community"—the soils, waters, plants, and animals that make up our environment. But the actions, policies, and innovations we highlight also serve the well-being of the wider world insofar as they reduce Wisconsin's contribution to global climate change and provide models that others can learn from or emulate.

In *Climate Forward: A New Road Map for Wisconsin's Climate and Energy Future* we also provide an overview of a potential way forward. Like any road map, this document offers a variety of ways we can reach the destination: a more sustainable and resilient Wisconsin. The report is not prescriptive in terms of policy, but does highlight policies that appear to be benefiting neighboring states and notes where specific policy changes might advance particular approaches to energy and climate issues in Wisconsin.

Our goal is not to offer a comprehensive plan, but rather to shine a light on current conditions,

barriers to progress, and opportunities—if Wisconsin chooses to engage and lead in this arena. We also want to distill some of the key lessons learned, and to create a straightforward summary that can be used as a resource for discussing solutions and strategies. Finally, it is notable that the practices described in the profiles, while often on the leading edge, are not revolutionary technologies—they are practical, proven, and attainable. Ultimately the barriers to addressing our climate and energy challenges are largely not technological, but are a matter of values and public will, and the courage to chart new territory.

Climate change and energy policy are enormous topics. The evidence clearly shows that continuing on our present course is not sustainable. In order to understand the problems we face and find solutions to those problems we'll need many forms of expertise, from climatology to economics to psychology.

But *everyone* should be a part of this conversation. All Wisconsinites—especially future generations—have a stake in the choices that we are making now, and those we will make in the coming years.

If we are to lay the foundations for a sustainable future with a high quality of life for all, our choices need to be based on the best information and insights available. They must respect our most precious environmental, social, cultural, and moral values. And whether politicians, CEOs, government agencies, or individuals make those choices, they should do so in the context of an informed, civil, public dialogue.

With *Climate Forward: A New Road Map for Wisconsin's Climate and Energy Future,* the Wisconsin Academy of Sciences, Arts & Letters hopes to further that dialogue. We can and *should* have a wider and deeper conversation about this topic in Wisconsin.

—Jane Elder, Executive Director
Wisconsin Academy of Sciences, Arts & Letters

Executive Summary

Wisconsin, like the rest of the world, is experiencing negative effects from a rapidly changing climate. In the United States, some of these impacts are most severe in northern states, including Wisconsin. Even now, changes in our climate are leading to increases in extreme weather events, higher than average temperatures, lake evaporation, and expanding ranges for invasive species, which in turn impact water quality and supply, public health and safety, shipping capacity, agricultural productivity, and, ultimately, our quality of life in Wisconsin.

Many of these impacts are related to the energy choices we make every day. Yet even with our strong conservation legacy, Wisconsin has fallen behind many other states in pursuing energy efficiency, renewable energy development, efficient transportation, and other strategies that will help slow the pace and reduce the scale of disruptive climate change.

Wisconsin is heavily dependent on coal for its electrical generation and, moreover, the state lacks a concerted plan to diversify its energy sources and reduce greenhouse gas emissions. As a result, Wisconsin is highly vulnerable to any potential prices that might be placed on carbon related to fossil fuels, which would be reflected in costs passed on to energy consumers. At the same time, renewable energy entrepreneurs are finding more fertile opportunities in other states, and taking related investments and jobs with them.

Wisconsin has a rich history of conservation leadership and public deliberation and decision-making informed by sound science. We all share a concern for our communities and future generations, as well as a quality of life enriched by our natural and human resources. These are the Wisconsin values you'll see reflected in *Climate Forward: A New Road Map for Wisconsin's Climate and Energy Future*, a new report created by the Wisconsin Academy of Sciences, Arts & Letters.

To recapture Wisconsin's capacity to lead in strategies that address climate change and clean energy, the *Climate Forward* report proposes five primary Pathways to Progress:

- increasing energy conservation and efficiency to help consumers save money and lessen the need for new power plants and transmission;
- expanding development and use of renewable energy to create local clean energy resources;
- enhancing transportation systems to provide more efficient and cost-effective options for people and products;
- managing forests, grasslands, and other living landscapes in ways to support natural processes that store carbon in plants and soils;
- encouraging business models that incorporate "whole business" strategies that embrace sustainability practices, learning and innovation.

Energy conservation and efficiency is the "first big step" given the substantial opportunity to reduce both energy demand and wasted energy. Practical actions include weatherizing and retrofitting residential and commercial buildings, installing advanced technologies such as LED lighting, using super-efficient design for new buildings, increasing efficiencies in manufacturing processes, and waste reduction.

Profiles of Wisconsin leaders in this area include: West CAP's low income housing retrofits; Johnson Controls and its energy-efficient, environmentally friendly and sustainable headquarters building; Quad/Graphics' efficient production and smart energy strategies; NewenHouse Kit Homes' design for super-efficient green houses and simple living, and MilllerCoors' commitment to measuring its energy efficiency improvements and fostering a sustainability culture in the workplace.

Renewable energy is an under-developed opportunity for Wisconsin, given that only 10.2 percent of Wisconsin's electricity is generated from renewable sources, and neighboring states are pursuing much more aggressive goals. With the price of solar energy becoming increasingly competitive with other energy sources, this is a great time for Wisconsin to embrace solar energy for generating on-site photovoltaic electricity as well as for heating buildings and water.

Wisconsin also has untapped wind capacity. Through careful siting and using today's sophisticated turbines, wind energy could play a much larger role in the state's electrical generation; and while there are infrastructure costs, wind has the advantage of having no fuel charges.

Wisconsin is also well-positioned to expand its bioenergy capacity. The state already has many co-generation plants that burn a combination of biomass with conventional fuels to generate heat and/or electricity, and the Dairy State has a vast supply of raw material in the form of manure and other agricultural products for biodigesters that can capture methane and produce electricity at large-scale farms or through multi-farm cooperation.

Profiles of Wisconsin leaders in renewable energy include The City of Milwaukee, for its first wind turbine by Lake Michigan, powering city buildings; the City of Monona, which boasts the largest solar array on municipal buildings in the state; SC Johnson, which has reduced its carbon footprint globally through using clean renewable energy and other sustainable practices; Emerald Dairy, which is using "whole farm practices" including a biodigester which helps power its onsite operations; and the St. Croix Valley Eco-village project, which includes solar powered neighborhoods and other advances in sustainability.

Transportation of both people and freight is responsible for about one third of greenhouse gas emissions. As a state heavily dependent on highways for our transportation, Wisconsin could make significant advances in reducing emissions by modernizing and diversifying our transportation systems, and providing more choices for mobility through designing walkable neighborhoods, and bike-friendly streets, as well as expanding regional transit and freight capacity. Rethinking transportation has the potential to not only reduce greenhouse gas emissions, but to also reduce congestion, make better use of state and federal transportation budgets, and improve business productivity.

Profiles of Wisconsin leaders in transportation include Kwiktrip, which is using compressed natural gas to fuel its fleet; Schneider, a trucking, shipping, and intermodal transport services firm that uses alternative fuels, sophisticated fleet design and operations, and innovative logistics to move freight efficiently; and the City of Madison,

for its transportation planning and design that has made it one of the most bike-friendly cities in the state.

Natural carbon storage is as old as photosynthesis, with green plants converting carbon in carbon dioxide gas into plant fiber, where it remains until it is digested, burned, or decays. Trees, grasses, and other plants are natural storage systems, as are many kinds of healthy soils that contain rich levels of organic matter, such as natural wetlands. With extensive forests, as well as grasslands, wetlands, pastures, and other perennial covers, Wisconsin's living landscape can play a role in sustaining and growing our capacity to support natural carbon storage.

Research into the types of soils, plants and natural systems that do this best will help us make informed decisions about land conservation and management practices that can reduce our carbon footprint while maintaining healthy ecosystems and meeting needs for food, fiber and fuel.

Building the capacity to lead includes learning from those already in the vanguard. Common characteristics of businesses, agencies, and communities in leadership roles include:

- Leadership that is forward-looking and drives change.
- Corporate or organizational culture that embraces sustainability in principle and practice.
- Concerted effort to establish baselines and regularly measure gains in energy efficiency and reduction of carbon footprint.
- Conservation and efficiency across products and processes, such as "co-conservation" strategies for water and materials, and full-cycle stewardship from source materials to ultimate re-use.
- Commitment to continual learning and innovation.
- Creative public-private partnerships, where public investments are leveraged to spur advances in technology, productivity and community goals as well as to offset initial costs in new technologies and business start-ups.
- Pride in communicating accomplishments and eagerness to tell their story of sustainability to other businesses, communities, or institutions.

Game-changing Wisconsin innovators include Gundersen Health System, which uses a "two-sided green" strategy to reduce the cost of health care and lower emissions that are harmful to humans health and the environment; Gundersen plans to be completely energy independent by the end of 2014. Also featured is CROPP-Organic Valley, whose energy strategies are focused on energy efficiency in operations, incorporating renewable energy, and promoting on-farm energy efficiency among their nearly 2,000 farmer members. Given the significant energy costs related to moving and treating water, Milwaukee's Metropolitan Sewerage District is noted for its strategies to reduce the energy and financial costs of existing water management and industrial operations and setting goals for institutional change ranging from integrated watershed management to internal energy use.

Each of these organizations are successful becuase they embrace whole-system sustainability strategies that work.

Public engagement is also essential to building our leadership capacity. A well-informed and

engaged public needs the information and tools to comprehend, grapple with, and solve complex climate and energy problems in their businesses and homes, communities and counties. Sustainability education should be explicit in addressing climate and energy issues and preparing students for incorporating green innovation, new technologies, and sustainable approaches into their lives and careers.

At the same time, public communication efforts from multiple sectors will be important to help citizens better understand options for practices in their homes and workplaces that can contribute to solutions. Civil conversation and deliberation are essential processes to help Wisconsin make sound decisions for its future.

The way forward will be through leveraging Wisconsin's existing and emerging capacities to make advances across a combination of actions within the pathways to progress. In keeping with recommendations from the international scientific community, this report recommends reducing Wisconsin's fossil fuel emissions by 80 percent by the year 2050. Steps to move toward this goal are outlined in a list of Options and Opportunities that includes dozens of specific actions within the five pathways that could reduce Wisconsin's carbon footprint and/or diversify and grow its clean energy portfolio. Most notable are the suggestions that Wisconsin incrementally increase its energy efficiency goals by two percent each year, and also increase its renewable energy resources by 1-to-1.5 percent a year. Many other states already have similar or more ambitious goals.

In addition to the options in the five pathways, putting a price on carbon would have a significant affect in driving down carbon emissions. Research from diverse fields can and will expand Wisconsin's potential for further breakthroughs. Any endeavor at this proposed scale should develop measures by which progress can be assessed.

Wisconsin can play a positive, solution-oriented role as our world faces climatic changes that threaten our health, safety, and the stability of natural systems that sustain Wisconsin as we know and love it. Change creates opportunity, but that opportunity comes with the responsibility to pursue options that will benefit and sustain the people of Wisconsin, our environment, and our economy in a global context.

Photo credit: Moonlight Bay Bedrock Beach State Natural Area, Door County. By Thomas A. Meyer

Wisconsin's Climate and Energy Challenge

Wisconsin is a special place with a unique quality of life, and the millions who call it home are here for a reason. For some, it may be the farms and fields that grace so much of the landscape, or the cities and towns that have a strong sense of community. For many, it is the four seasons and the full range of weather and experiences they bring. And, of course, there are the rivers, lakes, forests, and other wildlands across the state that refresh us and help define us. For others, Wisconsin may be special because of a good job, the fourth generation family farm, or the state's progressive tradition and conservation heritage. In Wisconsin, people and place matter.

A changing climate will affect the way we live in Wisconsin. To safeguard the things we value, we need to be prepared to respond to these changes in ways that will be good for our environment, our economy, and our way of life. To do that, we need to be aware of climate changes that are already upon us and the options we have for adapting to them. We also need to explore our options for reducing the pace and scale of disruptive climate change and do our part to reduce carbon dioxide (CO_2) emissions. The good news is there are many practical and effective actions that Wisconsin leaders are already taking that have potential for wider application. We will showcase some of these successful strategies in this report.

The climate challenge

Around the globe, climate change is hitting the northernmost and southernmost latitudes the hardest and, from a planetary perspective, Wisconsin qualifies as a region of northern climate.

Moreover, Wisconsin is uniquely positioned at the transition zones of three distinct ecosystems—the central hardwood forest, the prairie and oak-savanna, and the northern mixed hardwood and conifer forest. Being at a transition zone, which is also the edge of their optimal ranges, means each of these native plant communities and their animals may be even more sensitive to significantly warmer temperatures and highly variable and intense precipitation. Climate change is re-shaping our weather and, in turn, our natural environment.

Climatologists expect the change in Wisconsin climate will have the following features:

- More extreme weather
- Increased precipitation, especially in spring and fall
- Increased lake evaporation and higher humidity
- Increased number of warmer days and warmer nights

All of these changes have impacts on people and the environment.

Extreme weather

Extreme weather is already upon us—from intense rainstorms to wide swings between prolonged drought and Midwestern monsoons—and the trend is toward more of these extremes. The growing frequency of intense storms has also increased the incidence of flash flooding, multiple "500-year floods" within a ten-year span, hail storms, and other disasters. These storms have caused severe erosion, massive losses in property and crops, as well as damage to roads and other infrastructure, and, in some cases, loss of life (see figure 1). The year 2013, which brought widespread drought to Wisconsin but also the massive flooding events in the city of Superior, was a particularly devastating and expensive year of extremes. Often such disasters hit the most vulnerable communities and families, including low-income neighborhoods in flood plains or farmers whose crops don't qualify for crop insurance under the federal commodity programs. State, federal, and local agencies (and thus taxpayers) end up picking up the costs of emergency response and disaster aid—one of the increasingly high costs of a changing climate. While variability in weather and storm events is normal, the recent *level* of variability and *intensity* of storms is evidence of disrupted climate patterns.

Intense storms also increase nutrient-laden runoff from farmland and paved urban areas. The waters of lower Green Bay in Lake Michigan, for example, have a growing dead zone, in which dissolved oxygen is absent. This is due in part to intense gushing rainstorms between April and June that flush massive loads of phosphorus and sediments from the large Fox River watershed and from other smaller rivers and creeks into the bay.[1]

Increased precipitation and evaporation

Taking the variability of weather, including periods of drought, into account, projections for the upper Midwest are for increased precipitation (rain and snow). However, the overall warming trend means that on average our lakes are freezing later in the winter and thawing earlier in the spring, affecting lake ecology as well as putting a damper on winter recreation.

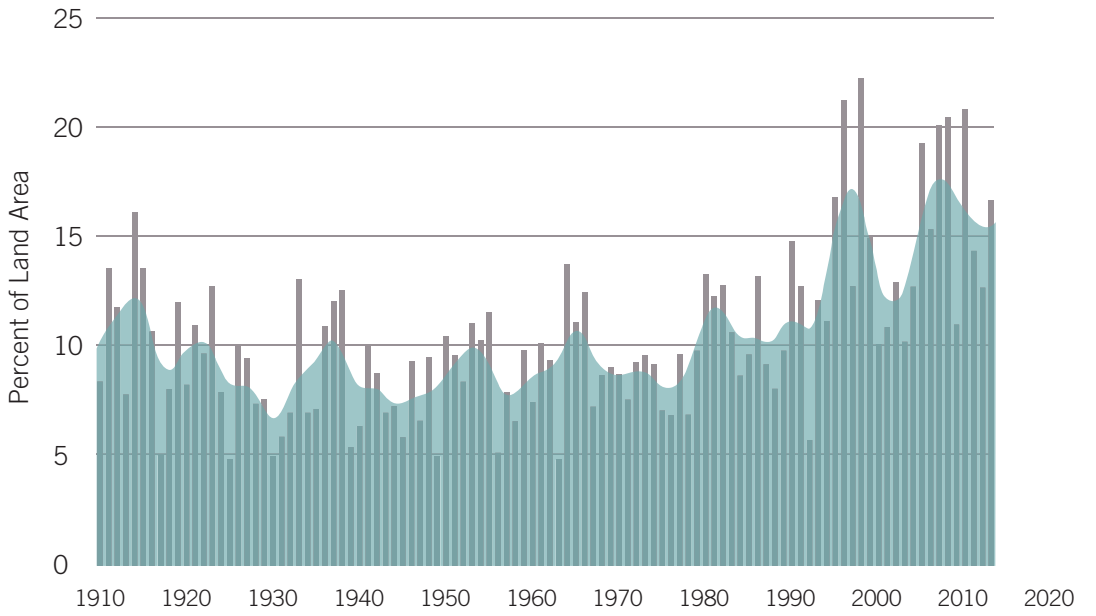


Figure 1. Extreme one-day precipitation events in the contiguous 48 states, 1910-2012.
Source: EPA, "Climate Change Indicators in the United States," updated May 2014.

In the Great Lakes, open water means more evaporation year-round, which predicts a trend towards lower lake levels. Lake Michigan harbors were at record lows in 2013,[2] reducing capacity for commercial shipping, and affecting recreational boating and even ferry services in Door County. The unusually prolonged period of subfreezing temperatures and extensive snow cover of the winter of 2013–14 illustrate the high variability in day-to-day weather even within a climatic warming trend. It also illustrates the influence that ice cover and heavy precipitation can have on the Great Lakes' levels. Noting that extensive ice cover reduced lake evaporation during winter 2013–14, the US Army Corps of Engineers predicted that Lake Superior would rise above normal in summer 2014 for the first time since 1998. Water levels in Lakes Michigan and Huron are expected to be 9 to 14 inches higher than a year ago. This is a significant recovery in one year, but still 9 to 12 inches below the lakes' long-term average.[3]

Increased number of warmer days and warmer nights

As our climate grows warmer, it affects Wisconsin life in countless ways—some subtle and others more dramatic.

Longer growing seasons but more pests

The growing season in Wisconsin increased by 5 to 20 days from 1950 to 2006, with the greatest change in the central and northern part of Wisconsin.[4] While this can mean some benefits for farmers, it also opens the door for crop and tree pests that we haven't historically had to manage in Wisconsin.

For example, pests like the corn earworm could expand their range in Wisconsin.[5] Currently the adult moths must migrate north to our region

each year. But with the warming trend, the moths will be able to arrive earlier and even survive here year-round. Apple growers who monitor insect life cycles in their orchards are seeing an increase in less common pests, such as San Jose scale, over the past ten years. Extreme disease pressure from apple scab, a fungus, is more common when springs are cool and wet, as they were in the 2013 growing season.[6] In 2006, unusually strong winds carried flower thrips from their southern habitat north, making a surprise attack on commercial strawberry patches and wiping out production for many growers.[7]

Changes in the kinds of plants and wildlife that will thrive in Wisconsin

White pine, birch, and maple trees are beloved in our landscape, but each of these species is unlikely to thrive in the warmer and more variable climate projected for Wisconsin. Wild rice—a staple and a treasured part of Ojibwe culture—is also at risk. Coldwater fish, such as trout, can't survive when stream temperatures rise above critical thresholds, and habitat for valued game species such as the ruffed grouse is also vulnerable.

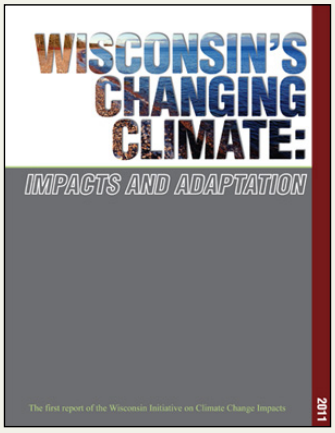
Many of the habitats that we think of as *Wisconsin* are already changing, and so will the life they can support.

Health impacts

A range of health impacts are related to warmer temperatures and heat waves. The number of days above 90 degrees Fahrenheit in Wisconsin has grown over the last decade, but perhaps more importantly, the number of warm nights has grown as well, reducing relief from the heat for people and livestock, increasing surface water temperatures and humidity levels, and exacerbating the urban "heat island" effect.

People with pollen-triggered allergies are reaching for remedies more often as carbon dioxide-rich air stimulates more pollen production in many plant species. Heat waves are on the rise in the region,[8] and they often correlate with ozone pollution from stagnant summer air masses. Those who struggle with asthma or other respiratory illnesses are particularly at risk from these conditions.

The US Environmental Protection Agency (EPA) notes that ticks carrying Lyme disease and



For a thorough discussion of climate change impacts in Wisconsin and strategies for adapting to these conditions, see the report, *Wisconsin's Changing Climate: Impacts and Adaptation*, produced in 2011 by the Wisconsin Initiative on Climate Change Impacts (WICCI). WICCI is a collaboration of the University of Wisconsin-Madison and the Wisconsin Department of Natural Resources and is coordinated by the Nelson Institute for Environmental Studies at UW–Madison. It is funded by Wisconsin's nonprofit Focus on Energy. WICCI's goal is to identify ways to adapt to the climate changes underway. The report is available online at www.wicci.wisc.edu/publications.php.

mosquitoes that can transfer West Nile virus are already a nuisance in the Midwest, but will survive in greater numbers as winters become milder, increasing the risks of these diseases.[9]

On the farm, dairy cattle produce less milk when they are heat stressed, and extreme heat stresses other livestock as well, hurting productivity and increasing financial risk for farmers.

Whether it is fruit from our orchards, winter recreation, water quality, wildlife habitat, or traditions we cherish, life in Wisconsin is changing with the climate. Some effects may be beneficial (such as longer growing seasons), but many will have profound impacts on our way of life and health, the state's prosperity, and what Wisconsin *means* to us.

The energy challenge

While Wisconsin must pursue strategies to adapt to an altered climate, we also have the opportunity and *responsibility* to reduce our contribution to global climate change. To make informed and responsible choices about our production and use of energy, it is essential to understand the consequences of maintaining the status quo. What will the continued reliance on burning fossil carbon and inefficient ways of using energy—and the resulting impacts of climate change—mean for Wisconsin?

Today, over 80 percent of Wisconsin's energy supply derives from fossil sources like coal, petroleum, and natural gas—all of which contribute to CO_2 and other emissions that drive climate change. Because none of these are natural resources in Wisconsin, nearly all the fuel we use to generate electricity, heat and cool buildings, and drive our vehicles comes from out-of-state sources. In 2011 we sent $15.9 billion out of Wisconsin for energy—around $2,700 for every person in Wisconsin.[10]

Despite modest efforts to boost locally available renewable energy, today Wisconsin is extremely dependent upon external energy supplies and fossil fuels. In addition to the economic drain, our dependence makes us vulnerable to interruptions in the supply chain, unexpected price shifts, as well as spills and accidents. The propane shortages in the winter of 2014 illustrate the impacts on Wisconsin families and businesses when supplies run out and prices soar. As we look ahead, we can expect Wisconsin's electric rates to become some of the highest in the region because of our dependence on fossil fuels.[11] Neighboring states, such as Iowa and Minnesota, that have increased their reliance on locally produced renewable energy are seeing more stable rates.

Clearly, there is much at stake for Wisconsin in our energy choices. Continued climate change threatens many of the things we value most about Wisconsin: its varied landscape of prairies, forests, rivers, and lakes; our seasonally based traditions and outdoor recreation; and the livelihoods and local economies based on farming and tourism. Our current energy system, based on burning imported fossil carbon, has serious liabilities for our economic efficiency, vitality, and independence as well as for our physical health. If we wish to maintain and enhance the quality of life in this state for ourselves and for future generations, we can no longer consider our present path to be a viable option.

Wisconsin has abundant scientific, technical, and entrepreneurial talent, in addition to strong values and traditions of environmental stewardship, civic responsibility, and concern for others

(not to mention a can-do attitude). Our state has the capacity to be a leader in responding strategically and comprehensively to these critical challenges.

Planning not only to adapt, but also to reduce emissions

There are two general strategies for addressing climate change.

One strategy is "adaptation"—anticipating the inevitable impacts, given current changes already underway, and adapting to them as best as possible. Adaptation strategies may include actions such as moving neighborhoods out of floodplains that are frequently inundated by intense storms; expanding green infrastructure (natural floodplains, wetlands, and other open space that can absorb rainfall); growing drought-tolerant crops to reduce the need for irrigation and growing perennial crops to keep soil in place during intense rain events; or creating more cooling shelters for urban areas affected by heat waves. As important as adaptation strategies are, they don't solve the primary problem, which is excessive emissions of carbon dioxide, methane, and other greenhouse gases released by human activity and building up in our atmosphere

To address this, the other strategic response is to reduce the emissions (frequently called "mitigation") and, in doing so, to reduce or curtail the pace and scale of climate change.

Wisconsin needs both strategies to plan for a resilient future and to ethically respond to the burden that climate change places on vulnerable people here and abroad, on future generations, and on other species.

Notes

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10. Funds leaving the state are equivalent to approximately 75 percent of total energy spending for the state, calculated based on data from Wisconsin Energy Office, "Wisconsin End-Use Energy Expenditures, by Type of Fuel," http://www.stateenergyoffice.wi.gov/docview.asp?docid=24719&locid=160.
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Photo credit: Over the Bars in Milwaukee, http://overthebarsinmilwaukee.wordpress.com/

Rising to the Challenge

Carbon footprint is shorthand for the amount of CO_2 emissions and other greenhouse gases we generate through our energy use, consumer choices, and other actions. It refers, in particular, to the emissions that drive global climate change. We have many practical and effective approaches that can reduce these emissions and the size of our footprint. These include reducing the amount of energy we use; the sources of that energy; the way we manage our forests, grasslands, and farms; the way we design cities and transportation systems; the way we operate businesses and industries; and countless other actions. The most significant choices center around energy.

Energy sources, uses, and options in Wisconsin

Wisconsin has the opportunity to be more energy independent and to transition to cleaner energy sources. Unfortunately, we are trending in the other direction.

Between November 2012 and October 2013, Wisconsin increased its reliance on coal for electrical generation by 19 percent.[1] This is due, in part, to the retirement of the Kewaunee nuclear plant (see page 13), as well as to the rising cost of natural gas. Without other guiding criteria or aspirations, near-term fuel costs are likely to be the determining factor in Wisconsin's energy profile, which is problematic if we are to achieve carbon reductions, longer-term energy security, and global competitiveness. The figures on page 11 illustrate the dominant role that coal plays in producing electricity in Wisconsin (figure 2), as well as overall energy use in the state (figure 3).

Energy analysts typically break energy use into three major categories: electricity generation, heating and cooling (thermal energy), and transportation. Each of these arenas has opportunities for advances that will reduce greenhouse gas emissions and provide other social, economic, and environmental benefits. Yet, Wisconsin is falling behind neighboring states on sustainable energy development in all of these categories. Figure 4 shows energy consumption for combined electricity and thermal uses for residential, commercial, and industrial sectors.

Because the weather in Wisconsin and the Midwest is cooler than other areas of the US, space heating (56 percent) makes up a greater portion of energy use in homes compared to the US average (figures 5).

Reducing energy consumption

One of the easiest ways to reduce Wisconsin's carbon footprint is through improving energy conservation and efficiency. As a northern state, we use a lot of energy heating buildings, from private homes to commercial buildings, school campuses, manufacturing facilities, and more. Energy conservation improvements in buildings through better insulation, the wise use of spaces and smart design in new construction, and the incorporation of passive solar heating and geothermal heat exchangers are some of the lowest-hanging fruits in a figurative orchard of opportunty.

There are myriad other opportunities for improving efficiency: purchasing Energy Star (efficiency-rated) appliances; using efficient light bulbs; pursuing innovations in manufacturing processes; recycling and reusing materials and using local materials; and applying *cradle-to-cradle analyses* that look at total energy costs in the life cycle of a product or technology—from extraction of raw material to disposal and re-creation of the item as a new product.

Wisconsin ranked 23rd in the 2013 State Energy Efficiency Scorecard (see figure 6), published by the American Council for an Energy-Efficient Economy (ACEEE), a national energy efficiency information and advocacy organization.[2] The state dropped six positions compared to 2012, continuing a downward trend over the last five years. ACEEE states that one reason Wisconsin has been losing ground on its State Scorecard is that "[Focus on Energy] budgets and savings were significantly lower than in years past due to a transition between program administrators." Another factor may be that other

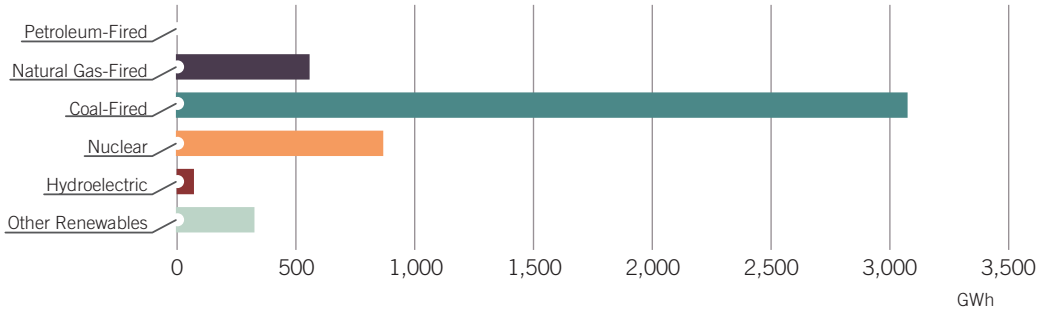

Figure 2. Wisconsin net electricity generation by source, November 2013

Source: US Energy Information Administration (EIA), Wisconsin State Profile and Energy Estimates

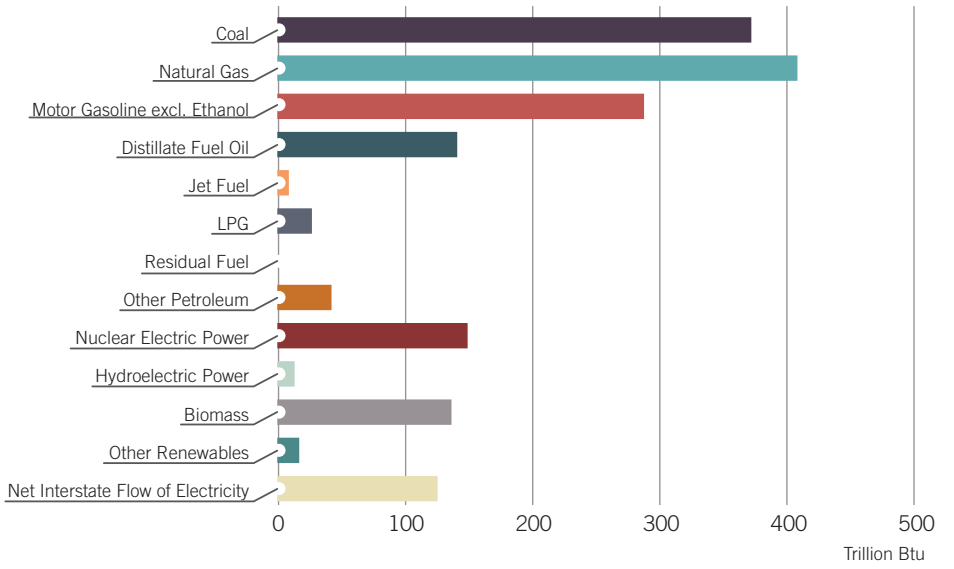

Figure 3. Wisconsin energy consumption estimates, 2012.

Source: EIA, Wisconsin State Profile and Energy Estimates

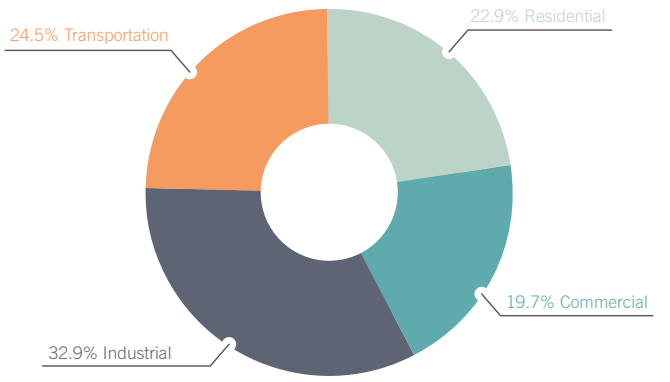

Figure 4. Wisconsin energy consumption by end-use sector, 2012.

Source: EIA, Wisconsin State Profile and Energy Estimates

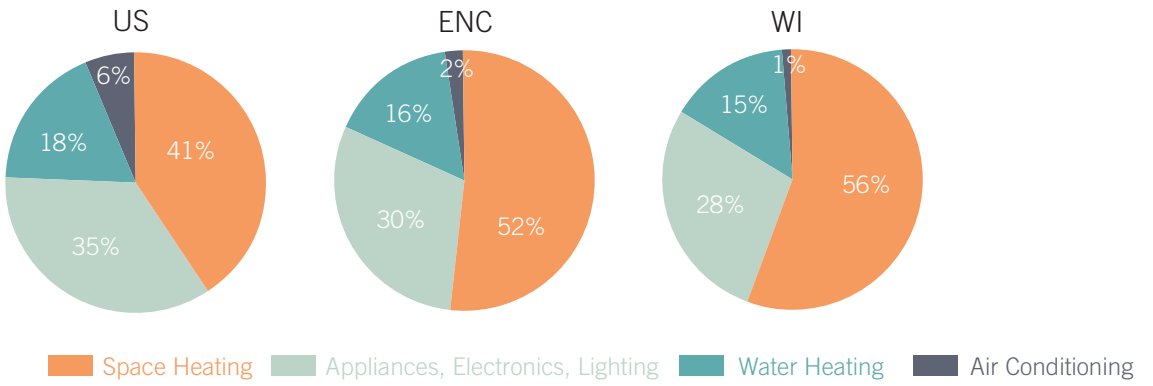

Figure 5. Household energy consumption by end use.
Source: EIA, Household Energy Use in Wisconsin

states are making more rapid gains in this arena and are overtaking us.

Focus on Energy is Wisconsin's utility-based energy efficiency and renewable energy resource program. It was created in 2001 to provide education, resources, and cash incentives to Wisconsin residents and businesses to increase the use of energy-efficient products and systems, from furnaces to solar panels to vending machines. Since its inception, more than 91,000 businesses and more than 1.7 million residents used the program and saved $2.20 for every dollar spent, according to 2011 Focus data.[3] While in 2010 funding was approved by the Legislature's Joint Finance Committee for $256 million in 2014, the Legislature in 2011 rolled back the initial approval amount to $100 million.[4]

While the Legislature has the authority to set the budget for Focus, the program is not funded through state tax dollars. The electric and natural gas utilities fund Focus through customers' payments, equivalent to 1.2 percent of their gross revenue. Their funding is capped at a percent of utility bills rather than based on identified opportunities to save energy.

Expanding renewable energy

Wisconsin renewable energy sources currently only provide 5.4 percent of Wisconsin's energy (accounting for all fuels).[5] For electrical generation, renewables provide 10.2 percent.[6] Renewables includes solar, wind, biomass (such as wood, crop residue, and animal wastes), geothermal applications, and some hydro-power. (Renewable energy sources for electricity, thermal uses, and transportation are discussed in greater detail in Renewable Energy: Status and Opportunities, see page 34.) Much of Wisconsin's development of these sources has been the result of past policies that provided incentives to explore, develop, and demonstrate their potential, such as Wisconsin's Renewable Portfolio Standards (RPS) for generating electricity from renewable sources.[7]

Because our current scale of renewable capacity is so modest, Wisconsin has the opportunity to make major gains by expanding technologies such as solar and wind, which have become increasingly cost efficient in recent years, as well as biogas from digesters, for which the state already has proven technology in place. However, if we don't expand our renewable energy sources, Wisconsin risks

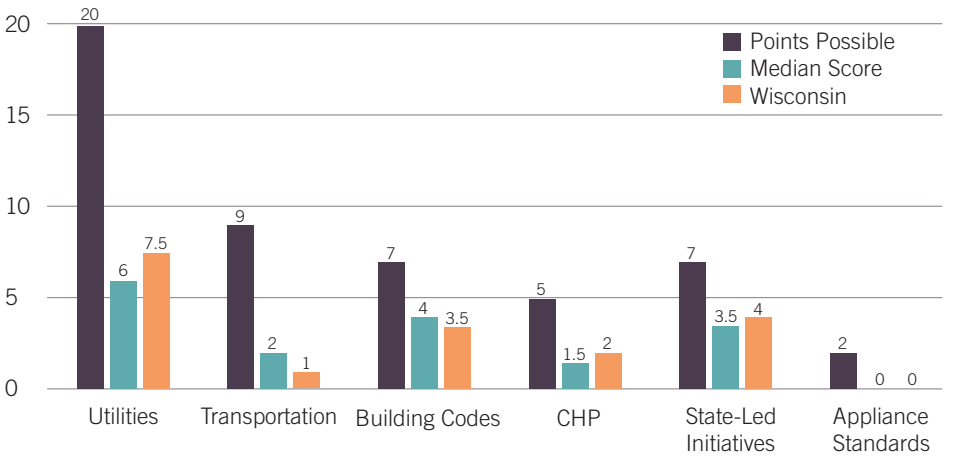

Figure 6. Wisconsin's 2013 energy efficiency score.
Source: ACEEE, State Sheet

falling even further behind neighboring states that share a similar climate and economic base—and that are well ahead of us in diversifying renewable energy sources and building local capacity.

Evaluating nuclear energy's role in reducing fossil fuel dependence

Wisconsin is home to aging nuclear facilities situated on the shore of Lake Michigan—including the recently shuttered Kewaunee Power Station, which was one of the oldest operating nuclear reactors in the country. The only remaining commercial nuclear plant in Wisconsin is the Point Beach plant. Reliance on nuclear power remains a controversial issue, but it was near-term energy economics and the relatively cheap price of natural gas that drove the decision to mothball the Kewaunee plant. Regardless of one's viewpoint on nuclear energy, Wisconsin's CO_2 footprint has increased with Kewaunee offline, because the 556 kilowatts of energy it produced (approximately eight percent of Wisconsin's electricity) is now being supplied by natural gas-fired and coal-fired boilers at other facilities.[8] As Wisconsin considers its long-term energy strategies, the role of nuclear power needs to be carefully weighed, given the complex suite of economic, safety, radioactive waste management, and small carbon footprint considerations for this energy source.

Exploring transportation choices

Wisconsin is not a leader in public transit; highways are still the primary way of getting people and products from one place to another in a state that is largely rural. A proposal for major improvements in passenger rail in southern Wisconsin was rejected in 2010, and there has been little movement in this direction since. Local transit has seen more success, such as popular bus systems in Madison and Milwaukee. Bike trails and bike commuting are growing in several communities, and some cities are exploring better options for more integrated transit design. As in the rest of the nation, gasoline consumption in Wisconsin is trending downward, likely a result of the suppressed economy, increased fuel efficiency in vehicles, increased use of hybrid and electric vehicles,[9] and, possibly, the result of younger adults choosing alternatives to the personal car, including local bus systems and bikes.[10] Wiscon-

sin does have a robust rail and marine transportation network for the movement of freight and, to a limited extent, passengers. These modes are moving toward natural gas as a primary fuel to reduce emissions and energy consumption.

Other opportunities to reduce our carbon footprint

Maximizing natural carbon storage

All green plants, as they grow, pull carbon dioxide from the air to photosynthesize sugars. They also produce cellulose and its relative, lignin, from which they assemble cell walls and woody material respectively. Cellulose is a tough, tightly bonded molecule containing six carbon atoms per unit. Even after a plant—or its leaves or a branch die—the cellulose and lignin are relatively slow to decompose, especially if they become buried in cold soil.

As a state with extensive forest, pasture, and croplands as well as wetlands, Wisconsin already stores significant carbon in its soils and plant communities and, with thoughtful management, could increase this capacity. From perennial plantings—such as orchards, pasture grasses, and tree farms—we can produce crops without substantially disturbing soils (which can release CO_2 and methane). Less disturbance means less release of CO_2 and methane from buried plant debris, making these lands valuable *carbon sinks*.

Wisconsin is exploring opportunities to grow both native perennial grasses, such as switch grass, and woody plants as biofuel sources on lands not amenable for conventional crops. These landscapes could contribute to carbon reductions by storing carbon in the soil and also in the living plants, prior to their harvest as a renewable fuel source.

Anticipating a cost on carbon

One reason that Wisconsin and other states still lean so heavily on fossil fuels is that strategies to put a price on carbon emissions (by taxing carbon emissions or establishing emission caps and permitting trading emission quotas among sources) haven't made much headway at the federal or regional level. Thus, the many real collateral costs related to CO_2 emissions are not yet internalized and these fuels remain relatively cheap compared to investing in renewables.

Leading up to 2010, Wisconsin was becoming a leader in the Midwest Governors Association's Midwestern Greenhouse Gas Reduction Accord, which sought to create a market-based approach to curbing regional greenhouse gas emissions. Similar to the Regional Greenhouse Gas Initiative in the Northeast and the Western Climate Initiative in the West, this program would have linked our energy use to emissions and created a cap and trade system for carbon dioxide. As momentum gathered for federal climate legislation, however, support for regional efforts waned in anticipation of a promising new federal-level policy. By the time efforts for a federal policy failed, Wisconsin and other Midwestern states had backed away from earlier interest in a regional approach.[11] Where regional initiatives are already in place, their trading system has produced revenues for improving efficiency and has not caused an increase in utility rates.

Most long-term strategies for reducing emissions assume that a decisive factor will be some type of price on carbon emissions. Five major US oil companies are among those already factoring a price on carbon into their long-range planning,[12] and firms such as Disney and Microsoft have imposed their own internal "carbon tax" on their business activities.[13] If Wisconsin remains as

heavily dependent on coal as it is today, any future carbon tax or fee would affect Wisconsin more than neighboring states that have more diverse energy portfolios with a larger portion of renewable energy sources.[14] Anticipating this cost and factoring it into our energy strategies will reduce our risk of price increases linked to fossil fuels.

Wisconsin can embrace new strategies and lead

Many states are moving forward on energy strategies without waiting for federal policy to address carbon markets. Wisconsin, too, can pursue improvements in efficiency and Wisconsin-grown renewable energy sources. If we don't take steps in this direction, our net reliance on fossil fuels will likely lead to less economic stability, higher costs for consumers, and increased greenhouse gas emissions.

Conversely, by cultivating locally produced sustainable energy sources, we would be less at the mercy of global and regional energy markets and future carbon prices. More energy production dollars would be invested in Wisconsin communities, and we could also reduce CO_2 and other greenhouse gas emissions. Managing greenhouse gas emissions and managing energy can and should go hand in hand.

Wisconsin, with its conservation heritage, world-class research institutions, and entrepreneurial spirit, can be a leader in finding and testing a wide range of responsive solutions—solutions that will reduce our dependence on imported fossil fuels while at the same time curbing emissions and providing complementary benefits, from healthier air quality to wildlife habitat.

According to the EPA, the majority of states have some kind of climate or energy plan that includes specific recommendations to address climate change and reduce greenhouse gas emissions. Wisconsin issued a report from a governor's task force in 2008 that outlined policies but was never adopted.[15]

Looking forward, elements of a broad Wisconsin climate action plan should include strategies that:

- reduce our carbon footprint through fuel choices, conservation, and efficiency
- capture and store carbon dioxide and other greenhouse gases in our forests, grasslands, wetlands, and agricultural lands
- anticipate the impacts of a changing climate and support ways for communities and various sectors (such as agriculture, manufacturing, and forestry) to adapt
- support social and economic resilience where possible
- support ecological resilience and key ecosystem functions in a time of rapid change
- modernize the business model for energy utilities to allow *two-way* transmission and other innovations

This report explores opportunities that can provide the building blocks of such a plan, with a focus on ways we can reduce our carbon footprint.

Building on Wisconsin values

Opportunities become solutions only through leadership and action, and Wisconsin has many leaders already stepping forward in diverse arenas. These leaders include municipalities, businesses, community groups, farmers, utilities, hospitals and health care systems, university and college research programs and initiatives, and countless individuals. But their pioneering solutions will catch on and be adopted in wider circles only if the actions therein reflect widespread

Wisconsin values—and that is what this solution-oriented leadership does.

Wisconsin culture embraces responsibility, self-reliance, and gumption, but we also care about each other—especially our future generations. No one wants to leave our children and grandchildren with a Wisconsin that is less than it is now. These characteristics, plus strong concern for the natural environment, make Wisconsin an ideal place to forge 21st-century solutions that can do good, and also help us do well in the process.

In any discussion about shifting energy production to renewable sources or undertaking other climate solutions, there are competing values, concerns, and conflicting priorities across the spectrum of energy users, producers, and political players. When values are in conflict, it is difficult to take bold steps forward. Discussing the status of Wisconsin's current and future energy consumption involves recognizing the multiple lenses through which Wisconsinites are judging the state's energy policy.

Factors that will shape our decisions

Price is perhaps the dominant influence on energy decisions. Some believe Wisconsin is doing well if its energy is inexpensive now (as shale gas is currently); others are concerned about the hidden costs of so-called "cheap" energy (*e.g.*, impacts from mining of the Wisconsin frac sands used to extract shale gas elsewhere). If we remain dependent on fossil fuels, who will absorb these external costs when they finally come due in the future? Price is also linked to values such as equity, fairness, and justice.

Public health is another factor, but is often overlooked in energy decisions. Reducing airborne particulate pollution from coal-burning power plants is very important to a person with asthma or respiratory illness; making sure low-income families can afford heat and electricity is also a concern. Public health is linked to values such as responsibility, compassion, justice, accountability, and fairness.

Environmental impacts are becoming increasingly visible, and concerns about these impacts and their costs will weigh into our choices. Some impacts will affect us directly, such as losing valued fish, game, and plant species; and others indirectly, through rising food prices, and lost or degraded ecological processes such as bedrock's natural filtration of ground water or a wetland's entrapment of polluting sediments.

Cultural impacts will be felt from such things as the potential loss of wild rice habitat, important to Native Americans. Changes in dominant tree and wildlife species, and in the onset of seasonal activities that are deeply ingrained in our sense of what Wisconsin *is*, are other important possible impacts.

Self-reliance is important to many who wish to reduce our dependence on energy purchased from outside Wisconsin by producing more in the state. For some it is linked to a sense of independence—being less dependent on the grid; to others it is important because it increases energy security and resiliency in the face of market fluctuations.

Responsibility is a core value in the overall energy and climate change discussion. Are we taking responsibility for addressing the impacts of the greenhouse gas emissions Wisconsin generates; are we acting responsibly for future generations?

The factors that matter to an individual or group are shaped by the values that drive their personal, professional, and political decisions.

The actions and innovations we highlight in this report are a window into a Wisconsin future that is within our grasp. It can happen if our shared values drive the choices that will make a cleaner and more energy-resilient Wisconsin a reality.

Policy matters. Energy efficiency and low carbon emissions are key components of sustainability. Many Wisconsin leaders in business, healthcare, agriculture, and energy research see these as smart practices in a competitive global economy, and many have taken the plunge. However, many were able to do so only because of public-private partnerships, and programs such as Wisconsin's utility-funded Focus on Energy as well as federal energy programs like the Energy Infrastructure program and the Energy Efficiency and Renewable Energy Research and Investment program. Both are funded under the American Recovery and Reinvestment Act of 2009, commonly called the "economic stimulus package." These have been critical motivators for early adopters.

Individual efforts are promising, but aren't sufficient to address the scale of the challenge. They will have greater impact if they are woven into a more cohesive strategy that builds on the capacities, leverage, and leadership of both the public and private sector. Sound policy has played a critical role and will continue to be crucial if we are to succeed in meeting our energy challenges.

Notes

1. Roy Thilly in discussion with Jane Elder, January 2014.
2. ACEEE, "2013 State Energy Efficiency Scorecard," http://aceee.org/state-policy/scorecard.
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6. June 3, 2014 Electric Provider Renewable Portfolio Standard Compliance for Calendar Year 2013. Memo to the Public Service Commission of Wisconsin (PSC REF#:206461). http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=206461.
7. Renewable energy comes from a source that is continuously replenished by natural processes. State law (Wis. Stat. §196.378(1)) defines the following as renewable resources when used to create electricity: wind energy; solar thermal energy (using heat from the sun to create electric power); photovoltaic energy (a system that directly converts sunlight into electric power); biomass (wood or plant material or residue, biological waste, crops grown for use as a resource or landfill gases; it does not include garbage or nonvegetation-based industrial, commercial or household waste); geothermal technology; hydroelectric (with a capacity of less than 60 megawatts); tidal or wave action; fuel cell (using a renewable fuel as determined by the Public Service Commission), http://psc.wi.gov/theLibrary/publications/electric/electric07.pdf.
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Photo credit: Urban Ecology Center, Milwaukee

Pathways to Progress

There are many opportunities that can provide the building blocks of a Wisconsin climate and energy plan. We explore these and profile businesses, communities, and individuals who are leading in these areas:

- advancing energy efficiency and conservation in realms such as product design, technology, manufacturing processes, agricultural applications, and urban planning
- developing renewable and sustainable energy sources such as biomass, wind, and solar energy
- improving transportation systems
- conserving land through practices that foster carbon and methane storage
- making system-scale changes and developing sustainable business models

Conservation, efficiency, and sustainable practices

Conservation, in the context of energy, means using available resources prudently, from turning off the lights when leaving a room, to caulking the leaky window frames and insulating the attic to reduce heat loss. Efficiency is defined as the ability to complete a task without wasting materials, time, or energy. An efficient process maximizes the finished goods produced from raw materials. Efficiency is central to successful business operations and a thriving economy.

Energy efficiency can be best described as using less energy to get the same or better outcome, like a well-lit room, hot shower, or cold beverage. Energy *saved* is generally the least expensive energy resource; it reduces energy costs as well as the pollution that would otherwise come from burning fossil fuels.

Wisconsin households and businesses have strong affinity for efficiency. We do not like waste; ever pragmatists, we like to wring the maximum value out of things we purchase, and that includes energy.

Sometimes the waste is embedded in our habits—the way we have always done things. An idling vehicle is a good example of habitual waste. Twenty years ago auto manufacturers recommended idling to warm up car engines, especially in colder months. But today's owner's manuals are clear that idling more than 30 seconds is not needed; still, many people continue to idle vehicles, wasting a gallon of gasoline for every hour of idling.

Other forms of waste lie in outdated equipment or appliances. An aging boiler might consume resources at two or three times the rate of a newer unit. Incandescent lighting also consumes significant energy. Some waste requires technical expertise to identify, but the upgrades can pay for those costs in a few months because the increase in efficiency is so substantial.

Strategies by sector

The American Council for an Energy-Efficient Economy (ACEEE) outlines how we can improve our nation's energy efficiency across residential, commercial, industrial, and transportation sectors, as well as through addressing human behavior dimensions. Each sector offers myriad opportunities for saving energy, materials, and other resources through improvements in efficiency. The following discussion is adapted from ACEEE with permission.

Homes and appliances[1]

American homes use almost 25 percent of the energy consumed in the United States. While home energy use has increased steadily over the past 25 years, it has increased at a slower rate than the rate of population increase, indicating some gains in efficiency. However, these gains are being offset by increases in the number of household electronics and appliances in the average home. The larger opportunities for efficiencies are in *whole-home performance* such as insulation and heating and cooling systems.

Commercial buildings and equipment[2]

Commercial buildings, such as office and retail buildings, educational and health-care buildings, and hotels and motels use 19 percent of the energy consumed in the United States. Because more than half the energy used by commercial buildings

goes toward heating and lighting, whole-building improvements in either or both systems could have dramatic impacts. Recent advances in LED lighting systems have particular promise. Other opportunities include improving the operations and maintenance of existing buildings, employing the kind of split incentive agreements that often occur between the bill-payers and the tenants of rented properties to pay for upgrades in energy conservation.

Manufacturing[3]

The industrial sector consumes more energy than any other sector—about one-third of all end-use energy in the United States. While industrial energy efficiency has increased steadily over the past three decades, there are still tremendous opportunities for energy savings, as well as the potential to instill the tenets of energy efficiency in a sector that employs and influences millions of people. The industrial sector has found energy efficiency investments to be an attractive avenue to increase shareholder value and reduce expenses, especially in a global marketplace.

Agriculture[4]

Farmers and agricultural businesses are actively seeking efficiencies to reduce costs and stay competitive. Dairy co-ops were pioneers in the logistics industry with their efforts to realize transportation efficiencies by aligning regional milk hauling routes—from farm to farm and from farm to creameries. Energy is a significant cost for today's farmer and typically includes the energy to dry corn after harvest, to fuel tractors and other farm equipment, to run a modern electric milking parlor, to transport products to processors and markets, and much more.

New organizations and expanded programs are emerging to aid producers and rural businesses in reducing their costs with a range of tools: offering rebates for energy-efficient farm equipment, providing online or on-farm audits, or lending technical or financial support. These can be crucial in keeping farms afloat during periods of sky-rocketing fuel prices. In turn, these successes lead to increased rural economic development, food security, reduced dependence on foreign energy sources, and improved environmental quality.

Transportation[5]

The transportation sector consumes approximately 28 percent of all end-use energy in the United States. In 2012, the Obama Administration set new fuel efficiency standards for cars and trucks. The goal is to reach an average of 54 miles per gallon across a manufacturer's fleet (from super-efficient vehicles on one end to gas-guzzling autos or heavy trucks on the other) by 2025. With many vehicles already on the road reaching close to that average now, technical improvements in vehicles and reasonable policies that encourage vehicle efficiency could make even greater gains than the new standards.

Providing wider transportation choices, from walkable neighborhoods to high-speed rail, will also increase mobility while conserving and making more efficient use of transportation energy sources. The movement of freight from trucks to more environmentally friendly modes of trans-

portation, such as rail or marine, will reduce energy consumption, air emissions, accidents, and expenses. As these modes move to cleaner natural gas fuels, the advantages will be even more compelling.

Electrical generation and transmission

In addition to the sectors that use energy, our energy systems themselves have inherent inefficiencies built into their design, simply because of the laws of thermodynamics.

For example, energy is lost when we move electricity over long distances through transmission lines, or when we convert energy from one form to another, such as burning gas to heat water to create the steam that powers turbines that generate electricity.

So there are needs and opportunities for improving energy efficiencies in electrical production and delivery itself.

Human Behavior[6]

One of the greatest opportunities for conservation and efficiency is in human behavior—how we use energy and materials, how we make decisions, and why we take some actions and not others. As ACEEE points out:

> *Everything* always comes back to behavior, even when the discussion turns upon the installation of technology: No matter how efficient the light bulb standard is, people still need to get to the hardware store, select the right bulb, take it home, install it, and use it properly before the benefits can be realized.

Our behavior is shaped by many factors, from our backgrounds and values to levels of education and access to resources, as well as by the influence of our peers or other external rewards and incentives. Any successful strategy for making significant gains in energy efficiency, conservation, and sustainable practices across various sectors needs to consider human behavior. We all play roles as energy users, producers, and stewards of our communities and environment.

Efficiency *matters*. When we can identify and implement means to improve efficiencies, we do more—produce more goods, heat more square footage—with fewer resources. The benefits to the economic and ecological bottom lines are substantial. By identifying and eliminating waste and lost capacity, we can reduce the overall demand for new energy, while also improving other aspects of design and functionality in countless processes and products.

Profiles in Conservation and Efficiency

The following profiles highlight Wisconsin programs and businesses that are embracing efficiency, pushing beyond "just what is required," and reaping the rewards. Many Wisconsin innovators—from public agencies to private entrepreneurs—have gone far beyond the minimum efficiency standards and building codes to pioneer approaches that are on the leading edge of conservation and efficiency. They are also combining those efforts with other sustainability practices that illustrate how climate-smart and sustainable strategies can be winning approaches for Wisconsin communities and businesses.

West CAP: Retrofits for low-income housing

One of the first community action agencies formed in Wisconsin, West CAP (West Central Wisconsin Community Action Agency Inc.) helps families overcome poverty and works to create a more just and sustainable society. Based in Glenwood City, Wisconsin (St. Croix County), the organization has worked since 1965 to provide low-income rental housing; to weatherize existing homes for low-income families; to prevent homelessness and home foreclosures; to assist low-income families with transportation, food security, job skills and literacy training, and family development case management; and to help low-income folks gain employment and build assets. West CAP also works to help create more sustainable and resilient communities in west central Wisconsin.

The rising energy cost for generating electricity has a particular impact on low-income households that have little flexibility to absorb higher rates. The inefficiencies in converting coal and gas into electrical energy are part of the problem. According to West CAP Executive Director Peter Kilde, in Wisconsin, 4,442 kilowatt/hours (kWh) of energy input from coal, for example, delivers only 1,814 kWh of electricity to the end user. Fossil-fuel-derived energy also causes substantial greenhouse gas emissions.

Newly renovated by West CAP, this historic building on Main Street in Boyceville serves as the nonprofit's regional food pantry and has four energy-efficient apartments on the second level. Photo credit: West CAP/Peter Kilde.

"Coal is the energy source that generates 63 percent of Wisconsin's electricity. For coal, using Wisconsin's average electricity cost of $.10/kWh, every time you spend $181 on your electric bill, that means you have also put one ton of carbon dioxide into the atmosphere," says Kilde.

In response to these negative impacts on both low-income home energy costs and on climate change, West CAP developed the Residential Alternative Energy and Conservation Program. The program rehabilitates existing low-income housing

to improve energy efficiency and uses locally harvested, renewable, carbon-neutral energy sources to meet the remaining home energy requirements.

Energy load reduction

To work toward the goal of 80 percent energy use reduction on existing housing and ultimately to achieve zero net energy use (meaning that the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site) or better, West CAP's approach includes a number of components.

After an extensive energy audit, they "super insulate" the foundation, walls, ceilings, and other parts of the wall assembly with four-inch insulation on the exterior in addition to the six-inch stud walls. They use the REMOTE Wall system (Residential Exterior Membrane Outside-insulation Technique, from the Cold Climate Housing Research Center in Alaska), which offers an alternative frame construction to minimize the heat loss inside the house.[7] Instead of applying a vapor barrier to the inside of the stud framing, West CAP installs the vapor barrier to the outside of the sheathing, moving approximately two-thirds of the wall's insulating value to the outside. In this way, REMOTE allows more space for insulation and prevents humidity by keeping the air temperature above the dew point (at which water vapor condenses and turns to liquid water or frost).

In addition, the program uses energy-efficient glazing on the windows. "Essentially we turned the house into a kind of giant beer cooler," Kilde explains. The program also protects indoor air quality by using 95-percent-efficient ERV (Energy Recovery Ventilation) or HRV (Heat Recovery Ventilation) systems operating 24 hours a day to exchange fresh air from outside with exhaust air from the home.

Renewable energy use

West CAP uses on-site renewable energy to substitute for fossil fuels, including:

- Using the Solmetric Suneye technique, which analyzes the solar energy availability on site.
- Installing solar hot water systems at suitable sites, which can provide up to 71 percent of the energy needed for heating household water.
- Installing solar photovoltaic panels for grid-connected electrical generation at some sites, as well as solar hot air panels to supplement home heating.

Other renewable energy technologies used by West CAP are geothermal or air-source heat pumps for both heating and cooling, off-peak thermal storage heating, biomass heating, and other passive house features. (A *passive house* is extremely air tight and highly insulated with triple-glazed windows. It is geographically situated to maximize winter sun and minimize summer sun and often has a ground earth heat exchanger or solar panels.)

A fundamental shift that works

An analysis of a retrofitted duplex in Menomonie shows that the insulation saves 14.4 million BTUs of energy for heating and cooling per year, and the 10.9-kilowatt photovoltaic system can even bring a net gain of 1,107 kW/hours of electricity annually. And it works. The first electric bill West CAP got for this property after the retrofit was a $354 *credit.*

In Kilde's opinion, the shift from conventional energy use to renewables is a fundamental change: "The systems for harvesting clean, free energy on-site are qualitatively different from the systems burning fossil fuels. This is a paradigm shift, not

just a matter of cost-and-benefit analysis or payback analysis."

To learn more, visit **www.westcap.org**.

Johnson Controls: Energy-efficient, environmentally friendly, and sustainable

Johnson Controls is a Milwaukee-based company providing products, services, and solutions to optimize energy and operational efficiencies of buildings, automotive batteries, electronics, and interior systems for automobiles.

Incorporated in 1885, Johnson Controls has 170,000 employees globally and has served customers in more than 150 countries. It ranked 67th among the 2013 Fortune 500.[8] The corporation's philosophy is that "energy efficiency helps control rising energy costs, reduce environmental footprints, and increase the value and competitiveness of buildings."[9]

In 2008 and 2009, Johnson Controls renovated or built-new four buildings on its Glendale campus. For all of these energy-efficient, environmentally friendly, and sustainable designs, the Glendale campus received LEED (Leadership in Energy and Environmental Design) Platinum certification in September 2010 from the US Green Building Council; the campus boasts the largest concentration of LEED Platinum buildings ever awarded on one site.

Precise design for optimal performance

The use of 3-D modeling software and a global positioning system helped to determine siting for the 272 geothermal heat-pump wells and to make the measurements so that the 180,000 feet of piping that connect the wells could be manufactured to precise specifications, a simpler and more cost-effective process than fabricating each one by hand. The wells and their network of pipes utilize the constant temperature of the Earth to help heat or cool the buildings, reducing winter heating costs by about 29 percent compared to natural gas boilers.

One of the largest solar panels in the state, the array near Johnson Controls corporate campus is capable of producing 250 KW of electricity. Photo credit: Johnson Controls

Other technologies and solutions used by Johnson Controls to promote corporate office energy conservation and minimize the carbon footprint of their new and renovated buildings include:[10]

- Solar photovoltaic panels capable of producing 250 KW of electricity on site.
- Solar thermal systems that supply more than 30 percent of the hot water for two campus buildings; the 1,330-square-foot rooftop installation saves 2,837 therms of energy annually.
- Skylights and increased window space to naturally light indoor spaces.
- A 30,000-gallon rooftop cistern to capture rainwater for reuse, along with low-flow

plumbing fixtures and dual-flush toilets that contribute to a 77 percent reduction in city water use.
- An energy-efficient security system that integrates access control with lighting and heating/air conditioning systems.
- On-site recycling that collected almost 90 percent of new construction waste and more than 75 percent of demolition waste from existing buildings.
- "Metasys," a building management system for maximum comfort, efficiency, and safety in buildings—and one of Johnson Controls' own products—can operate as a wireless control system or be used as a Web-based monitoring and control system.

Energy efficiency outcomes

Even after doubling its campus space, the company's energy use declined by 21 percent. Water usage has been reduced by 595,000 gallons a year. Annual greenhouse gas emissions have been reduced by 857,200 million pounds of CO_2 equivalent.

"All this was done—not by entirely building a brand new facility from scratch—but by restoring the more than 44 year-old architecture to not only look appealing but to function in an environmentally friendly manner," says Ward Komorowski, director of facilities and building services for the Glendale headquarters.[11]

Johnson Controls expects the campus's savings on energy efficiency to offset its cost within eight years. The company also uses many other sustainability practices that reduce its environmental footprint and those of its clients.

Learn more at **www.johnsoncontrols.com/content/us/en/sustainability.html**.

Quad/Graphics: Efficient production, smart energy strategies

Quad/Graphics has been awarded more than 25 major environmental achievement honors in the last decade. The Sussex-based company (Waukesha County) is a leader in the printing sector with energy efficient and environmentally conscious efforts that include choosing papers made from sustainably managed forests; using inks containing renewable plant-based materials; capturing and recycling compounds from photoplate making, and eliminating photoplate making whenever possible; collecting and recycling all trim and waste paper from its operations. Quad/Graphics uses electricity generated by wind and other green power sources, and also works to lower or eliminate potentially harmful emissions in coatings, adhesives, and solutions. It promotes conservation of resources and materials and aggressive recycling.

Efficient production

Quad/Graphics is driven by efficiency, seeking to reduce waste in every aspect of production and distribution.
- To achieve lean manufacturing, Quad/Graphics—like other forward-thinking manufacturers—has established formal processes to further reduce waste and add customer value at all stages of print production. For example, Quad/Graphics uses modern large-format presses that reduce energy consumption per printed page.
- It is also committed to reducing water consumed relative to production. Pumping, heating, and treating water is very energy intensive;

Quad/Graphics' modern, large-format presses reduce energy consumption per printed page while inline finishing reduces paper waste and minimizes logistics. Photo credit: Stephen Frink.

thus the less water used, the more energy conserved. At its Hartford, Wisconsin, plant, Quad/Graphics prints 5,800 pages per gallon of water consumed (an improvement of 35 percent in pages per gallon over its 2000 figure).

Smart energy strategies

Quad/Graphics was the first printer to join the SmartWay Transport Partnership, a market-based partnership program introduced by the EPA in 2004 to reduce fuel use, greenhouse gas emissions, and air pollutants from the freight sector.[12] This partnership has led to efficiencies that have prevented the emission of 12,611 tons of CO_2 in 2009—the equivalent of taking 2,187 passenger cars off the road for a year.

With the industry's largest co-mailing operations, Quad/Graphics can reduce postal costs for its clients while cutting fuel consumption and delivery emissions by combining different magazine and catalog titles into a single mailstream. Co-mailing not only provides postal savings for customers, it also results in efficiency that's good for the environment because fewer and larger pallets mean fewer trucks on the road and fewer miles driven. Responsible mailing is further accomplished with Quad's "list hygiene" services that purge invalid address labels, reducing the pieces of mail that need to be forwarded or returned, saving customers money and reducing the number of wasted print products.

Quad/Graphics' electricity is supplied, in part, through low-impact hydroelectric generation—turbines on an adjacent river turn generators to produce electricity. Unlike large-scale hydroelectric operations, low-impact hydroelectric generation preserves the flow of a river, allowing it to maintain healthy oxygen levels while also allowing fish migration to occur. This on-site generation lowers the company's demands on the power grid.

Quad/Graphics also uses many other practices to support conservation, efficiency, and environmental sustainability.

To learn more, visit **www.qg.com/aboutus/environment**.

NewenHouse Kit Homes: Building for green and simple living

Entrepreneur and sustainability expert Sonya Newenhouse has been seeking solutions for greener and lighter living over the course of her career. In 2011, she designed and built a sustainable kit home in Viroqua, where she, her husband, and their son now live.[13]

This 970-square-foot home is the prototype of a line of kit homes Newenhouse is developing, which are more than 50 percent smaller and 80 to 90 percent more energy efficient than the average

home.[14] The home is Passive House certified and aims for LEED Platinum certification, making efficient use of the sun and heat recovery without using conventional heating systems even in the coldest of winters. "It only needs the equivalent of one hairdryer to heat the entire home," Newenhouse says.

The house combines concepts from three movements: small homes, green building, and sustainable lifestyles, setting an example for smart design in response to climate change and energy issues on a personal, local scale.

With special insulation and triple-paned windows, Sonya Newenhouse's 970-square-foot NewenHouse prototype in Viroqua is Passive House Certified. Photo by Martin Jenich.

Small homes

Newenhouse will launch her business with three home sizes to choose from: a 600-square-foot one bedroom, a 735-square-foot two bedroom, and a 1,000-square-foot 3 bedroom 2 bath. With ingenious storage spaces, such as under the steps of the stairs, NewenHouses optimize the use of interior space while maximizing the feeling of spaciousness in the house. Basements are replaced with a detached 250 to 270-square-foot *stuga* (the Swedish word for *cabin*) accessible off the breezeway, which contains even more storage space, a root cellar, a sleeping loft for guests, and a sitting area that becomes a screened room in the summer.

Green building and design

The home's design incorporates numerous green building practices. The large south facing windows capture the sun's heat and provide an abundance of daylight. The home retains heat from the sun, appliances, and people, rather than needing a traditional furnace, and makes maximum use of natural light for interior spaces. This tightly constructed, super-insulated, passive solar home enjoys indoor temperatures in the mid 70s Fahrenheit with no active heat source , even when outdoor temperatures fall well below zero in the winter. In addition, the house has a solar hot water and photovoltaic (PV) electric system to supply most of its power needs, striving to reach a goal of zero net energy, producing enough energy to offset the energy used. Currently the house uses 50 percent less energy than the energy model predicted, about 3,780 kWh/year. The home's current 10-panel PV system supplies about 2,000 kWh/year.

The construction details take green design even further. The 18-inch double wall system is filled with dense pack cellulose made of recycled newspaper. Along with triple-pane windows with insulated fiberglass frames and building tape covering every seam in construction, the home meets the rigorous airtightness required by the Passive House standard. The roof uses energy-heel trusses, which are extra high trusses used where wall meets roof line. They allow an even thickness of insulation to be applied across the full width of the ceiling, providing continuous thermal protec-

tion. The attic is laid with 26 inches of cellulose insulation, while the slab sits on 12 inches of foam and includes a 4-foot wide and 8-inch deep frost skirt, a technique borrowed from arctic construction methods.

Ventilation is achieved by an extremely quiet Heat Recovery Ventilator (HRV), which has 92 percent heat recovery.[15] The house has two 400-watt wall unit and two 250-watt ceiling unit radiant heaters to warm the house on the cloudiest days.

Many other material choices and design features—such as sustainable cabinetry and designing for ultra-low electrical magnetic fields—also contribute to the "small footprint lifestyle," a significant focus of NewenHouse kit homes.

Sustainable lifestyle

The prototype house pays considerable attention to reducing energy consumption while maximizing the use of renewables. Newenhouse eliminated some customary appliances (TV, dryer, and microwave) and opted for basic appliances and water fixtures that use minimal amounts of energy and water. According to Newenhouse, her monthly average utility bill (not including water) of $25 will save her upwards of $104,000 over the 30-year mortgage. Adding four more PV panels as planned will create a zero net energy home, thus further increasing savings and creating a solar return on investment. She plans to market the kit homes to like-minded green living seekers and welcomes visitors to the prototype at 422 Hickory St. Viroqua, WI 54665.

Visit **www.madisonenvironmental.com** to learn more.

MillerCoors: A commitment to assessment and sustainability

MillerCoors is a joint venture between SAB-Miller and Molson Coors Brewing Co. and is the second-largest beer company in the United States. In 2012, MillerCoors generated a total of $8.97 billion in revenue. In Wisconsin, MillerCoors operates Leinenkugel's craft brewery in Chippewa Falls and two facilities in Milwaukee: Milwaukee Brewery and a microbrewery (Tenth Street Brewery). At the Milwaukee Brewery, nearly 720 employees brew 10 million barrels of beer every year.

Sustainability assessment

MillerCoors uses a measurement and benchmarking system, based on sustainability priorities such as embedding environmental stewardship in operations and the supply chain, and conducting business in an ethical and transparent manner. They are continually striving to improve water and energy efficiency and to regularly report on these and other sustainability measures.

"A commitment to sustainability is part of our heritage, and it's something our employees and consumers demand. Quite simply, it's good business and the right thing to do," says Tom Long, CEO of MillerCoors.[16]

MillerCoors' corporate-wide adoption of sustainability measurement, analysis, and reporting follows the Global Reporting Initiative Guidelines—an internationally recognized framework for sustainability reporting.[17] By developing a calculated weighted average for the amount of energy used to brew one hectoliter (100 liters) of beer, they are able to better determine energy and carbon reductions during the brewing process.

Through energy audits, MillerCoors has aggressively reduced energy use and has seen return on investments in technological upgrades, such as installing more energy efficient coolers, refrigeration systems, pasteurizers, and lighting. Greenhouse gas emissions (figure 7) are calculated by measuring energy consumed and using the Greenhouse Gas Protocol developed by the World Resources Institute.[18]

Corporate culture and employee engagement

MillerCoors has embedded sustainability principles into everyday corporate culture by engaging their employees at the executive, management, and operation levels. Marco Ugarte, MillerCoors Sustainability Manager for Energy and Water Stewardship, explains that the Milwaukee Brewery has created an inclusionary environment that encourages input from all employees. This, plus the rich historical tradition of the Milwaukee Brewery, has instilled a sense of pride among Milwaukee employees and has helped foster a concern for sustainability.

MillerCoors recognizes strategic supply chain risks associated with climate change—such as impacts on grains and hops and even the water supply for the brewery; on the fuel costs of manufacturing cans, bottles, and paper; and the costs of shipping raw materials and finished products— and potential effects on Wisconsin's cultural and natural landscape. Timely adaptation to these threats and mitigation require engaging employees, suppliers, distributors, and others in order to change traditional perspectives and build resilience into the system over time.

MillerCoors Environmental Engineer Joan Meyer surveys the green roof at Milwaukee plant. Photo by Susan Bence/WUWM.

Water stewardship

As noted, water conservation and efficiency are importants part of energy conservation and efficiency, since it takes energy to pump, transport, and purify water. In beer making, not only is water used during the brewing process, but it is also used during the growing of barley and hops.

In 2013, MillerCoors officially endorsed the CEO Water Mandate, an initiative in which chief executive officers (CEOs) of companies acknowledge their responsibility to take a lead in making water management a priority in their industry. This initiative also assists companies in the development, implementation, and disclosure of water sustainability policies and practices.[19] To conserve and sustain water, MillerCoors developed a Water Stewardship Strategy and set a goal of reducing water usage by 15 percent in 2015 (figure 8).

To learn more about environmental stewardship at MillerCoors, including their water strategy, visit **www.millercoors.com/GBGR/Environmental-Stewardship**.

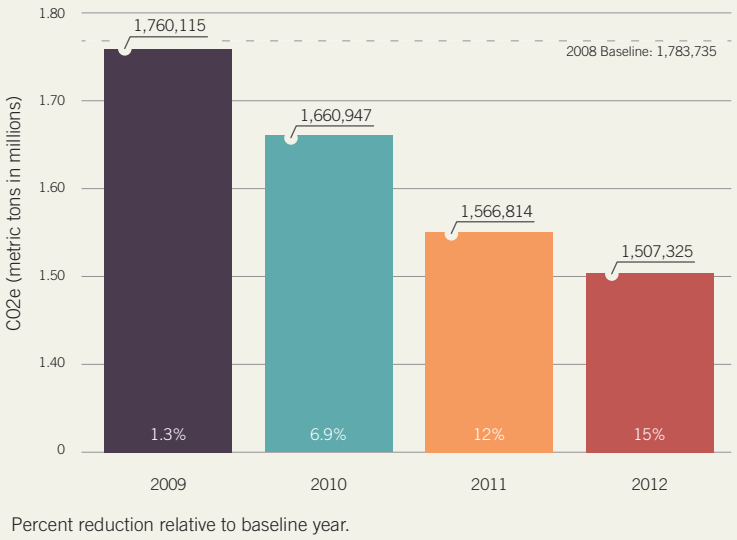


Figure 7. MillerCoors greenhouse gas emissions inventory.
Source: MillerCoors 2013.

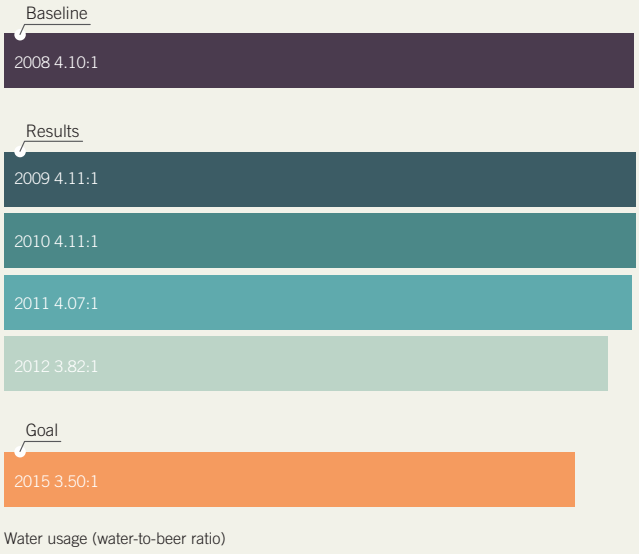


Figure 8. MillerCoors 2015 goal to reduce water usage. A 15 percent reduction will achieve a 3.5:1.0 water-to-beer ratio.
Source: MillerCoors 2013.

Renewable Energy: Status and Opportunity

The road to a sustainable economy in Wisconsin is built on the foundation of our own clean, renewable energy sources. By integrating locally available renewables into our economy, we engage a vast supply chain of local manufacturers, distributors and installers, farmers, builders, entrepreneurs, and related professional workers.

Local renewable energy sources can provide Wisconsin, a state with no fossil or nuclear fuel reserves, with relatively clean, risk free, and low maintenance energy. These sources also help keep energy dollars circulating within Wisconsin and produce energy with a zero or low carbon impact. Expanding our commitment to renewables is one of the simplest ways we can develop more sustainable energy strategies for Wisconsin.

Where are we now?

Total usage of renewable energy in Wisconsin has been driven, to date, primarily by complying with government regulations, such as meeting the goals of Wisconsin's Renewable Portfolio Standards, and by creating markets for renewable energy.

Electricity

Currently, about 10 percent of Wisconsin's grid-supplied electricity comes from renewable energy sources. However, about half of that electricity is imported, primarily as wind power from Iowa and Minnesota, and thus those energy dollars leave the state (figure 9). Wisconsin's $2.3 billion investment in renewable energy was driven by the state's legislative mandate for reaching a 10 percent renewable electric standard by 2015 (the Renewable Portfolio Standards).[20] Wisconsin's home-grown renewable electrical generation

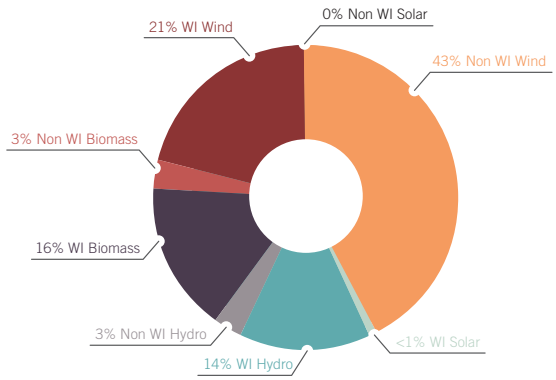


Figure 9. Renewable energy sales for Wisconsin in 2012. Source: Wisconsin Public Service Commission.

comes from approximately 200 renewable energy power plants supplying electricity to the grid (both small local plants and cogeneration plants) using hydroelectric, wind power, bioenergy, and solar sources.

In addition to electricity from Wisconsin's electrical grid network, there are also an estimated 1,500 distributed applications of renewable energy in Wisconsin, collected and used directly at businesses, homes, and farms. (*Distributed energy* refers to locally produced and "behind the meter" electrical generation from diverse sources, such as wind turbines on farms; photovoltaic solar collectors on homes and office buildings; biogas facilities on farms, at landfills, and in food processing industries; and some small scale hydroelectric dams that supply adjacent facilities.)

The vast majority of these distributed renewable installations participated in the state's Focus on Energy program from which they received technical and financial assistance.[21] In addition to reducing the need for ever larger and more expensive transmission lines, distributed use of renewables has many other social and environ-

mental benefits. Distributed renewable systems reduce dependence on fossil carbon fuels (and thus reduce emissions that drive global climate change). But they also develop capacity for greater security, reliability, and resiliency in the face of major climate events by making electrical service less dependent on a single, grid-based source vulnerable to damage from extreme weather and peak demand stresses during heat waves.[22]

Transportation fuels

In addition to generating electricity, renewable sources can also produce fuels for cars, trucks, and other engines. About five percent of Wisconsin's auto fuel is supplied by the state's nine ethanol processing plants that use corn as a fuel feedstock. The resulting ethanol is commonly blended with gasoline. Biodiesel, synthesized from various plant and animal oils and fats, is a very small fraction of transportation fuels in Wisconsin. There is vast potential to use low value biomass feedstocks for transportation fuels, but technical and economic barriers have yet to be overcome. (See discussion on bioenergy and biofuels on pages 36 and 40.) Where methane is released from landfills, animal waste storage areas, and other sources, it can be captured and then liquefied or compressed to be used for transportation fuel.

Thermal energy (heat)

As a cold weather state, Wisconsin uses a lot of energy to heat buildings and water. Renewable energy sources can play an important role in producing heat. From wood burning stoves to geothermal and air source heat pumps to passive solar design, renewables can provide alternatives to conventional heating fuels like natural gas, propane, and heating oil in many applications. Various incentives have helped expand the use of renewable heating technologies. Through 2013 the Focus on Energy program supported rewards for residential installations of geothermal heat pumps, solar water heaters, and photovoltaic electrical generation, but recent changes in the program have hampered some renewable energy markets.[23]

The solar resource (that is, sunshine) in Wisconsin is about twice as abundant in the summer as in the winter, but even so, depending on the site, flat thermal air panels installed on the south side of a house can supply up to 40 percent of a house's heating needs, as projects in Minnesota and northwestern Wisconsin have shown.[24] Passive solar heating from south facing windows is the most practical way to heat with solar in Wisconsin.

In addition, biomass, primarily wood, provides space heating in residential, commercial, and industrial rural applications in modern clean-burning appliances in areas where the wood supply is local and abundant. (Specific applications are discussed in greater detail on page 37.)

Where are the opportunities?

It is technically possible today for homegrown renewable energy to supply 100 percent of Wisconsin's energy needs. This audacious statement is true; but whether it is practical and/or economically feasible is another story.

Recent major studies by the National Renewable Energy Laboratory and the Rocky Mountain Institute have both stated that renewable energy could provide 80 percent of the nation's energy needs by 2050 using "existing technologies that are economical today."[25] This percentage for 2050 appears to be a reasonable goal for Wisconsin.

Solar

Wider utilization of solar energy has the greatest potential to provide Wisconsin's future renewable

energy. Although Wisconsin is not known as the sunshine state, there are adequate resources here to supply the entire amount of electricity used during the peak daytime hours, just by installing panels on existing roof tops with solar access.[26] Solar electric generation has gone through both a massive technological advance and a price reduction in the past three years and is now close to "grid parity," where the cost of producing solar electricity, at the site where it is used, is similar to or less than buying electricity from the local utility. Solar has been growing at 50 to 80 percent annually across the United States, and this growth can occur in Wisconsin as well.[27]

Of course the sun does not shine at night and all days are not sunny, so Wisconsin's solar would benefit from advances in battery storage technologies. But they are advancing—and we can expect that a revolution in the application of solar will soon follow. It is very possible that adoption of solar will follow similar adoption curves as cell phones or digital TVs, where not having solar will be the exception.

Wind

Although it ranks 17th among the American Wind Energy Association's top 20 states for wind energy potential, Wisconsin has only 648 megawatts (MW) of wind energy installed capacity. In contrast, other Midwestern states—Iowa, Illinois, and Minnesota—have 5,178 MW, 3,568 MW, and 2,987 MW, respectively, of installed wind capacity.[28]

While Wisconsin is not regarded as a state with *exceptional* wind resources, there are still many sites on hilltops where wind energy can be developed economically. The National Renewable Energy Laboratory estimated that Wisconsin could provide four times its electrical needs from wind.[29] A major issue to consider is the value of importing more wind-based power from states to our west, which have better wind resources, or developing Wisconsin's own resources, or using a strategic mix. Importing will take more transmission lines. Building locally will create more local jobs, although in some cases local wind power may be costlier than imported wind energy.

Bioenergy

Bioenergy is energy derived from biological sources, such as grasses, trees, crop residue, food production wastes, animal wastes, and even algae. Wisconsin is a major agricultural state and has been blessed with adequate sun, rain, and soil to produce large amounts of food products, and to store energy and carbon in the growing tissue of crops and forests. Byproducts and "wastes" from crops and forests are potential energy resources that can be used directly through combustion or converted to gases and liquids and used elsewhere. Since biomass is stored energy, it can provide a complement to other intermittent renewable resources such as wind and solar. Practical uses include burning forest and farm waste in electrical plants, furnaces, or stoves for businesses, farms, and homes for power and/or heat. Farm and food waste can be converted to biogas through digesters; then the gas in turn is burned to generate electricity and heat. While bioenergy combustion does release carbon emissions, it does not release *fossil-stored* carbon.

Biomass for heat and cogeneration

Using grasses, trees, crop residues, and logging and sawmill wastes (typically called *biomass* in this context) as a direct fuel for heating buildings and firing boilers for electrical generation has so far received a modest reception in Wisconsin, which is surprising given the large Wisconsin bio-

mass resource. Several New England states, such as Vermont, have made much greater strides in developing biomass for heating school buildings and other facilities.[30] Thermal uses (direct heating) of biomass are generally the most energy-efficient applications.

Direct heating from wood

Wood is a widely used renewable energy source in Wisconsin, although it is losing ground to solar and wind power, especially for electricity production. Wood, compared to an equal amount of a condensed fossil fuel like coal, contains about half the potential energy relative to its mass. This means more area is required for wood's storage and more energy required for its transportation. For this reason, about two-thirds of wood energy is used in stoves by consumers to heat private residences. It is, however, used occasionally as a fuel in some industries, especially those already heavily reliant on wood as raw materials, like paper production and furniture manufacturing. There are over 200 commercial and industrial wood energy users in Wisconsin.[31] Pelletizing wood can increase its combustion and heating efficiency, and pellets can also be made from other natural materials, including corn kernels and nutshells.[32]

Co-burning and cogeneration

Co-*burning* is the practice of burning more than one fuel at once. Biomass in combination with fossil fuels is primarily used to produce steam in boilers to drive the turbines that generate electricity in power plants. The use of biomass for electrical generation rather than heating might lower the overall efficiency of biofuels because so much energy is lost in the multiple stages of energy conversion. However, electricity is a much higher quality of energy than heat and can be used for multiple purposes. So the analysis of efficiency needs to take the end use into consideration.

Cogeneration is the production of electricity and heat as part of the same process. Wisconsin has over 200 CHP (Combined Heat and Power) facilities.[33] (Some projects in the planning stages were canceled when natural gas prices dropped dramatically in the last few years.) Nearly all biogas plants and paper mills in Wisconsin are using both biomass and cogeneration. For example, Domtar Corporation recently installed a 50 megawatt cogeneration plant at its paper mill in Rothschild, Wisconsin (Marathon County). Increasing the use of CHP by about 30 percent can reduce Wisconsin's CO_2 emissions to five percent below 2011 levels by 2020.[34]

Securing a steady supply of reliable biomass fuel can be a challenge for either heat or electrical generation, and proximity to the fuel source is an important factor in reducing transportation and processing costs. Thus the most promising options for using forest biomass are likely to be in facilities close to forested lands or biomass waste streams (such as pulp mills and dairy farms).

Grass biomass has tremendous potential across much of the Wisconsin. There are some challenges with grasses, however, because they retain minerals that can foul combustion chambers, produce more ash than wood, and contain less stored energy than wood. Grasslands store much of their carbon in long-lived root systems and soils. Conversely, much of the carbon in forests is bound up in the tree's above-ground trunk and branches, as well as its root fiber, and thus, decades of stored carbon can be released by combusting wood.[35] As a result, when weighing the climate and energy benefits of various biomass uses, the type of biomass makes a difference, as

does the management of the land and practices for tree or grass regeneration following any type of harvest.

Methane capture and biodigestion

Capturing methane from landfills or from manure digesters is another way to produce energy and also reduce greenhouse gas emissions. Methane from manure management and landfill emissions account for more than one-fourth of all US methane emissions (figure 10), and Wisconsin is one of the nation's leading producers of cow manure. Wisconsin produces 4.77 million dry tons of cow manure per year, which is the potential energy equivalent of replacing one large-scale coal plant.[36] Although Wisconsin leads the country in the number of farm-based biogas plants and has over 100 biogas production facilities, the state could quadruple its output to match the level of biogas use per capita in Germany, which is Europe's biggest biogas producer. In 2010 there were 5,905 biogas plants in Germany.

Capturing and using more of our methane would be worth the effort. Pound for pound, the comparative impact of CH_4 (methane) on climate change is over 34 times greater than that of CO_2 over a 100-year period.[37]

Overall, Wisconsin has the potential to use 12 million tons per year of biomass according to the National Renewable Energy Laboratory.[38] This could provide about twice the amount of bioenergy Wisconsin currently uses.[39]

Biodigesters

Wisconsin leads the nation in the number of farm-based biodigesters, which are essentially large, sealed tanks in which manure and other organic wastes are contained and then broken down by bacterial digestion. The process yields methane gas, nutrient-rich wastewater, and, after drying, sterile solids. The captured gas can be used to generate electricity or heat. Wisconsin also has an active supply-chain infrastructure that supports the design, building, and maintenance of over 130 biodigestion energy systems located at farms, food processing plants, landfills, and municipal wastewater treatment facilities. However, if we compare ourselves to Germany, which leads

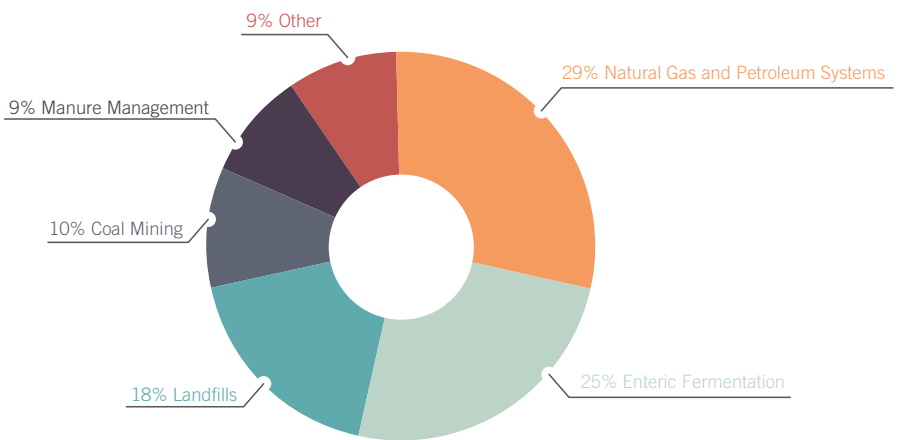


Figure 10. US methane emissions by source, 2012
Source: EPA, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2012* (Washington DC, April 15, 2014)

the world in biodigester applications per capita, we see there is still potential to harness four to five times as much energy from similar applications here in Wisconsin. At such a level of digester adoption, a reduction of up to three million tons of CO_2 equivalent per year is possible, similar to removing from the road half a million Wisconsin cars driving 12,000 miles a year.

Wisconsin is known as "the Nation's Dairyland," with about 1.3 million milking cows. Cows are prodigious producers of manure. From a wastewater perspective, Wisconsin's dairy population is equivalent to 35 million people, more than six times the number of people in Wisconsin. Biodigesters, although not a complete panacea, are an effective way to process the manure from large farms that use confinement systems into energy and nutrients in a controlled environment. (Animals are confined to a barn or yard and harvested feed is brought to them; a system that makes it easy to collect manure.) Biodigesters help reduce greenhouse gas emissions by reducing the amount of methane released from *uncontrolled* breakdown of organic material into the atmosphere, and by substituting digester-produced methane for *fossil* carbon fuels to produce electricity.

Driven primarily by federal stimulus incentives, four large biodigester projects were completed in Wisconsin in 2013 (Table 1). These are some of the largest biodigesters in the state and represent a growing trend towards large projects in Wisconsin

Project	Location	Electricity Capacity	Cost	Feed stock	Companies involved
2nd Dane County Community Digester	Town of Springfield	2,000 kW	$10 million	Dairy manure	Ziegler Dairy Farm, Blue Star Dairy, Hensen Brothers Farm, Gundersen Health Systems, US Biogas
Forest County Potawatomi	Milwaukee	2,000 kW	$20 million	Food & beverage waste	Rockwell Automation, Waukesha Gas Engines, Miron Construction Co., Symbiont, Titus Energy, Greenfire Management Services LLC
GreenWhey Energy	Turtle Lake	3,200 kW	$28 million	Dairy whey wastewater, soy processing waste	Lake Country Dairy, Saputo's Almena cheese plant, Comstock Creamery, Advanced Food Products, World Food Processing, Miron Construction Co., Symbiont
Rosendale Dairy (Milk Source)	Pickett	1,400 kW	$7 million	Dairy manure	UW Oshkosh Foundation, Milk Source, Soil Net, Alliant Energy, Infinity Lawn and Garden

Table 1. Wisconsin biodigester projects completed in 2013

References for this table and the "Methane Capture and Biodigestion" section are taken from the following sources:

CHANGE program, Nelson Institute for Environmental Studies at the UW–Madison. "Got Gas? An Analysis of Wisconsin's Biogas Opportunity" http://www.sage.wisc.edu/pubs/reports/GotGas_FINAL_3march.pdf.

Baker Tilly. "Biogas energy applications from dairy and cheese manufacturing waste." http://www.bakertilly.com/biogas-energy-digester

US Environmental Protection Agency. "Operational LFG energy projects, sorted by state and landfill name (XLS)." http://www.epa.gov/lmop/projects-candidates/operational.html

Wisconsin Focus on Energy. "Anaerobic disgester methane to energy: a statewide assessment." http://www.mrec.org/pubs/anaerobic_report.pdf

and the rest of the nation. Each of these projects involved significant technical and business skills to develop, design, finance, and construct. They all utilize local organic wastes, which produce local renewable energy, viable businesses, and reduce greenhouse gases significantly.

Biofuels

Liquid biofuels have been part of Wisconsin's energy production for several decades, primarily in the form of corn-based ethanol. The production process mashes corn kernels to release their high starch content (50 to 60 percent). The mash is then fermented by yeast into alcohol and distilled.

Nationally, 40 percent of the corn harvest is now being used for ethanol production and its feed byproducts instead of for primary feed or food products. However, federal tax credits for domestic ethanol production and a tariff on imported ethanol expired at the end of 2011.[40] With the loss of federal incentives, it is unclear whether corn utilization for ethanol will continue to grow.

As a biofuel, corn-based ethanol has been problematic because conventionally grown corn typically requires high inputs of fertilizers and often pesticides. Energy (primarily from fossil fuels) is also needed to plant, harvest, dry, and transport corn and to convert it to fuel.[41] Consequently, the net energy savings and carbon footprint of ethanol are a matter of debate. Analyses of net energy yield depend on which costs are included or excluded in the analysis and what assumptions are made about each of the measured variables.

There is little debate, however, that intense corn cultivation year after year can increase soil erosion, which contributes to soil depletion and the release of carbon stored in the soil. Surface water from eroded cornfields can be laden with nutrient pollution that fertilizes algal blooms in lakes and streams. Thus the search for other plant sources for biofuels has been a major focus of energy research.

Ethanol or other transportation fuels can be made through a "ligno-cellulosic" conversion process using forest waste and crop residues, although this technology has not yet achieved commercialization status. The process focuses on breaking down the lignin and cellulose that form the cell walls of all plants. Like corn kernels, cell walls are rich in sugars. But they are also different, the sugars being chemically cross-linked and tightly bound in long chains that do not easily break and ferment.

Researchers are also trying to unlock the secrets of capturing the energy bound up in the chlorophyll molecules in perennial grasses and other plants. Chlorophyll is the molecule that captures the sun's energy and enables the plant to create sugar from water and CO_2. Possible energy products are chlorophyll-based photovoltaic cells or batteries. Wisconsin currently has a significant investment in biofuel research through the Great Lakes Bioenergy Research Center, a joint project of the University of Wisconsin and Michigan State University with funding from the US Department of Energy. Its mission is "to perform the basic research that generates technology to convert cellulosic biomass to ethanol and other advanced biofuels."[42]

However, the practical application of this technology depends on breakthroughs that are still down the road. Federal mandates are in place to use these new feedstocks, but there is debate on how this can be accomplished because the market is untested. Madison-based Virent Inc. is one of the companies on the cutting edge of cellulose to liquid fuels development.[43]

Biodiesel is another green fuel alternative, made from a mix of feedstocks including recycled cooking oil, soybean oil, animal fats, and crops like canola, a plant with oil-rich seeds. Since its commercial scale production in the early 2000s, the amount of biodiesel produced nationally has increased from 25 million gallons to almost 1.1 billion gallons in 2012.[44] SunPower is a Wisconsin biodiesel producer, which claims its product releases up to 70 percent fewer emissions than petroleum diesel fuel. Located in northwestern Wisconsin, SunPower's plant uses canola as the chief feedstock and soy as a supporting feedstock and produces three million gallons per year.[45]

If research is successful, and if biofuel development becomes a viable pathway in a clean energy economy for the state, it will be important to establish criteria for determining which feedstocks to encourage, taking into account both maximum long-term net energy yields and the need to minimize collateral environmental costs. Biofuel production must be aligned with Wisconsin's strategies for all forms of renewable energy, as well as recognize the vital role that perennial grasses, food crops, forests, and other potential biofuel feedstocks play in sequestering carbon and supporting our capacity to adapt to changing environmental conditions.

Hydroelectric power

Wisconsin already has over 100 dams that produce power. However, it is unlikely that more large dams will be built in the future; many smaller dams are being removed for ecological reasons. Surveys have identified existing dams that do not now generate power and also current power-generating dams that could be optimized to produce more power with limited environmental impact. Run-of-the-river power technologies that do not require a dam are used in some situations (see Johnson Controls profile, page 41), but they have their own technical and ecological issues and at this time are unlikely to be major power contributors in the future.

Profiles in Renewable Energy

The following profiles illustrate practical steps that communities and businesses are taking to embrace renewable energy and achieve measurable gains in lowering costs for electricity, reducing greenhouse gas emissions, and conserving energy resources.

The City of Milwaukee: Wind energy on Lake Michigan

In February 2012, the City of Milwaukee commissioned its first wind turbine, making use of the Lake Michigan shoreline's untapped wind resources to offset energy needs at the city's Port Administration building and return surplus energy to the We Energies grid. (We Energies is the electric utility serving Milwaukee.)

Public-private partnership

The project was made possible by a public-private partnership in which Wisconsin businesses played a key role. Funding was provided by government and utility grants that covered the $580,000 cost of the turbine in its entirety. More than $300,000 in federal renewable energy stimulus money was provided through the American Recovery & Reinvestment Act, and $100,000 in grants were given by both the Focus on Energy Program and We Energies utility.

Milwaukee's wind turbine was principally a Badger state endeavor. Although Vermont-based Northern Power Systems supplied the turbine, more than a dozen Wisconsin companies took part in the project.[46] Kettle View Renewable Energy in Random Lake installed the generator, and Milwaukee-based RL Davis aided in site construction. Bassett Mechanical of Kaukauna built the 121-foot tower—the first wind turbine component that the company has ever fashioned.

The Port of Milwaukee's wind turbine not only generates power for the Port Administration building, it also serves as a tool to educate the community about wind power. Photo courtesy of the Port of Milwaukee.

Clean energy for a public facility

The Port Administration building's electricity consumption provides insight on the benefits of the wind turbine. In 2010, before the turbine was built, the building used 100,240 kWh of fossil-fuel-generated electricity, which cost the city $12,351 a year, and released 76 metric tons of carbon into the atmosphere. Since the turbine was completed, it has produced between 109,000 to 152,000 kWh per year, which not only supplies the electrical energy the building needs, but also produces between 9 and 52 percent surplus kWh, which can be sold back to the We Energies grid. The city saves $14,000 to $20,000 a year in electrical costs, and the turbine produces no carbon emissions.

The revenue gained from selling surplus energy back to the We Energies grid, *and* the elimination of the negative environmental and social impacts of using fossil fuels for energy

production, make the Port of Milwaukee's wind turbine more than an energy source. It stands as a symbol of the city's dedication to a clean energy future as well as its commitment to maintaining Milwaukee and Wisconsin as a hub of American manufacturing.

To learn more, visit **www.northernpower.kiosk-view.com/portofmilwaukee**.

The City of Monona: Solar panels on city buildings

Five years ago, the City of Monona (Dane County) passed a resolution committing itself to greatly expand its own use of renewable energy by 2025. As of October 2013, Monona now hosts the largest solar electric project serving a Wisconsin municipality. The city contracted with a third party, Colorado-based Falcon Energy Systems, which installed, owns, and maintains the 156 kilowatt solar electric system, supplying renewable energy directly to four city-owned buildings (City Hall, Public Library, Public Works Garage, and the Public Works Department's Well #3). All told, the solar arrays will produce more than 220,000 kWh of clean energy per year, providing up to 30 percent of the four buildings' combined electricity needs.

The city will receive a stream of renewable energy credits along with the electrical output under its solar service partnership agreement with Falcon Energy Systems. The solar generating arrays were manufactured by tenKsolar of Bloomington, Minnesota; Madison-based Full Spectrum Solar installed and will service the equipment. The project team was assembled by Solar Connections LLC, a Madison consulting group.

- The project will reduce CO_2 emissions by an estimated 2,200 tons per year.

Solar panels on Monona City Hall (pictured here) and other municipal buildings produce more than 210,000 kilowatt-hours of clean energy per year, equating to 30% of the buildings' combined electricity usage. Photo credit: Kurt Reinhold.

- Previously the city paid about 18 cents per kWh during peak use. Now that the solar panels have been installed, the city will pay approximately 9 cents per kWh during peak use.
- The city will also save over $250,000 on its energy bills over the next 20 years, although the system is expected to last much longer with minimal maintenance.

The importance of third-party ownership

The solar energy agreement with Falcon Energy Services is a six-year agreement. In the seventh year, the city may choose to renew the agreement, cancel the agreement, or purchase the solar arrays. While the agreement is in place, Falcon Energy Services will receive federal tax benefits for investing in solar energy and pass a portion of the refund on to the city of Monona.

The project is the first time a municipal government in Wisconsin has worked with a third party that owns, installs, and maintains a solar system for the city in exchange for a share of the renewable energy credits earned by the system.

The city took a risk, not knowing whether the system would infringe on Wisconsin's utility service territory law, which allows only regulated utilities to sell power to retail customers. Madison Gas & Electric, the local utility, chose not to challenge the project since all the power will be used within the city's property. The project is estimated to save the equivalent of 220,000 kWh a year, almost all of which is during peak time periods when power is more expensive.

This third-party ownership arrangement is the key driver in about 60 percent of all solar systems that were installed nationwide in 2012, but until now they have not caught on in Wisconsin because of the ambiguity of Wisconsin's utility law. Third-party owners that can utilize the federal tax credits can save about 50 percent of the installed cost of a system. Governments and other nonprofit organizations cannot take advantage of the tax credits as they do not pay taxes, but the third-party arrangement allows the owner to share the tax credits with the nonprofit entities.

The implications of Monona's initiative are significant, given that 140 Wisconsin communities have passed similar resolutions to use renewable, low-carbon energy in their municipal facilities and are looking for cost-effective ways to implement the resolutions. Third-party ownership allows a win-win for communities and other nonprofits that cannot take direct advantage of the federal tax credits; they can achieve their climate and energy objectives and save money at the same time. In addition, there are no capital expenditures on the part of the municipality and no technology risks, as those risks are shifted to the third-party investor.

"With this action, Monona joins the growing circle of Wisconsin businesses, communities, and individuals committed to serving themselves with renewable energy produced on-site," said Michael Vickerman, program and policy director of RENEW Wisconsin, a statewide renewable energy advocacy organization. "Through their actions, forward-thinking entities like Monona will reduce Wisconsin's dependence on imported fossil fuels in a way that creates jobs and invigorates the local economy."[47]

To learn more, visit **www.mymonona.com/687/Monona-Solar-Project**.

SC Johnson: Reducing its footprint through clean, renewable energy

SC Johnson, headquartered in Racine, Wisconsin, is one of the world's leading manufacturers of products for household cleaning as well as for home storage, air care, pest control, and shoe care. The 128-year-old company, which generates $9 billion in sales annually, employs nearly 13,000 people globally and sells products in virtually every country.

A leader in renewable energy initiatives, SC Johnson is committed to reducing its carbon footprint around the globe through the use of cleaner, renewable energy. "As a family company, SC Johnson has long been committed to reducing its environmental footprint, and investing in renewable energy is a critical part of our business strategy," says Kelly M. Semrau, SC Johnson's Chief Sustainability Officer.

For more than 20 years, SC Johnson has set environmental goals every five years. Since 2000 the company has lowered its greenhouse gas emissions (GHG) by 40.2 percent and reduced global manufacturing waste by 62 percent. It aims to reduce its global energy consumption and get

In addition to harnessing wind power, SC Johnson's Waxdale campus employs a cogeneration system that uses landfill methane and natural gas to generate electricity. Photo courtesy of SC Johnson.

33 percent of its total global energy from renewable sources by the year 2016.

In January 2013, RENEW Wisconsin honored SC Johnson as the Renewable Energy Customer-Generator of the Year for its efforts in increasing renewable energy use to 30 percent in its global manufacturing operations. The company's exploration of renewable sources includes wind power, cogeneration, biofuel, and solar power.

Wind power

SC Johnson has been purchasing wind power since 2008 to provide electricity for its Bay City, Michigan, factory, replacing almost half the fac«tory's annual purchase of coal-fired electricity and helping to cut about 28,000 metric tons of GHG emissions per year. In 2013, SC Johnson increased wind power purchases by 50 percent, expecting an additional 14,000 metric tons of GHG reduction annually at Bay City for a total of 42,000 fewer metric tons of emissions.

In December 2012, the company installed two 415-foot, 1.5 megawatt (MW) wind turbines at Waxdale, the company's largest global manufacturing facility, in Mt. Pleasant, Wisconsin. These turbines have a new design that generates more energy with lower maintenance cost. The new turbines produce about eight million kWh of electricity annually while cutting 6,000 metric tons of GHG emissions.

SC Johnson has also launched wind power projects at its other sites, including Lowell in Arkansas, Racine in Wisconsin, as well as in Mexico and the Netherlands.

Cogeneration

SC Johnson employs two cogeneration systems at Waxdale, combining landfill methane gas and clean-burning natural gas to generate electricity. This cuts 47,250 metric tons of GHG emissions annually. Combined with the two new wind turbines, Waxdale can produce, on average, 100 percent of its on-site electrical energy.

With less dependence on fossil fuel use, SC Johnson aims to reduce emissions from its operations globally by 48 percent, compared to its 2000 baseline output, by 2016. Also, it has cut 105,734 tons of CO_2 emissions from its US freight operations since 2007, when it joined the EPA's voluntary SmartWay Transport Partnership, an initiative to help businesses track—and improve—the energy use and carbon emissions record of their supply chain and make better transport decisions.

In line with renewable energy exploration, SC Johnson is working towards zero waste being sent to the landfill through reuse, recycling, and, ultimately, through disposal without the use of incineration. It aims to reduce its global manufacturing waste by 70 percent by 2016. Between 2000 and 2012, SC Johnson reduced waste by 62 percent.

To learn more, visit **www.scjohnson.com/en/commitment/overview.aspx**.

Emerald Dairy: Beyond biogas to whole farm strategies

Long before many of his colleagues, John Vrieze saw the need for a carbon neutral dairy operation. The founder and owner of Emerald Dairy in St. Croix County, Vrieze owns 2,600 cows across three dairies: Baldwin, Emerald, and Emerald II.

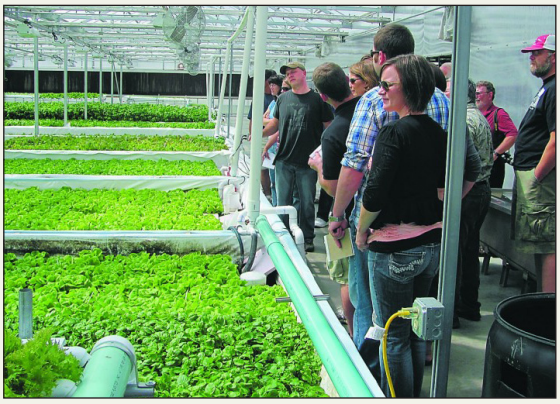
Innovative renewable energy through public-private partnership

In 2004, Vrieze began planning for a digester to spur the greening of his farms. Digesters often require sticker-shocking capital investment. The price tag for Emerald was no exception: $3 million for the digester and its supporting technology.[48] Vrieze patched together funding from the Wisconsin Department of Commerce, the University of Minnesota, investors, bank loans, and his own pocketbook. The Twin Cities company GHD Inc. assembled the digester, which was designed to produce 160,000 cubic feet of methane gas over a 21-day digestion cycle.[49]

Today Vrieze's digester provides gas for his farms and for 875 homes in the nearby village of Baldwin. Project developer Agri-Waste Inc. partnered with Northern Natural Gas to transfer excess gas via Northern's Pipeline System for delivery and sale to the manufacturing company 3M to supplement its green energy portfolio.[50]

Whole farm strategies

But biogas is not the only byproduct of digestion. Vrieze quickly realized the many potential uses for the digester wastewater. Used as fertilizer for the farm, the wastewater helped Vrieze reduce his fertilizer purchase by 95 percent.[51] He added phosphorus-capture technology, which limited the potential for harmful runoff into nearby streams, and also produced fertilizer pellets that he could sell. With every improvement, the water became a little cleaner, and eventually Vrieze was able to eliminate his now obsolete manure lagoons. His treated wastewater was clean enough to discharge directly into nearby Dry Run Creek.[52]



A group tours a Future Farm greenhouse, a 27,000-square-foot aquaculture complex that produces lettuce and other leafy green vegetables as well as fish. Photo credit: Heidi Clausen/Eau Claire Leader-Telegram

But Vrieze wasn't done; he installed another digester at his 1,050-cow Baldwin Dairy. Here the wastewater was used to feed Future Farm, a high-tech greenhouse and fish farm cofounded by Vrieze and Steve Meyer. Gas and heat from the digester provide the energy. The wastewater flows first to the fish farm, nurturing thousands of tilapia. Then the aquaponics greenhouse uses the tilapia water to grow lettuce and herbs, cleaning the water at the same time.[53]

It's a lot of moving parts, and economic returns are not yet complete. But, after some down and neutral years, profit is on the rise.[54] Vrieze, Meyer, Emerald Dairy, and Future Farm are breaking trail towards sustainable, closed-loop food systems that will help green Wisconsin's dairy industry.

Emerald's scale of production allows for million dollar investments in efficient, high-capacity

biogas systems of which there are only 30 in the whole state. However, biogas has a bright future in the dairy industry. As desire for reliable, home-grown, renewable energy grows, Wisconsin's dairy industry has the potential to fill a growing and increasingly profitable niche.

To learn more, visit **www.afuturefarm.com**.

St. Croix Valley Eco-Village Project: Solar-powered homes and neighborhoods

Volunteers from Andersen Corporation and a future eco-village home owner carry a Structural Insulating Panel (SIP) wall. Photo credit: Andersen Corporation.

The St. Croix Valley Habitat for Humanity Eco-Village Project is a great example of what low- to moderate-income housing can become in the rapidly emerging solar economy.

In partnership with the St. Croix Institute for Sustainable Community Development at the University of Wisconsin–River Falls, the Eco-Village Project takes a holistic approach to carbon *negative* solar-powered neighborhoods that produce more renewable energy than the energy (fossil or other) they consume. The St. Croix Valley project is distinguished from other sustainability projects by a quadruple-bottom-line that encompasses design and performance across four metrics: environmental, social, economic, and *community*.

Comprising 18 LEED Platinum houses with both solar hot water and five to six kilowatts (kW) of grid-tied photovoltaics on each (besides an additional 75 kW solar farm), the eco-village is capable of renewable energy-positive and carbon-negative performance. Rainwater harvest, edible landscaping, community gardens, permeable driveway and trails, rain gardens, a community center, and many other permaculture-inspired features elevate the standard of living for eco-village residents while offering a long-term return on investment.

The sustainability-driven concept for the Eco-Village Project originated in 2007, with formal planning, design, and partnerships underway in 2010, and ground breaking for the first six homes in July 2012. The anticipated five-year build out for Eco-Village 1 is being fast-tracked to completion within three years. Eco-Village 2 is already in discussion and conceptual planning in a neighboring community, and will be roughly twice the scale as the first. According to Kelly Cain, director of the St. Croix Institute for Sustainable Community Development, all Eco-Village 1 homes will be completed in 2015 and construction on Eco-Village 2 is expected to begin in 2016.

Thanks to this collaboration between corporate sponsors, community partners, and Habitat for Humanity International, the solar-powered potential of the future is already becoming a reality for those most in need but typically least able to afford it. The Eco-Village Project models moving "beyond sustainability" to "re-localization of community economics" based on a solar economy.

To learn more, visit **www.scvhabitat.org/eco-village**.

Transportation

Transportation is a major energy use sector and, nationally, nearly one-third of greenhouse gas emissions are released from transportation-related activities (figure 12).

Transportation is the fastest growing source of greenhouse gas emissions in the country. Since 1990, transportation-related emissions have grown by more than 18 percent. Over 50 percent of emissions from the transportation sector come from private vehicles such as passenger cars, SUVs, small trucks, and minivans. Freight trucks account for 22 percent of emissions, followed by other transport types, including aircraft, ships and boats, and rail.[55] The rapid increase in transportation related emissions can be attributed largely to the ubiquity of the automobile. Since the construction of the Eisenhower Interstate System in the 1960s, Americans have driven nearly three trillion miles each year. At the same time, freight trucking has also increased. In 2005, trucks carried 70 percent of US domestic cargo by value and 60 percent by volume. More than 90 percent of food is hauled by freight truck. Trucking deregulation over the past 30 years has reshaped the industry, saving shippers and consumers freight charges. The US Government Accountability Office (GAO) projects the volume of freight carried by trucks in the US will nearly double by 2035.[56]

Fuel consumption—especially of diesel fuel—by freight trucks increased significantly over the last several decades as freight "vehicle miles traveled" (VMT) increased. Medium- and heavy-duty freight trucks represent 3.5 percent of all vehicles and are responsible for 22 percent of greenhouse gas emissions from vehicles.[57] As the cost of fuel rises, fuel efficiency becomes ever more critical, especially for small- and medium-sized firms that may have difficulty passing increased costs along to shippers and consumers. Moving away from complete dependence on diesel fuel is one important way forward.

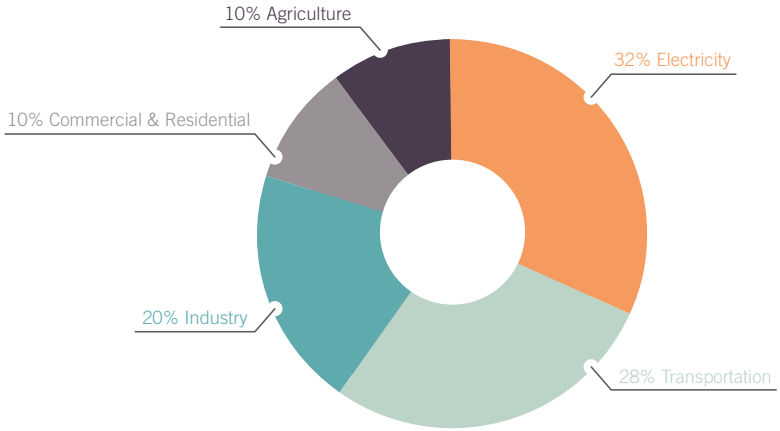


Figure 12. US carbon emissions by sector, 2012

Source: EPA, "Sources of greenhouse gas emissions," based on emission estimates from the *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2012*

Wisconsin transportation: Highway-focused

Wisconsin's successful industries, including those in the agricultural and manufacturing sectors, are dependent on a strong transportation system that allows for the free flow of people, produce, goods, and services. Today's system is focused on highways. This system comes at a price—significant carbon emissions and a network of highways that have eaten into valuable farmlands, wetlands, and forests; created urban and suburban sprawl; increased air pollution; and fragmented wildlife habitat. Wisconsin has invested heavily in its highways over the years, and created a mature road network that now takes hundreds of millions of dollars a year to expand, operate, and maintain (figure 13). This has created a largely one-dimensional transportation network that depends on people using cars—and that fosters inefficient, low-density development.

In Wisconsin, the Department of Transportation is the only state agency that has its own funding mechanism in the form of the state Transportation Fund. Over the years, it has routinely received nearly every requested funding increase, primarily for large investments in highway infrastructure. Conversely, the state has consistently reduced funding for public transportation, in addition to turning down nearly a billion dollars in federal funding for the development of a new high-speed rail system in 2010.

Reducing harmful emissions from transportation

We can reduce the energy and carbon impacts from vehicles by increasing their fuel efficiency, switching to cleaner fuels, and reducing the number of miles traveled.

Emission standards and cleaner fuels

Most transportation emissions come from burning gasoline and diesel—which have high levels of CO_2 and carbon monoxide (CO) emissions in addition to nitrous oxides and harmful particulate matter. Although the federal government has mandated stricter emission standards for new cars, we must continue to use cleaner fuels to achieve greater carbon emissions reductions. Some public transit fleets have already been retro-

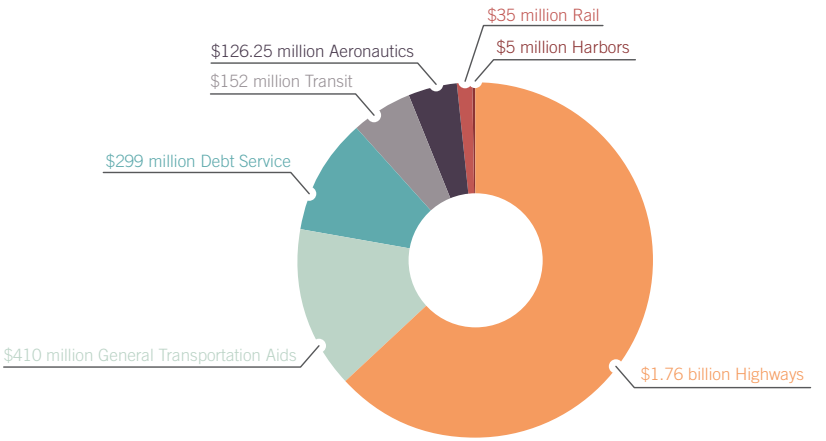


Figure 13. Wisconsin Department of Transportation Spending
Source: Wisconsin Department of Transportation, *Transportation Budget Trends 2012–2013*

fitted to run on compressed natural gas; others are increasing the use of electric or hybrid vehicles that are powered by renewable fuel sources and/or using low carbon emission biofuels.[58] The Madison Metro transit system has invested in several hybrid buses that emit less carbon dioxide and use less fuel than conventional buses.

Achieving significant emissions reduction from the transportation sector requires a multi-pronged approach that takes into account where people live and how they are provisioned food and other goods, and the modes of transportation they use to get to work, leisure, and other activities. Most of these seemingly "personal" factors are actually influenced by bigger things such as land-use and zoning regulations, transportation funding decisions, available transportation options, and technology. A transportation network that prepares us for our climate and energy future is one that gives greater priority to the movement of people and goods rather than their vehicles and allows for increased accessibility—backed up by efficient land-use patterns.

Integrating land-use and transportation planning to reduce miles traveled

Possibly the most important strategy in reducing CO_2 emissions from transportation is connecting transportation to land-use decision making. For decades, the state and local zoning practices have intentionally separated different land uses. For example, commercial, industrial, and residential land uses are typically zoned for different areas of a community. As a result, many people must commute long distances to work, or for shopping and leisure activities. We are now recognizing that denser, mixed-use developments can use land more efficiently, provide more jobs locally, and allow people to bike, walk, and use public transit, as an alternative to using a car. Reconnecting land-use and transportation planning can help create more choices for efficient and people-friendly mobility. State partnerships with local governments could encourage compact community development, the infilling of existing wasted urban spaces, and the design of interconnected transport in downtown areas—all in support of vibrant and sustainable communities. At the same time, by linking economic development to land-use planning and multi-modal freight transportation systems—where rail and marine transportation provide low-impact alternatives to highway transportation—we can strengthen our transportation infrastructure and improve efficiencies in energy, mobility, and distribution.

Congestion wastes time and energy

Despite best efforts to relieve congestion by building more lanes, congestion continues to be a problem in metro regions where it reduces fuel efficiency, causes drivers daily stress, and is a safety hazard. While truck traffic represents only five percent of total vehicle miles, the freight sector experiences 27 percent of all congestion costs in the form of additional wages, wasted fuel, and missed appointments.[59] Congestion also increases accident risk for truckers, which can result in higher insurance costs, more stressful, dangerous, working conditions for drivers, and high driver turnover.

Even as congestion continues to be a challenge in metro areas, passenger per capita and total VMT have been trending downward. Among urbanized areas across the country, those that include Milwaukee and Madison saw the second and third biggest drops in per capita VMT—21 percent and 18 percent, respectively.[60] The decreasing trend in passenger VMT is likely due to

a mix of a slower economy and changing demographic preferences.[61] As Baby Boomers retire, they are expected to have reduced driving needs, and Millennials (born in the early 1980s to early 2000s) are showing a preference for living where they can walk, bike, or take public transportation.[62] These trends aren't expected to change even as Millennials age (they are driving less now than their parents did at their age). However, our transportation system planning and funding mechanisms are based on an assumption of continued increase in VMT and the need for more highway capacity instead of investments in maintaining infrastructure and developing alternative transportation choices.[63]

For years, we have followed a cycle of expanding highway capacity by adding lanes to alleviate congestion. Research has shown that this is only a short-term solution and even contributes to increased traffic congestion and consequent carbon emissions due to a phenomenon known as induced demand: additional lanes with faster flow attract those who were not considering using a highway in the first place.[64] Soon, the additional lanes are clogged, as before, leading to calls to install even more capacity, and spawning sprawling land-use patterns that are auto-centric and wasteful. There are several examples of this happening in Wisconsin—the Madison Beltline, which was once a four-lane road, is now six lanes and there are renewed plans to expand capacity and even extend it to the north of the city. Wisconsin State Highway 23, connecting Fond du Lac and Sheboygan counties, is scheduled to be doubled in size, despite the downward trend in vehicle miles traveled.

Some possible measures to reduce congestion and driving are to install carpool lanes, support ride-sharing programs, increase the frequency of public transit service on heavily trafficked routes, encourage work-from-home initiatives, and implement congestion pricing, such as a road toll for travel at peak times. Public transit has consistently been proven to reduce traffic volume, and is more environmentally efficient than driving. Investing in a strong, public, high-quality transportation system will expand transportation choices, encourage a large-scale change in travel behavior, and motivate people to drive less.

Reduced funding for public transit, such as bus systems, over the last decade, has led to route cuts and limited many people's access to jobs, schools, hospital visits, and leisure opportunities. Although transit funding has not been fully restored, transit *demand* in Wisconsin remains strong—with several bus systems in Wisconsin posting record ridership numbers over the last two years.

The creation of Regional Transit Authorities (RTAs) would enable communities to generate funding for public transit through sales taxes for the maintenance and operation of transit systems that connect cities, towns, and villages, and can be sustained amidst ups and downs (or uncertainties) in state or federal funding. Such systems are especially important in Wisconsin with its large but dispersed rural population, which is currently almost entirely dependent upon autos.

Sustainable highway and street design

Transportation engineers often design to the highest levels of their code books—in the mistaken belief that wider and faster highways help prevent crashes. This has led to several over-designed systems that are used during peak rush hours but remain empty during the rest of the day.

Recent research, however, shows that there is no statistically significant correlation between highway widths and automobile accidents. Instead, highways that are designed to fit in with existing

natural features enable drivers to use these "contextual cues" to navigate, resulting in lower crash rates.[65] They are also more environmentally friendly as they do not require large areas of clear-spaces for oversized shoulders or lanes.[66] In addition, we must continue augmenting highway corridors to allow for multimodal use—such as bike lanes, public transit lanes, and pedestrian facilities—that reduce dependence on cars and encourage more environmentally sustainable uses.

Already, Wisconsin's Pedestrian and Bike Accommodation Law, passed in 2009, requires the inclusion of pedestrian and bicycle facilities in new road construction or road reconstruction where state and federal transportation funds are used. The law aims to ensure the creation of "complete streets" where pedestrians, bicyclists, motorists, and transit users of all ages and abilities are able to safely and comfortably move along and across a street. As this approach takes hold, it will provide children, the elderly, the economically disadvantaged, the disabled and those unable to drive—who have little or no access to the state's car-based transportation system—other ways to get to goods, services, work, and school.

Complete streets laws, which often include construction of sidewalks, also foster decreased driving and reduced emissions. A 2009 survey found that 39 percent of all trips in metropolitan areas are no longer than three miles, and 17 percent of all trips are no longer than one mile. Many of these trips could be made on bike or foot *if one could do it safely*—and complete streets legislation allows for the necessary infrastructure to support these options.

Freight systems

Incentives to encourage off-peak freight movement have been used effectively in New York City and the Port of Los Angeles/Long Beach, and used extensively by large companies, like Wal-Mart, Home Depot, and Target, as well as many small and medium-size companies.[67] These include expanding hours that curb side space is available to delivery vehicles, a reduced charge for cargo delivered at night, and incentives to retailers to receive deliveries late in the day.

Other ways to reduce freight travel and congestion include installing dynamic information screens on highways to indicate congested routes and reversible lanes. Also, encouraging cooperation on freight logistics among clusters of businesses can result in more efficient product delivery by conserving fuel and better serving rural and urban communities alike. In Wisconsin, the sustainable food and farming cluster in several southwestern counties is poised to take this next step.

One innovative solution to managing freight travel demand is to develop a system of Urban Truck Ports. This system would require strategically placed lots outside urban bottlenecks where load swapping could occur between long-distance trucks and local trucks for off-peak deliveries. Facilities could include basic driver services, truck and trailer parking, and personal vehicle parking. Some swap sites might be developed at existing truck stops. They could also offer alternative fuel services for fleets running on liquid natural gas or hydrogen fuel cells, or for electric hybrid trucks. Urban Truck Ports would separate urban driving from rural driving, encouraging companies to invest in the most fuel-efficient vehicles for each segment of a trip. Not only would this approach relieve congestion, it would allow for greater fuel efficiency and reduce greenhouse gas emissions.

Investing in multi-modal freight options

After decades of neglect, intermodal freight service, especially for domestic shipping, is rapidly growing. "Intermodal" refers to freight that can be easily transferred from one transport mode to another, such as a container ship or barge to rail car or flat-bed truck. The increased popularity of intermodal is, in part, a response to increased fuel prices, truck driver turnover, highway congestion, and increased regulation of freight trucking.

In Europe, the break-even point for miles between intermodal terminals is between 250 and 600 miles; in the US it falls between 500 and 1000 miles. Increasing the intermodal service in rural areas in the US is a challenge, particularly with recent unprecedented growth in rail's portion of intermodal freight movements taxing the capacity of rail networks. Even with railroads currently investing billions of dollars in capital improvement and rolling stock, rail lines in many Midwest locations are at or near capacity. Railroads are reluctant to build new infrastructure without long-term contracts from shippers that ensure an adequate return on investment.

One solution is to encourage major shippers in the region to take the lead in anchoring rural terminals. An example of this is Menard's, a home improvement business headquartered in Eau Claire, Wisconsin, that operates 285 stores in 14 states. Menards has taken the lead as a dedicated intermodal shipper in the Chippewa Falls–Eau Claire metro area. It guarantees sufficient cargo volume to support this rural intermodal terminal.

Expanding the use of Wisconsin's marine transportation systems

Recent studies show that marine transportation has the lowest energy consumption, air emissions, and social costs of all modes of transportation.[68] Marine transportation has significant positive environmental and economic benefits for Wisconsin.[69] Hundreds of millions of tons of cargo move on the Great Lakes and Mississippi River as part of Wisconsin's marine transportation system (MTS). Wisconsin's commercial ports handle over 30 million tons of cargo a year, and the Lake Michigan ferries transport thousands of passengers for an economic impact in the billions of dollars.[70] Existing and future Wisconsin rail and highway systems could not accommodate the waterborne freight if there were an MTS system failure. The Wisconsin MTS has the potential to move even more cargo and passengers with minimal cost by upgrading river locks and other infrastructure. The Baltic region, which has weather and water conditions similar to Wisconsin's, uses its marine transportation system to a far greater extent as an alternative to road and rail.

In an effort to reduce air emissions associated with marine transport, the Great Lakes Maritime Research Institute (GLMRI), a consortium of the University of Wisconsin–Superior and the University of Minnesota–Duluth, has been working with the US Maritime Administration and industry to convert Great Lakes vessels from heavy fuel oil to natural gas.[71] GLMRI has prepared feasibility studies for steam vessels. They have brought international experts on natural gas fueling of vessels to public meetings in Wisconsin and Ohio.[72] GLMRI is working with development agencies in Wisconsin and Minnesota to establish natural gas liquefaction plants to provide LNG for multiple user groups. Interlake Steamship Company, which makes regular vessel calls at Wisconsin ports, has announced plans to convert vessels to LNG fuel.[73]

Profiles in Smart Transportation

Wisconsin has many opportunities to develop cleaner and more integrated transportation strategies, and innovative businesses and communities are already making important strides. The following profiles highlight advances in cleaner-burning fuels, shipping logistics, and bike-friendly urban design.

Kwik Trip: Leading the way with alternative fuels

A big part of a sustainable transportation system is expanded use of alternative fuels in all modes of transport, from private autos to marine vessels. One of the companies leading this effort is Kwik Trip, a fueling station and convenience store company headquartered in La Crosse, Wisconsin, that is investing boldly in alternative fuels

In addition to selling E85, biodiesel, and Stage 1 electric charging for vehicles, Kwik Trip has committed to building a functional compressed natural gas (CNG) infrastructure throughout Minnesota, Wisconsin, and Iowa, as well as converting its own fleet to natural gas power.[74]

In April 2012 Kwik Trip opened a first-of-its-kind Alternative Fuels Fueling Station in La Crosse. The station is home to Kwik Trip's ever expanding fleet of CNG and liquefied natural gas (LNG) powered vehicles and is open to outside customers. (CNG is primarily methane gas that is compressed at normal temperatures and requires strong, high-pressure containers. LNG is also methane that, when subjected to very cold temperatures and high pressures, enters a liquid state.) By opening this station, Kwik Trip has shown its commitment to the environment and dedication to promoting new clean-fuel technologies. The alternative fuels are sold in liquefied and compressed form at 15 of the 430 retail filling stations the company operates in Wisconsin, Minnesota, and Iowa. Currently, 34 of the firm's own trucks and tractors use LNG and CNG because managers wanted experience with both types. Vehicle price premiums range from $30,000 to $60,000 each, depending on the fuel tank package.

The tall sign at Kwik Trip's flagship station in La Crosse advertises ten fuel varieties, from biodiesel and ethanol to propane and compressed natural gas as well as liquefied natural gas. Photo credit: BanksPhotos

Joel Hirschboeck, Kwik Trip's Superintendent of Alternative Fuels, says, "We had Agility (the fuel system supplier) come out and install the vehicle tank systems on site, and we now can install the systems on our own. We have 15 natural gas stations, and the cost for each was $750,000 to $1.5 million," with LNG equipment being more

expensive. Natural gas fuel (either CNG or LNG) is half the price of diesel, so the break-even point for trucks is 200,000 miles. Kwik Trip sells about 1,000 gallons of natural gas a day, including sales to the public, and the fleet's trucks use the same public facilities.[75]

To learn more, visit **www.kwiktrip.com/Fuel/Alternative-Fuels/**.

Schneider: Alternative fuels and efficient freight logistics

Schneider, a truckload, logistics, and intermodal services provider headquartered in Green Bay, is also investing in alternative fuels. Schneider is testing the use of natural gas for heavy-duty trucks, introducing LNG trucks into their fleet in 2011. Early adoption of this technology is taking place within specific, shorter-haul work configurations. Schneider is also testing biodiesel fuel blends for various attributes such as engine wear, fuel economy, and winter operability—and participating in the American Trucking Association sub-group that is reviewing regulations, production, standards, and use of biodiesel.[76]

The EPA's SmartWay Transport Partnership (a voluntary collaboration between the EPA and the freight industry to increase energy efficiency while striving to reduce greenhouse gases and air pollution) recognizes Schneider's enterprise-wide commitment to the environment.[77] Schneider was a charter member of the program in 2003. All three of Schneider's business sectors (trucking, logistics, and intermodal transport services) are SmartWay Transport members.

As the largest truckload carrier in the US, Schneider employs 15,000 drivers who travel some 1.4 billion miles a year. The fleet is equipped

By working to reduce greenhouse gas emissions, improve fuel efficiency, and upgrade the energy efficiency of their facilities, Schneider has become the most energy-efficient fleet and transportation provider in the industry. Photo credit Schneider

with aerodynamic tractors and trailers; uses speed management strategies, such as limiting speed to a maximum of 65 mph; and engines have a two-minute idling limitation.[78] These measures improve efficiency and add up to savings in the millions of both gallons of fuel and dollars. Engineers at Schneider are also developing two innovative games to help employees and clients better understand how transportation networks function and how human decision-making—focused on optimizing energy savings—can create efficient logistics.

Visit **www.schneider.com/sustainability** to learn more.

The City of Madison: Transportation planning and urban design

The City of Madison historically has been at the forefront of sustainable transportation planning and design. During the creation of the Eisenhower Interstate Highway System in the 1960s, unlike

almost every other major city in the United States, Madison decided not to build an urban freeway through its downtown core. This was the first step towards the creation of a multimodal system that encouraged bicycling, public transit, and walking.

The Wisconsin legislature in 1973 passed a law known as the "three foot rule," which mandated giving bicyclists at least three feet of space while passing them in an automobile. Shortly after that, Madison adopted its first bicycle transportation plan.

Today, Madison has an extensive network of bike lanes, bike boxes (a roadway engineering treatment that allows bikers greater visibility and a "safe space" to stop at intersections), boulevards, and bike parking spots. These investments in bicycle infrastructure have contributed to an 88 percent growth in bike ridership over the last 11 years. Over six percent of all commuter trips are now made by bike in Madison, which is much higher than the national average.

Madison has also developed an urban bike-share system, allowing users to rent bikes from readily available stations in the city and return them to another station, close to their destination.[79] The system proved so popular that it was expanded shortly after implementation, and now consists of 35 stations across the city, with over 350 bikes available for use.

Madison also has a comprehensive public transit network, with dedicated lanes for buses. The city's transit system, Madison Metro, had record ridership numbers in 2011. Madison Metro attributed this to significant cost savings (over driving and parking) for transit passengers, improved internet and mobile technology enabling more reliable trip planning for passengers, and convenient access methods such as unlimited yearly ride passes. These successes led to recognition of the system by the American Public Transit Association as the best transit system of its size in North America. The Association cited various sustainability initiatives as factors in their recognition, such as Madison Metro's use of green power, participation in local sustainability programs, reduction in printing costs through electronic communication efforts, and the induction of 19 hybrid buses into its fleet.

City of Madison investments in bicycle infrastructure have contributed to an 88 percent growth in bike ridership over the last 11 years.

Madison's transportation investments have resulted in a shift away from driving and towards more multi-modal travel. The Federal Highway Administration estimates that the annual miles driven per-person across Madison's entire urbanized area decreased from 8,900 per person in 2006 to 7,300 in 2011—the third largest such drop in the nation.[80]

To learn more, visit **www.cityofmadison.com/bikemadison/**.

Natural Carbon Storage

When we talk about carbon storage, we are talking about carbon dioxide (CO_2) that is temporarily not in play in the atmosphere. This may be because the CO_2 is tied up in living organisms, primarily green plants and trees; or it is stored away in the soil as organic debris; or it is buried under sufficient layers of sediment that it is inactive for an indefinite period in the way that fossil fuels once were.

Before the Industrial Revolution began, there was a relative balance between CO_2 released by humans' combustion of fuels such as wood, peat, and small amounts of coal and oil versus the CO_2 picked up and stored by plants during photosynthesis, sequestered by geologic processes, or absorbed by the oceans.

But after the late 1700s, the invention of the steam engine and, later, the internal combustion engine opened the way for fossil fuel exploitation and a new trend in Earth's carbon cycle. With dramatically increased burning of coal, the CO_2 captured by the plants of swampy woodlands many millions of years ago and long-buried under deep layers of sediments was released to join the CO_2 of the current era. So too, was CO_2 contained in the fossil petroleum produced by oil-rich algae that collected on sea floors millions of years ago. Pumped up to Earth's surface and combusted, this ancient oil also released a huge volume of CO_2 that had been out of circulation for millions and millions of years.

To restore some balance to Earth's carbon cycle—and to the climate to which humans are adapted—we must reduce use of fossil fuels. But we also need to strengthen the carbon-storing capacity of modern ecosystems wherever possible. Soil carbon storage and sequestration through plant photosynthesis offer the possibility of large-scale capture and storage of greenhouse gases from the atmosphere. Additionally, carbon storage in soil has the potential to be continually renewed and recreated. In Wisconsin we are rich in land resources. The ways in which we manage these lands can offer advantages in sequestering or storing carbon.

Forests

Forests are thought to be the most important terrestrial sinks for CO_2. Trees take CO_2 from the air and convert it to sugars and cellulose, binding up CO_2 in their leaves, roots, and woody trunks and branches. Forests across north central and northeastern North America historically have been responsible for most of the continent's biological carbon storage, helping to slow atmospheric CO_2 increases. Most carbon is stored long-term in wood or in soil. Soil storage is more permanent than storage in living vegetation. In soil, decomposing and finely fragmented plant material can accumulate over hundreds of years and become deeply buried in cool, wet earth where decay and release of CO_2 are greatly slowed.

As forests in our region age—resulting in fewer but larger trees—and as forest pests and pathogens spread, there has been concern that the forests' rate of carbon sequestration will diminish. However, studies of forests in the Great Lakes region have shown an increase in sequestration; even with decline in leaf area, these forests actually have higher wood production. In fact, the more biologically diverse and structurally complex the older plots are, the more resilient they are to production declines with age.[81]

Innovative forest management can accelerate the development of forest complexity in terms of number of species, range of ages, and layers

of vegetation. With this comes improved carbon storage capacity.

Grasslands

In grass and grazing lands the majority of carbon storage is in the soil, where the extensive networks of fibrous roots penetrate deeply and enrich the soil with organic matter in death. The world's cultivated soils have lost between 50 and 70 percent of their original carbon stock.[82] That includes North America's vast grasslands, which nurtured deep, fertile soils, and have been largely transformed into agricultural lands. Through intense cultivation of these former prairies over the last two centuries, massive amounts of carbon once held in their soils have been released into the atmosphere.

Researchers are studying how land restoration and regenerative agricultural practices—such as planting fields year-round in crops or other protective plant cover, and practicing agroforestry that combines crops, trees, and animal husbandry—can reduce atmospheric CO_2 while boosting soil productivity and resilience to floods and droughts.[83]

No-till farming has long been advocated as a means of minimizing soil erosion and maintaining soil fertility, and has been on the rise. It also has the advantage of less soil disturbance and less release of stored CO_2 and methane. A drawback is heavier reliance on chemical herbicides to control weeds, but use of cover crops and other techniques are helping in this area.[84] Researchers are also studying how landform characteristics and ecosystem processes can influence the soil and vegetative cover and, in turn, the carbon storage potential.

Protecting wetlands, old growth forests, and woodlots, and improving management of pasture and croplands are important strategies not only for protecting habitat, but also for maintaining carbon storage and other ecological services provided by nature.

Studies are underway to identify where the greatest advantage for carbon sequestration in plants and soils may be.[85] The findings will help us better understand and take advantage of this potential.

Research in northeast Wisconsin has identified land areas that are not optimal for agriculture and would more suitably be dedicated to biofuel source crops such as perennial grasses or woody shrubs. These studies have evaluated economic and environmental outcomes of converting poorly drained, marginal agricultural areas into perennial, biomass yielding grasslands for electricity and heat generation in that part of the state. These are areas where planting annual row crops is often delayed, prevented, or unprofitable in wet years. Spring soil saturation is expected to maximize warm season grass production by providing ideal moisture availability during the more commonly water-limited summer.

The wetter conditions and finer textured, high-clay-content soils characterizing low-lying areas in northeast Wisconsin should maximize carbon-sequestration rates since wet clay conditions delay organic decomposition. Establishing perennial grasslands in these wet areas will not only maximize carbon sequestration per unit of lost agricultural productivity for food or fiber but also serve as a buffer between agricultural uplands and aquatic systems, reducing nutrient and sediment loading into waterways—an additional ecological benefit for the same land conversion costs.[86]

Profile in Enhancing Natural Carbon Storage

Throughout Wisconsin, innovative farmers, foresters, and other land managers are leading the way in land and soil management and conservation strategies that help support and enhance the capacity of living landscapes to store CO_2.

Let the cows do the work: Dairy grazing and carbon storage

Joe Tomandl's farm aims to "let nature provide the energy." Tomandl and his wife operate a grass-based dairy in north-central Wisconsin that has grown from 80 acres with 35 cows to 320 acres of pasture and 170 cows. The cows are systematically rotated through a series of subdivided pastures according to forage availability. The grazing principle is very simple: instead of planting and harvesting livestock feed and fertilizing fields intensively, "let the cows do it—let them go out and harvest their own feed and leave their manure on the land," Tomandl explains, "so that the farm can stay green."

The end result is a farm that is covered in green grass throughout the whole growing season. Pastures are always vegetative and actively collect the sun's energy and sequester carbon in the soil. "As soon as the permanent pasture greens up, I've got millions of photo solar collectors utilizing the energy and converting and storing carbon," Tomandl says. "It takes a while to develop thick permanent pastures, but that's what we are going after. We want to keep the farm green as long as we can during the year."

Conventionally, a corn field, for example, is tilled and planted in the spring, leaving soil exposed and more susceptible to erosion while the seed is waiting to germinate and develop a plant that can keep the soil in place. Meanwhile, we are also missing the opportunity to capture solar energy that will grow plants that can also sequester the carbon.

Photo credit: Joe Tomandl

Tomandl's dairy management practices provide a sound example of achieving both economic and ecological sustainability. They also demonstrate the promising potential of grazing land as an enormous and permanent reservoir for sequestering organic carbon.

Devoted to the dairy grazing movement and keeping more farmers on the land, Tomandl is program director of the Dairy Grazing Apprenticeship, an initiative of GrassWorks, a membership organization that promotes managed grazing and trains start-up dairy farmers to develop grazier skills and knowledge, links them to agricultural, environmental, and consumer groups, and ultimately boosts the dairy industry with independent dairy farm ownerships and the next generation of skilled grazing farmers.

For more information, visit **grassworks.org**.

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Photo credit: Craig Schreiner/*Wisconsin State Journal* Archive

Building the Capacity to Lead

To step into a leadership role in clean energy and climate solutions, we need to learn from those in the vanguard and identify opportunities for wider adoption, or needs for mid-course corrections. For the public to effectively engage in decisions about our state's future, they need to be informed and have the resources to think critically about the challenges and choices we will face. Education and communications about climate and energy topics will be essential.

Learning from the game changers

As we sought out energy innovators in Wisconsin, we found them using a diverse range of strategies and practices from the farm field to corporate headquarters. There are many Wisconsin individuals and organizations that are charting a different path—approaching climate change and energy issues holistically. Their efforts represent a cultural or paradigm shift that goes beyond mere isolated improvements in conservation, efficiency, or energy sources. These individuals and organizations represent pragmatic 21st-century business models with the kind of sound, far-sighted practices that underpin sustainability.

When we looked at attributes of leaders in sustainable and renewable energy, we found some common threads:

- Leadership that is forward-looking and drives change.
- Corporate or organizational culture that embraces sustainability in principle and practice.
- Concerted effort to establish baselines and regularly measure gains in energy efficiency and reduction of carbon footprint.
- Conservation and efficiency across products and processes, such as *co-conservation* strategies for water and materials, and full-cycle stewardship from source materials to ultimate re-use.
- Commitment to continual learning and innovation.
- Creative public-private partnerships, where public investments are leveraged to spur advances in technology, productivity, and community goals as well as to offset initial costs in new technologies.
- Pride in communicating their accomplishments and eagerness to tell their story of sustainability to other businesses, communities, or institutions.

This combination of attributes provides a practical toolbox of practices that can underpin our efforts to mainstream clean energy development and adoption in Wisconsin. These are not only good business practices, they are a way to define and brand Wisconsin as an innovative, sustainable, clean-energy place in which to live and conduct business.

Profiles in Game-changing Innovation

The following examples represent businesses and organizations that have put sustainability theory in practice into their missions and across their operations. While making that critical shift in behavior, they have paid close attention to the bottom line and have thrived. Like the many other groups and individuals featured in this report, they are models of how local organizations can lead in tackling the challenges of climate change.

Gundersen Health System: Community care at every level

"As a healthcare organization, it is our responsibility to not only take care of our patients in a hospital or clinic, but to help our patients and communities stay well," says Gundersen Health System CEO Dr. Jeff Thompson.

Gundersen Health System is a physician-led integrated health care delivery system headquartered in La Crosse, Wisconsin, that includes a major hospital in La Crosse; more than 25 regional clinics in Wisconsin, Minnesota, and Iowa; and nursing home, pharmacy, and medical transport services. Gundersen has received national recognition for its environmental program, Envision, and has become a model for how health systems can implement institution-wide changes to become more sustainable.

Under the leadership of Thompson, Gundersen has utilized a "two-sided green" strategy, meaning it both reduces the cost of delivering health care and also reduces emissions that are harmful to human health and the environment. Gundersen's goal is to become completely energy independent in 2014.

In the top 1 percent of energy efficient hospitals in the Upper Midwest, Gundersen's new eco-friendly Legacy facility in La Crosse is headed and cooled by geothermal heat pump system. Photo credit: Gundersen Health System.

The birth of Envision

In 2008, Gundersen's executive leadership realized that the utility bills from their multiple facilities were increasing by $350,000 each year. They decided to conduct energy audits at their largest facilities to identify areas where they could improve efficiency. These audits revealed that Gundersen could reduce energy use by 25 percent and save over $1 million each year by engaging in retro-commissioning (improving efficiency of the equipment in place) of their heating, cooling, and lighting systems; and by modifying employee behavior.[1] Gundersen partnered with Wisconsin's Focus on Energy program to implement these low-cost or no-cost measures, and the Envision program was born.

Making changes related to energy efficiency is a good way for health systems to get the most bang for their buck, according to Envision's Executive Director Jeff Rich. Improving energy efficiency

required relatively little financial investment from Gundersen, and it quickly resulted in lower utility bills. Rich also points out that the success of these low-cost measures demonstrated that such environmental programs make good financial sense, which helped to promote support for Envision's future projects.

Building on success

After Gundersen improved the energy efficiency of its facilities, the health system started to look for other ways to develop its "two-sided green" strategy. They decided to partner with La Crosse County to build a generator that converts biogas from a local landfill into electricity and heat for their Onalaska clinic in Wisconsin. They also built wind farms, installed solar panels and solar heating systems, and built a biomass boiler that utilizes wood chips from the region to provide heating for their La Crosse campus.

In addition to developing clean sources of energy, Gundersen decided to focus on reducing the amount of waste it produces. They successfully eliminated the use of food service Styrofoam in their hospitals, and implemented a comprehensive waste management system that has kept 17 tons of food out of landfills each year. Gundersen has also implemented over 30 recycling initiatives, including a joint program with the Coulee Region Retired and Senior Volunteer Program that recycles surgical blue wrap and turns it into tote bags, aprons, and patient education bags.

Gundersen is a leader in making healthy, locally grown food available to its patients, employees, and the communities it serves. It participates as an institutional buyer in the Fifth Season Food Cooperative centered in Viroqua, Wisconsin,

Cashton Greens Wind Farm, a partner project of Gundersen and Organic Valley Photo credit: Gundersen Health System

about 33 miles south of La Crosse. Gundersen holds a Class A buyer membership, which means it has a vote on the co-op's board of directors. The health group supports the participation of its employees in co-op projects and on its board of directors

Many of the benefits of the Envision program have been passed on to patients in the form of lower health care costs and a cleaner environment. Energy costs typically account for about one to two percent of a health system's expense budget. Though it may not seem like an enormous difference, money saved on energy bills has helped keep costs to patients below the inflation rate. In addition to these benefits, Gundersen's clean energy projects have kept more toxins, like particulate matter and mercury, out of the environment and out of patients' bodies.

"Everyone's on the green team"

Jeff Rich attributes Gundersen's success largely to two factors: having executive leadership that is fully on board with sustainability efforts, and having committed employees who make these initiatives happen. CEO Jeff Thompson has been instrumental in providing vision and leadership

to Envision. In 2013, the White House named Thompson a "Champion of Change" for his work with Envision, and he continues to represent the Gundersen in a variety of national environmental initiatives.

Rich is proud of the fact that Gundersen's sustainability efforts aren't confined to a single department. "*Everyone's* on the green team," he says, "it's *everyone's* job." Gundersen has gotten cross-sector input on sustainability from departments such as finance, marketing, security, legal, nutrition services, and custodial—to name a few. Employee engagement is evident in the diversity of projects that Envision has undertaken, from waste reduction to renewable energy to employee participation in ridesharing programs.

Continual growth

The Envision program is continuing to grow. Two biodigester projects were recently completed in Middleton (2013) and Sun Prairie (2014) that will turn cow waste into energy, doubling the amount of renewable energy that Gundersen produces throughout the state. Gundersen built a new hospital in La Crosse, which is in the top one percent of energy-efficient hospitals in the Upper Midwest, and began receiving patients in January 2014.

Gundersen is on track to achieve energy independence by mid-2014. This impressive goal has been accomplished through the hard work of a team of committed individuals who have constantly challenged ideas of what a health care system is capable of doing. Gundersen is setting the bar for health systems looking to reduce their environmental impact and improve the health of their patients.

Visit **www.gundersenenvision.org** to learn more.

CROPP/Organic Valley: Remaking the American farm

The Cooperative Regions of Organic Producer Pools (CROPP) is a farmer-owned and -governed cooperative that produces and markets organic food under the Organic Valley and Organic Prairie brands. It was formed by seven farmers in 1988—a time when family farms were on the brink of extinction—in the belief that a new, sustainable approach to agriculture could help family farms and rural communities survive. Now, with nearly 2,000 member farmers, they continue to base decisions on the health and welfare of people, animals and the earth. CROPP farmers practice pasture-based farming and holistic animal care, which are healthy for animals and for ecosystems and also contribute to soil carbon sequestration.

"If a company is going to make a difference in today's world, it's going to have to think differently," says George Siemon, CROPP Cooperative's CEO and one of its founding farmers.

While sustainability is typically associated with energy, CROPP formed its sustainability concept on the "triple bottom line" philosophy of environmental, social, and economic benefits.[2] They have been tracking sustainability metrics for several years and taking action where it counts.

As a leader in sustainable, organic farming practices, CROPP took its model for delivering regional dairy products to regional markets and kicked it up a notch, marketing organic produce from the Upper Midwest to other regions in the nation. Organic Valley, CROPP's major marketing label, had 43 regional milk pools across the US in 2011. As such, they lead the way in regional food distribution logistics, helping other regional food producers see ways that transportation logistics could result

in greater fuel efficiencies. For instance, some of Organic Valley's products, such as milk and eggs, are both regionally and nationally distributed. Because the co-op's only soy members are in the Midwest, however, its line of soy milk products is largely confined to the region. There is no blanket rule, making overall operations and sustainability of the business complex and challenging.[3]

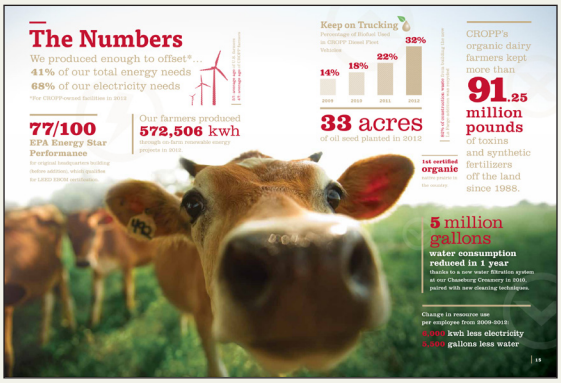
CROPP's energy efforts are focused on three main areas: energy efficiency in operations, incorporating renewable energy, and promoting on-farm energy efficiency among their members.

Operational energy efficiency

Energy efficiency features at CROPP's La Farge, Wisconsin, headquarters include storm water collection; on-site permaculture and habitat restoration; LED parking lot lighting (reducing energy use and light pollution); priority to local, recycled building materials; bicycles for in-town trips; low VOC (volatile organic compound) levels in paint and carpet; dual-flush toilets, waterless urinals, and low-flow faucets; triple-paned windows and solar cells in south-facing windows; solar tracking panels, solar hot water, and solar roof panels; occupancy sensors on lights; natural day-lighting; and zero-chloroflourocarbon (CFC) refrigerants, which are damaging to the ozone.

Renewable energy

Renewable biofuels, like sunflower and canola oil, make up an increasing percentage of CROPP's energy mix, which includes electricity, natural gas, propane, and petroleum. CROPP has a lot of work to do to meet its goal of energy neutrality in CROPP-owned facilities by 2020, by which point CROPP will produce enough renewable energy



CROPP Cooperative Sustainability Report, courtesy of Organic Valley / CROPP Cooperative Wisconsin

to offset the equivalent of 100 percent of its total energy (fuel and electricity) needs for owned facilities.

Just as they support decentralized dairy production, CROPP advocates for distributed (or decentralized) energy networks as the path to energy independence and security. In Wisconsin, they are pursuing wind, solar, and biodiesel energy projects.

In collaboration with Gundersen Health System they developed Cashton Greens Wind Farm, the state's first community wind farm. This two-turbine operation generates enough electricity to power 1,200 homes for a year. CROPP's half of the energy generated by the wind farm powers the cooperative's 81,000-square-foot headquarters and additional warehouse facilities in La Farge, plus the ten-story cold storage distribution center and its 75 offices in Cashton. In the first seven months of turbine operation, they produced enough wind power to offset 68 percent of the electricity in CROPP-owned facilities.

Solar installations at the La Farge facilities (tracker-mounted and roof-mounted solar panels, solar water heaters, and transparent solar cell windows) generate approximately 86,000 kilowatt hours of energy a year.

CROPP has been integrating biodiesel into local fleet vehicles (vanpools and grounds maintenance vehicles) since 2002 and growing their own oil seed crops since 2007. Extracted oil is processed into biofuel, with the byproduct providing a nutritious, high protein livestock feed. Currently 32 percent of diesel fuel used by CROPP's local fleet is bio-based or straight vegetable oil. The goal is to increase that to 60 percent by 2015.

CROPP is developing "fuelsheds," which are modeled on watersheds—topographically distinct land areas whose linked drainage ways flow to a larger body of water. In a fuelshed, fuel sources are sought that have proximity to their ultimate point of use and can be readily accessed. This concept is being developed in the Midwest and eventually will apply in all regions with co-op farmers. In these fuelsheds, oil seed crops will be grown, pressed, and used to benefit the greatest number of people with the least environmental and financial impact.

On-farm sustainability

CROPP is helping farmers become energy independent by offering no-cost energy audits to identify areas for improvement and sources of renewable energy that would work well on their farms. Since 2008 the sustainability team has helped more than 100 farms complete audits and 50 farmers to obtain renewable energy site assessments. The co-op has secured approximately $3 million in grant funding on behalf of farmers to implement renewable energy projects. Total cooperative-wide, on-farm, renewable energy installations now generate 572,506 kWh annually.

CROPP takes its social responsibility seriously, providing education about organic farming, giving to community groups, and supporting partners with related missions. A wellness program for employees offers fitness and other on-site personal wellness classes, encourages employees to grow their own food in the organic garden at the La Farge headquarters, and makes organic food accessible to employees during working hours.

Economic sustainability

CROPP/Organic Valley is there to serve its farmer-owners (cooperative members) and their communities. Organic Valley, which markets milk, cheese, other dairy products, meats, and produce, operates with a small profit margin, paying farmer-owners first. Farmer-owners are organized into pools according to their products and their regional location. Each pool contracts with the co-op for a target price based on the regional production costs and projected volume of product. The result of these contracts is stable prices for the producers.

The co-op's standard arrangement is to have milk processed on contract with dairy manufacturing plants located close to the regional milk pools. Organic Valley prefers working with family-owned, independent processors when possible. It also contracts for transportation of both its raw milk and finished products. The co-op provides many services including helping farmers become certified organic and finding organic sources of livestock feed.

CROPP, with its wide range of farmers and marketing services, is the largest employer in Vernon County, providing stable employment in one of the most economically depressed areas of the state.

Most farmers are over 55 years old, but CROPP has a growing number of farmers under 35, what they call their "Generation Organic," or Gen-O, farmers. These young farmers will carry on the

legacy of organic farming and become the next generation of CROPP leadership. CROPP supports these farmers with educational opportunities, regional meetings, and technical assistance. In 2012, CROPP/Organic Valley formed a Generation Organic Executive Committee to advise the board on issues affecting the co-op's young farmer demographic.

To learn more, visit **www.organicvalley.coop**.

Milwaukee Metropolitan Sewerage District: Regional strategies to work with the landscape and the community

The Milwaukee Metropolitan Sewerage District (MMSD) is a regional government agency that provides water reclamation and flood management and other services for about 1.1 million customers in 28 communities in the Greater Milwaukee area. Headquartered along the Menomonee River near downtown Milwaukee, MMSD serves 411 square miles that cover six watersheds. It has two water reclamation plants, located at Jones Island in Milwaukee and at the South Shore in Oak Creek.

As a regional water treatment giant, MMSD is a big energy consumer, using energy to pump and move water, aerate sewage, and process sewage byproducts. Currently, MMSD facilities heavily rely on natural gas: in 2011, the energy budget was $14 million, with 52 percent for natural gas. Meanwhile, MMSD produces a large amount of carbon dioxide (CO_2): in 2007, CO_2 emissions from its facilities were 91,800 metric tons while the reporting rule threshold is 25,000 metric tons.[4] Upon entering the 2010s, in order to reduce the energy and money spent on existing water

Water flows from a natural spring on Greenseams Hoerig property. Photo credit: MMSD

management and industrial operations, MMSD established a set of goals for institutional change, ranging from integrated watershed management to internal energy use.

In 2011, MMSD adopted the 2035 Vision that aims to achieve zero overflows, zero basement backups, improved stormwater management, and increased energy efficiencies. Guiding principles of the 2035 Vision include:

- Future planning, design, and operational decisions will be based on a sustainable bottom line approach, considering economic, environmental, operational, and social values.
- Water quality leadership and collaboration will foster strategic alliances to develop regional, watershed-based approaches to protecting and improving water quality.[5]

MMSD recognizes sustainability as an overall core value and operational philosophy. In 2005, it adopted an Environmental Sustainability policy to carry out its role as an environmental steward for the Greater Milwaukee watersheds. To commit to the policy, MMSD looks to: encourage and optimize the use of renewable, recyclable,

eco-friendly materials; reduce energy consumption and emissions from fossil fuels; and have a positive impact on the region's economic, social, and environmental resources while maintaining the desired level of services in a financially responsible manner.[6]

In 2009, MMSD released "Fresh Coast Green Solutions," an educational guidebook, to promote the use of green infrastructure within the region.[7] In 2012, MMSD received the US Water Prize for its pilot watershed-based permitting program that offers southeast Wisconsin a more sustainable form of water resource management.[8] The watershed approach, encouraged by the EPA, applies management planning to the natural boundaries of watersheds rather than being confined to political jurisdictions or individual industries.[9] Watershed-based management not only addresses specific water problems, but also targets a variety of chronic issues that contribute to a watershed's decline. The success of this approach relies on:

- Working with whole watersheds (looking to Nature's boundaries, not man's)
- Using sound science (applying scientific data, tools, and techniques)
- Enlisting public involvement (working with concerned individuals, agencies, or organizations).[10]

MMSD's 2035 Vision focuses on two strategic areas: watershed management and energy efficiency.[11]

Integrated watershed management

The goals are to integrate activities of watershed partners, integrate management of urban and rural stormwater, and achieve zero combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs). The integrated approach seeks a balance between the gray infrastructure of the watersheds, which consists of roads, pipes, and treatment plants, and green infrastructure, which relies on natural landscape features, such as forests, floodplains, and wetlands, as well such as porous pavements to infiltrate, evaporate, capture, and reuse water.

Currently, the Deep Tunnel dominates the gray infrastructure, successfully capturing 98 percent of polluted water since it became operational in 1993. The Deep Tunnel is a storm water storage system that runs for 28 miles deep beneath the city of Milwaukee. It is capable of keeping 520 million gallons of polluted runoff out of Lake Michigan until the water can be processed through the city's two sewage treatment plants. MMSD will also expand the use of green infrastructure through acquiring additional land as river buffers, and increased capture and harvest of rainfall.

Climate change adaptation

The goals here are to use energy more efficiently, to increase the percentage renewable energy, and to anticipate and plan for changes in the water system due to climate change. By the year 2035, MMSD aims to:

1. Meet 100 percent of its energy needs with renewable energy sources, with 80 percent being self-produced.
2. Provide for 30 percent sequestration of its carbon footprint through the Greenseams Program, an innovative initiative to prevent future flooding by protecting water-absorbing soils.
3. Reduce its carbon footprint by 90 percent from its 2005 baseline.
4. Anticipate, to the greatest extent practicable, and respond to, a range of climate

change impacts when considering surface water, groundwater, and the management of stormwater and floodwater.

To achieve the energy efficiency objective, the first step is to minimize energy use. The Jones Island Water Reclamation Facility is currently upgrading the aeration system with a higher efficiency blower that is expected to save up to $300,000 per year. The South Shore Wastewater Reclamation Facility is also increasing its anaerobic digester gas production for the plant's electricity use. This is expected to save up to $600,000 per year.

Another step is to maximize the use of renewables, including landfill gas (LFG), regional biosolids, sewer thermal, solar, and wind energy. The $43 million MMSD Landfill Gas Project will replace natural gas with landfill gas for the system's energy use. In 2010, MMSD signed a 20-year agreement with Veolia Environmental Services (VES) to transport the LFG produced by its Emerald Park Landfill to Jones Island through a 19-mile-long pipeline. The gas began flowing in January 2014.[12] MMSD will pay VES 48 percent of the price it pays for the natural gas, which will save tens of millions of dollars over 20 years.[13]

Concurrent with the sustainability mission, MMSD has been supplying Milorganite® (Milwaukee's Organic Nitrogen), a fertilizer made from the biosolids that remain after the sewage water reclamation process is complete. Since 1926, the sale of Milorganite® has largely reduced sewer rates.[14]

"Looking forward to the next 25 years, MMSD sees a quarter century of efficiency, innovation, and sustainability," MMSD states in its 2035 Vision, forecasting a healthier Milwaukee region and a cleaner Lake Michigan. By 2035, MMSD also expects success in fostering green facilities, improving energy conservation and efficiencies, and promoting renewable energy use.[15]

To learn more, visit **www.mmsd.com**.

Public engagement

The issues and choices inherent in the climate and energy challenge are vast, and the perspectives and interests of the people affected are diverse. We therefore need to foster an inclusive public conversation that is grounded in economic and environmental realities; responsive to shared values of fairness, freedom, responsibility, and sustainability; and productive of individual and collective choices for a secure and abundant future for all.

Environmental education and literacy

Wisconsin—home to John Muir, Aldo Leopold, Gaylord Nelson, and other pioneers of the environmental movement—has long put a priority on environmental education, ethics, and literacy. Environmental education is a lifelong learning process that contributes to an informed and involved citizenry, able to take action to help ensure an ecologically and economically sustainable environment.[16]

Our state's diverse natural resources and mixed-use rural and natural areas have exposed generations of Wisconsin families to the outdoors. Our agricultural history has kept much of the population in touch with the state's ecosystems and natural cycles. Wisconsin is also home to countless nature centers, urban ecology centers, gardens, parks, and museums that play an important role in environmental education, working closely with schools and the public to provide hands-on environmental experiences for all ages. These facilities connect visitors with the natural world in ways that often cannot be replicated in the backyard or classroom. Maintaining these organizations and Wisconsin's collective environmental ethic is imperative.

Environmental education has long been a part of the state's formal education systems. In 1935, Wisconsin became the first state to require that teacher certification in science and social studies include "adequate instruction in the conservation of natural resources." Beginning in the 1980s, the Wisconsin legislature required all school districts in the state to integrate environmental education into curriculum plans at all grade levels.[17]

However, no *standards* for environmental education have yet been explicitly embedded into Wisconsin's curricular framework. Some teachers and schools have found it increasingly challenging to incorporate 21st-century environmental literacy— encompassing complex concepts of globalization, energy, technology, and climate change—into curriculum currently dominated by assessments in math and reading.

To assist teachers, the Wisconsin Department of Public Instruction and environmental education partners authored a plan to support development of pre-K to 12th grade student environmental literacy through field experiences and teacher professional development.[18] Resources like this will be important as schools, teachers, parents, environmental organizations, and legislators work together to put formal and non-formal structures and supports in place to advance the environmental literacy of current and future generations of Wisconsin students.

Higher education is also doing its part to produce graduates who understand the importance of living and working in a sustainable way. One example is the UW–River Falls (UWRF) Kinnick-

innic Project, a campus-wide effort to integrate sustainability into the curriculum.[19] Faculty members initiated the project after attending a leadership workshop hosted by the Association of the Advancement of Sustainability in Higher Education in 2011, and later developing an AASHE Sustainability Curriculum.[20]

Nearly forty Sustainability Faculty Fellows, representing all UWRF colleges, participated in a similar annual workshop within the first three years of the project to explore environmental, social, and economic components of sustainability issues. These Faculty Fellows commit to infusing both concepts and practices of sustainability into their courses, whatever the topics, and have enacted curricular changes in courses from accounting to biology to education to theater. The project provides a community of practice for faculty, creates a greater awareness of how sustainability pertains across disciplines, and fosters dialogue among colleagues and students about local, national, and global sustainability issues.[21]

It is increasingly urgent to arm our state's current and future generations with the tools needed to comprehend, grapple with, and solve complex climate and energy problems. Sustainability education should be explicit in addressing climate and energy issues and preparing students for incorporating green innovation, new technologies, and sustainable approaches into their lives and careers.

Communication and public awareness

Ongoing efforts by media, government, business, and community and civic organizations are important to raise public awareness and encourage climate and energy-smart practices in homes, businesses and industries, farms, and communities.

State and local government can educate citizens about energy and climate issues and inform them of related policies. They can provide tips or institute programs on what individuals and households can do to conserve energy or to prepare for climate change impacts (*e.g.*, EnAct, **www.enactwi.org**, a community program that provides guidelines for reducing household environmental impacts). Like businesses, governmental agencies can and should publicize their own clean energy and climate adaptation initiatives in order to share best practices and encourage others to do likewise. Both governments and businesses can institute workplace programs that encourage employees to make energy-saving changes in the office and at home (*e.g.*, Cool Choices, **www.coolchoices.com**, a workplace-based program that offers fun and social incentives for adopting a sustainable lifestyle).

Faith communities of all sorts can practice as well as teach what their traditions have to say about our ethical responsibility to care for people and other forms of life by exercising wise stewardship of natural resources. They, together with social service and advocacy organizations, can help ensure that the interests of the most vulnerable and disadvantaged members of our communities are protected and promoted by energy policies and practices.

All of these institutions can take advantage of the growing body of research and literature on how to communicate effectively about environmental, social, and public health issues in ways that connect with people's concerns and values and promote more environmentally responsible behaviors and attitudes. It has been shown that

people are more likely to adopt conservation practices when they have some assurance that those practices will work, especially when they see others like themselves involved, such as a similar type of business, or a community in a similarly rural or urban setting.

Wisconsin households and businesses try new technologies or adopt new practices based on available information, on their own observations, and on what seems "normal." It is critical here to realize that norms can shift over time and that everyone can help (or hinder) that shift. When schools across the state put theory into practice and demonstrate environmental, climate, and energy literacy not just within the classroom walls but through the design of the school buildings and the management of the school grounds, the shift begins. And when industries, businesses, and communities surrounding students and their families do the same, the shift is reinforced and is on its way to the *new* normal.

In Fort Atkinson, Wisconsin, most of the public schools are heated and cooled with geothermal systems, which are much more efficient than conventional heating and cooling systems. For students in Fort Atkinson, geothermal technology is normal; some students will graduate from high school never attending a school that is heated any other way. Similarly, for decades it was normal in Wisconsin for households to opt for high efficiency furnaces, even though our neighbors in Minnesota and Michigan were buying much less efficient units. In that case, contractor education and merchandise stocking that included more efficient practices helped shift the market in our state, saving households millions of dollars in heating costs. Leaders across the state have a major role in helping to reshape what is normal in Wisconsin.

Civil conversation and deliberation

At the widest level, we need not only to formulate new public energy policies but also to promote new social norms and expectations for individual and collective behavior in all areas of society. We will need to use existing channels and also create new public forums for constructive, civil conversations and deliberations that avoid, to the extent possible, partisan polarization and ideological gridlock.

The obstacles are great, but there are steps we can take: identifying and making use of trusted nonpartisan groups who are known to create safe spaces for the purpose of civil dialogues; practicing and promoting norms for respectful, constructive conversation in the media and public forums; employing best practices and well-grounded research for framing issues and facilitating discussions in ways that promote thoughtful democratic deliberation.

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Photo credit: Photo credit: "Madison State Capitol" by Franco Folini, https://flic.kr/p/8TxyLE CC License 2.0

The Way Forward: A Green and Growing Strategy for Wisconsin

Wisconsin has the capacity to be a leader in developing strategies to reduce the pace and scale of disruptive climate change and to ensure safe, clean energy sources for today and tomorrow. Innovations and practical improvements in energy conservation and efficiency, renewable energy, transportation systems, land management, and 21st-century business models will have multiple benefits. There are myriad options for moving forward now, that, in combination, will make a significant difference in our carbon footprint and quality of life.

Benefits of a fresh approach to energy

There are many advantages to stepping up to the leading edge of energy innovation, from health and social to environmental and economic benefits.

A healthier population

Reducing our reliance on fossil carbon-based energy sources would reduce sources of air pollutants such as fine particulates, mercury, and smog. Reducing our dependence on automobiles could also lead to positive health outcomes from more walking and biking. Less air pollution and more exercise would mean lower health care costs, increased productivity from a healthier work force, and improved quality of life for Wisconsin residents.

A way of life that aligns with Wisconsin values

By advancing a cleaner, more sustainable, less wasteful, and more just energy economy, our generation can live up to Wisconsin's values and traditions of responsible stewardship.

Aldo Leopold's land ethic and Gaylord Nelson's Earth Day are among Wisconsin's signature contributions to the world. Coupled with a willingness to take responsibility for the global and intergenerational consequences of our decisions, our positive, can-do, sleeves-rolled-up attitude can fulfill the promise made by Wisconsin's motto: *Forward!*

In the process, we will protect and expand not only energy supply and savings, but also the quality of life for the generations that follow us.

A better environment in which to live, work, and play

The quality of Wisconsin's land, air, water, and wildlife has always been a key factor in attracting people to the state and enticing them to stay. For ourselves, as well as for future generations, we want to keep our air, water, and land healthy, and reduce, as much as possible, the negative by-products of a carbon-based energy system—such as coal ash, spilled oil, and air pollutants. Beyond preserving the healthy natural landscapes that we already have, good land management and restoration practices can increase our capacity to naturally store carbon in wetlands, prairies, and forests and also enhance the landscape for both humans and wildlife.

Growing an economy that supports competitive technologies and jobs

Renewable energy technologies are becoming increasingly cost-effective, and more businesses and consumers are demanding access to renewable sources of power. For example, when Facebook selected a Des Moines, Iowa, suburb as the site for a $300 million data center, it cited access to clean and renewable wind power as a factor in its decision to locate there.[1] Developing reliable renewable energy sources will help us become more competitive within the Midwest region and beyond.

Of the currently planned Midwest wind energy projects, 99.4 percent will be built *outside of Wisconsin*.[2] If Wisconsin fails to increase investment in energy advances, eagerly sought jobs and related economic development—from energy retrofits to wind turbine design and American-made solar panels—will continue to go to states that welcome this development. However, more

home-grown renewable energy will keep dollars circulating through Wisconsin's economy that would otherwise be sent out of state to purchase imported coal, oil, gas, or nuclear fuels.

Building on our own capacities

Wisconsin already has the capacities to succeed in a high-end, clean energy economy: talent pool, superior work ethic, quality of life, research and development capabilities, fast-growing export markets, abundant clean water, clean air, reliable energy supply, and good roads and infrastructure.

Talent pool

Because of Wisconsin's past leadership in energy efficiency and renewable energy, we have an exceptionally deep pool of talent in sciences and engineering related to building design, construction, and operations. We are a state replete with nationally—and internationally—recognized experts, nonprofit organizations, and businesses in these areas.

Manufacturing capacities

A typical wind turbine has 8,000 parts. Wisconsin is tailor made for clean energy development, with its manufacturing heritage that includes tool and die making capability, heavy construction and installation capabilities, design expertise, and specialty metal manufacture. Milwaukee has nearly a century of manufacturing expertise linked to energy, engines, and electricity. Its endeavor to be a global center for water use and treatment technologies is already fostering advances in water use efficiency and related energy efficiencies.

An economic development group, New North, is working in northeastern Wisconsin to establish a wind energy manufacturing cluster; and the Capital Region is focusing on the cutting-edge technologies and high-paying jobs of the future *bioeconomy*, which includes developing fuels from various plant materials. Both are good examples of key regions helping brand the state as a great place for clean energy job growth.

Natural resources

We also have diverse land resources, including agricultural lands and managed forests whose crops and forest products are potential feedstocks for biomass energy. These same lands may also have capacity for capturing and storing carbon through sound soil management and harvest practices.

Research

Wisconsin has outstanding research and development capabilities for clean energy development, with institutions such as the University of Wisconsin-Madison Great Lakes Bio-energy Research Center paving the way on cellulosic ethanol research for bio-fuels. A wide range of other energy and climate research capacities throughout the University of Wisconsin System and Wisconsin's private colleges offers a wealth of knowledge that can inform our strategies.

An innovative edge

As the leadership profiles featured in this report illustrate, Wisconsin has an array of innovators who are testing and proving strategies across the spectrum of energy and climate change solutions. Their lessons learned can open doors for businesses, communities, farms, and other groups to embrace new approaches.

What is holding Wisconsin back?

With all this potential to advance clean, efficient energy production and distribution, what is keeping Wisconsin from moving forward?

A lack of long-term strategic energy planning—Because Wisconsin doesn't have integrated, long-term, statewide planning for our energy needs and fuel choices, it is difficult to articulate to the public the needs, risks, and tradeoffs involved in various options. Compared with its neighbors, Wisconsin is currently investing less in energy efficiency despite the known long-term gains.[3]

Complacency—For years Wisconsin was a leader in energy efficiency, but now we've fallen to the middle of the pack, which hurts our competitiveness.

Comfort with the status quo—We know how to run a fossil fuel-dependent energy system, and the familiar is an easy default, especially in the absence of an alternative state energy and climate plan that would provide both encouragement and financial incentives to develop cleaner energy sources.

A divisive political environment in recent years has meant missed opportunities for civil dialogue in the policy arena to explore practical opportunities to diversify and make green Wisconsin's energy sources in the ways that neighboring states have. Consequently, Wisconsin ...

- has created a hostile and confusing climate for wind energy—a development that has sent entrepreneurs and developers to other states;[4]
- now ranks among the worst of 29 states that have a Renewable Energy Portfolio Standard (a regulatory requirement that a specific fraction of a state's electricity come from renewable sources), with Wisconsin staying flat at a 10 percent standard, while neighboring states are pursuing and have met much higher levels.[5]

Complexity—We have an aging electric grid built around centralized generation. Integrating new technologies will require incorporating changes to the grid and to utility business models.

Our challenges include risks from inaction as well as complexity in the field of energy development and delivery. We can sit back, hold onto the status quo as long as possible and see what happens, or we can envision a path, make a plan, seize opportunities, and move forward. Sitting back will not eliminate the need to address change, of course, but it will limit our options and opportunities relative to those changes.

Making a plan and moving forward now will keep Wisconsin vibrant and competitive.

Other states are moving forward

Even with similar hurdles and in this lean economy, neighboring states are attracting clean energy jobs and investment while pursuing their competitive advantage. For example:

- In 2012 alone, Michigan installed more wind energy capacity than Wisconsin will have in total at the end of the year 2015.
- Minnesota is on track to have 25 percent of total electricity sales generated from renewable resources by 2025, and proposals have been introduced for a standard requiring up to 40 percent by 2030. In Minnesota, Xcel Energy is on track to have 30 percent of the electricity it produces generated from renewables by 2025.
- Minnesota's 2013 Clean Energy and Jobs policy provides a solar energy standard of 1.5 percent by 2020.

- Illinois, Michigan, and Minnesota all have aggressive energy efficiency goals (set as a percentage of consumption) whereas Wisconsin's targets are limited by a funding cap, despite evidence that Wisconsin could achieve financial savings by doubling its investment in energy efficiency.[6]
- Illinois, Iowa, and Michigan have adopted stronger residential and/or commercial building energy codes than Wisconsin.[7]

How can we chart a new way forward?

Wisconsin is still poised to be a global leader in the emerging clean energy economy, which includes energy-conserving and energy-efficient homes, commercial buildings, and manufacturing processes; renewable energy sources; smart urban design; and modern, sophisticated transportation systems. Moreover, caring for our lands in ways that maximize nature's own capacity to store carbon will support other ecological processes that are good for people and habitat. These are all elements of a business climate that attracts clean jobs and investment while pursuing our competitive advantage and fostering pride in Wisconsin. Putting it all together means Wisconsin can contribute in many ways to shaping a low-carbon, renewable energy future.

To have a meaningful impact on greenhouse gas emissions, *the Wisconsin Academy's climate and energy steering committee (the primary team that developed this report) recommends reducing Wisconsin's fossil fuel emissions by 80 percent by 2050*—a target that would align us with recommendations from the international scientific community. The road forward is not a single highway but rather a variety of avenues of action. Some actions will be at the individual and household level, some at the community or institutional scale, and some in public-private partnerships than can be bolstered by changes in public policy.

The suggestions that follow provide a wide range of options to move us forward. This is not a comprehensive list, nor does it constitute a prescription that will address all the challenges we face. Rather, these items provide grist for deeper discussion and further analysis. Moving forward with some combination of these options, however, can set a course of action toward achieving the 80 percent reduction goal.

Conservation and efficiency

Establish annual energy efficiency savings goal at two percent

If Wisconsin were to match Arizona, Maryland, Massachusetts, New York, and Vermont—states that have ramped up their targets to achieve energy savings of at least two percent of retail sales through efficiency—we could realize significant reduction in energy costs and emissions.[8] Moreover, the American Council for an Energy-Efficient Economy (ACEEE) found that adopting energy efficiency policies nationwide would, by 2030, create 611,000 jobs, increase GDP by $17.2 billion and reduce CO_2 emissions by 26 percent. Wisconsin can realize its portion of those benefits by joining other states on the leading edge.[9]

A two-percent reduction in Wisconsin's industrial energy use alone would reduce the state's greenhouse gas emissions by over 400,000 metric tons per year, according to a study prepared for the Wisconsin Global Warming Task Force.[10] Wisconsin companies are already independently taking steps to develop sustainable, clean energy sources. As the profiles in this

report illustrate, businesses such as Gundersen Health System, Quad/Graphics, Johnson Controls, MillerCoors, and others are setting their own goals and making investments in technology, practice, and new strategies, and these actions are reducing greenhouse gas emissions.

Options to move energy efficiency forward:

- Increase overall funding to Focus on Energy (*e.g.*, 10 percent per year for at least five years) to support improvements in conservation and energy efficiency; give priority to projects where there is the most bang for the buck and where the programs will help make the state more competitive. Set clear, measurable goals for efficiency improvements.
- Offer incentives to utilities to invest in efficiency programs.

Expand the pace and scale of energy retrofits

The adoption of energy retrofits, which address improvements in heating, cooling, lighting, and water use, is a cost-effective energy strategy that has contributed to considerable energy conservation in many states. Offering financial incentives for local implementation of new regulations has further aided regions as they strive to improve their energy efficiency. For example:
Wisconsin has already enacted enabling legislation for Property-Assessed Clean Energy (PACE). Sponsors of the legislation stated:

> Under PACE programs, municipalities and counties form special tax districts to help property owners finance energy retrofits by allowing a property owner to place an additional tax assessment on his or her property. Property owners who invest in energy efficiency measures and small renewable energy (RE) systems repay these assessments over 15 to 20 years via additional annual payments on their property tax bills. State and local governments that implement the PACE model can address two major roadblocks to clean energy growth at the residential level: lack of capital and hesitancy to make long-term investments in energy efficiency or renewable energy.[11]

These programs are already supporting local projects such as the Milwaukee Energy Efficiency (Me^2) program and Save Some Green in River Falls.[12]

Wisconsin recently enacted legislation to increase the historic preservation tax credit from 5 to 20 percent. When combined with a similar 20 percent federal tax credit, this could be a strong incentive to rehabilitate older buildings and incorporate green building and energy efficient practices as we reinvest in Main Streets in communities across the state.

Retrofits of public buildings, and especially schools, yield tax benefits to the local community (in terms of energy cost savings). These buildings also serve as a resource for students, teachers, and other community members to learn about energy conservation and efficiency, green building design, and sustainable systems.

Options to move retrofits forward:

- Phase in efficiency requirements at the point-of-sale for residential and commercial properties, coupled with financing for efficiency upgrades so that energy cost *savings* exceed monthly financing *costs*.

- Provide tax credits for new green-building facilities, coupled with financing, such as low-interest loans, making investments in efficiency upgrades profitable for purchasers.

Encourage energy benchmarking

We can better manage energy use if we can measure it. Benchmarking is a way for property managers to compare their energy use to use in similar buildings.

Right now, only five percent of Wisconsin's buildings —half of which are schools—are Energy Star certified.[13] (The Energy Star program, established by the EPA, identifies, promotes, and certifies products and buildings that meet their energy efficiency standards.) These buildings use an EPA online scoring system called Portfolio Manager to help track their performance in comparison to performance in similar facilities.

Options to move benchmarking forward:

- Provide tax incentives to property managers who benchmark and disclose the efficiency of their commercial or residential rental properties. Over time, phase in energy disclosure requirements for all rental properties.
- Provide revenue incentives to public school districts that use Energy Star Portfolio Manager to benchmark the energy efficiency of school facilities on an ongoing basis.
- Require the state to use Energy Star Portfolio Manager to benchmark the energy performance of all state buildings and set annual targets to increase efficiency of lowest performing buildings until all state buildings qualify for Energy Star certification.

Explore other policy changes to spur conservation and efficiency

Policy changes in key areas can promote efficiency and conservation through tax, financial, and regulatory incentives that reward energy conservation measures applied to buildings, manufacturing processes and facilities; and supply chain management.

Options for spurring conservation and efficiency:

- Provide tax credits for new LEED-certified (or comparable quality Green Building Initiative) facilities.[14]
- Set a statewide goal of *negawatts* to spur energy efficiency and clean energy technology. (*Negawatts* is a term coined to describe power saved through conservation or efficiency measures that can offset rising demand for power, both for businesses and the environment).[15]
- Consider instituting a revenue-neutral Wisconsin *feebate* to spur clean energy development and carbon footprint reduction projects. Feebates reward efficient resource users with fees paid by the inefficient. For example, an electricity sector feebate might set a price on CO_2 emissions per kWh. Firms with emissions per kWh above a certain threshold (averaged across their portfolio of generation plants) would pay a fee, while those with emissions below the threshold would receive a rebate. Over time, the CO_2 per kWh threshold would be reduced incrementally as more clean energy and carbon footprint reduction projects come online.[16]
- Enhance appliance standards in Wisconsin. (California and other states have ratcheted

theirs up beyond federal standards.) For appliances like furnaces, national standards are out of step with our cold weather climate and need revision.

- Provide tax credits for energy conservation measures and customer-based renewable generation, including utility-leased systems.
- Automatically update energy efficiency building codes for residential and commercial buildings to match the most recent International Energy Conservation Code (IECC).
- Require all *new* state buildings to meet the most recent efficiency standards.

Renewable energy

Make a commitment to expanding renewables

Wisconsin can realize a much larger role for solar energy, smart use of biomass, and expanded wind generation by committing to a minimum 1-to-1.5 percent average annual increase in renewable energy generation starting in 2015.

In order for this to happen, we need to acknowledge that these are immature markets and that shifting policy priorities can jeopardize market development. For example, inconsistent incentives at the federal level hurt wind development. Similarly, Wisconsin's changing priorities on renewables (*e.g.* limiting solar incentives) have hurt the solar industry in the state. Ambivalent attitudes toward wind development in Wisconsin have shifted investments to other states.

A balanced approach, supporting a variety of resources in varying amounts and increasing renewables in a measured but constant way is low risk and keeps a foot in most technologies and pathways. It will also move our manufacturing capacity toward 21st-century products.

Embrace solar

The costs of solar energy have decreased to the point where solar is becoming competitive with conventional fuel sources.[17] Recently, a major utility solar project outbid a natural gas project to win a contract to provide peak energy in Minnesota.[18] Minnesota and a number of other states have been instituting *value of solar tariffs* (also known as VOSTs). These tariffs use a formula to assess the per kWh benefit of distributed solar energy as it is placed on the grid. The formula takes into account technical, environmental, and societal benefits to the utility infrastructure, which strengthens the economic case for solar. There are multiple practical and effective uses of solar energy in Wisconsin, both for electricity from photovoltaic arrays and heat (for living space and for water) from both passive and active designs.

Expand smart biomass

Wisconsin is already invested in co-burning a mix of biomass and conventional fuels such as wood chips and coal at multiple facilities and has been a leader in developing biomass (manure and other organic matter) digesters. Co-burning makes good sense when renewable source materials are close to the generation facility and in relatively constant supply. With an abundance of wood chips and scraps, paper pulp mills are already demonstrating the value of this approach. In an agricultural state with one of the world's largest dairy industries, the expansion of biogas-producing digesters that generate both heat and electricity

also makes sense—especially for large farm and food production facilities.

Grass biomass as fuel for heat and cogeneration (*i.e.*, producing both heat and power) deserves more attention, given grass's additional benefits as a protective soil cover, a carbon storage site, and a potential feedstock for biofuels such as ethanol.

As research on cellulosic ethanol makes progress, Wisconsin should evaluate its goals and priorities for biomass feedstocks. The state must balance the need for lands dedicated to food crops, pasture, forests, wildlife habitat, and other uses against the need for land devoted to growing biomass for biofuel production and power generation. Decisions should be guided by criteria that protect public values.

Develop strategic wind power

While Wisconsin's wind capacity may not be as high as Iowa's or Minnesota's, it is still significant. With continual improvements in wind turbine efficiency, costs per kilowatt hour from wind are becoming much more competitive and, over the long-term, wind has the advantage of no fuel price increases from unpredictable global markets. Carefully sited high-efficiency wind turbines need to be part of Wisconsin's renewable strategy, both from a carbon reduction standpoint and from the standpoint of attaining competitive electrical rates in a regional and global economy. Wind can advance home-grown technologies to keep energy dollars active in local economies. Compared to Iowa, where transmission congestion charges for accessing Iowa's wind energy are an issue, Wisconsin—with adequate local transmission capacity—may look more promising to wind power developers.

Options to move renewables forward:

- Mandate that utilities take the lead in renewable development by requiring a minimum 1-1.5% average annual increase in renewable electrical generation (above and beyond customer installations) starting in 2015.
- Offset new growth in electrical energy demand with renewable energy sources.
- Allow third parties to own and lease distributed generation, such as roof-top solar.
- Create a renewable thermal energy standard to help develop markets for Wisconsin-based bioenergy products and services.
- Provide tax credits and loans for customer-based cogeneration facilities, and allow utilities to own and/or lease cogeneration systems, like the Domtar biomass system in Rothschild, Wisconsin.
- Once Wisconsin state government buildings have met cost-effective energy standards, require the government to purchase an increasing percentage of its electricity from renewable resources.
- Take advantage of changes in the existing grid infrastructure to incorporate more clean renewable energy. For example, the shutdown of the Kewaunee nuclear power plant could offer an opportunity to expand local wind and other renewable technologies in Northeast Wisconsin.

Transportation

Wisconsin has many opportunities to diversify and modernize its transportation systems in ways that could improve energy efficiency and increase mobility choices for people throughout the state while also providing more efficient distribution capacity for freight.

Options to move transportation forward:

- Support regional public transportation and non-motorized vehicle transportation initiatives around the state.
- Replace outdated planning assumptions about linear growth with new information on emerging transportation trends such as fewer passenger vehicle miles traveled.
- Spend a larger portion of gas tax revenue money on transportation infrastructure in cities and towns as opposed to new highway construction.
- Support economic development that provides rail and/or marine transportation options for freight.
- Require that state Department of Transportation plans consider options for a shift of freight from trucks to rail or marine transport when planning highway expansion.
- Provide tax credits for plug-in hybrid and all-electric vehicles.
- Restrict passenger and freight vehicle idling, especially outside of schools, malls, and other public facilities.
- Encourage communities to support energy-smart driving strategies by synchronizing traffic lights and by providing education about fuel-saving driving practices.
- Develop and execute a plan for high-speed rail between Chicago, Milwaukee, Madison, Eau Claire, La Crosse and Minneapolis (considering a spur route to include Green Bay/Appleton), to be fully completed by 2025.
- Encourage research and development for compressed biogas fuel use in transportation fleets.

Utility leadership

Wisconsin utilities have the opportunity to be pivotal players in a clean energy transition. America's Power Plan (APP) is a new initiative that is looking at many challenges: game-changing new technologies; increasing consumer demand for cleaner, more efficient energy; an aging and increasingly obsolete power grid; and opportunities for a dramatic reduction in the cost of renewable sources of energy—all of which are reshaping America's electricity sector.[19] APP notes that,

> The US electric power industry is changing fast. For a century, vertically integrated monopolies built power plants, strung transmission and distribution lines, billed customers, and were rewarded with a predictable return on investment. But now, consumers and businesses are demanding more control over the energy they use. Innovative power companies and technologies are rising to meet this demand, introducing new technologies, from smart control systems to rooftop solar panels.[20]

Options to move utility leadership forward:

- Reform the regulatory model to encourage utilities to pursue aggressive conservation and distributed renewable generation targets.
- Devise a timeline and strategy to retire Wisconsin's oldest and dirtiest coal plants so that they can be replaced with low or zero-carbon fuels.
- Work with other states to address aspects of utility structures and the electrical grid that present barriers to renewable energy development.
- Work with the Legislature and energy leaders to identify clean alternatives to propane-dependent energy for rural Wisconsin.
- Increase combined heat and power generation (cogeneration) in Wisconsin.
- Work with stakeholders, including utilities and electrical energy consumers, to develop robust state implementation of the EPA's Carbon Pollution Standards for power plants.

Put a price on carbon

Establishing a price on carbon emissions (through a tax or trading mechanism) is widely seen among climate change strategists as one of the most effective strategies for reducing emissions. While a federal solution would create clarity in the marketplace, Wisconsin can still explore ways to put a price on carbon.

Options for putting a price on carbon:

- Support research and data analysis on options for monetizing carbon.
- Explore reinstating a regional greenhouse gas market in the Midwest.
- Consider imposing a revenue-neutral carbon tax to fund conservation and efficiency.

Research and data analysis

While significant gains can be made with current technologies, research can carry us toward new breakthroughs. Data analysis can help us evaluate which approaches are effective.

Options to move research on clean energy, carbon storage, and improved energy efficiencies forward

Invest in public and private research and development for:

- Great Lakes wind[21]
- Bioenergy—capitalize on potential for greater use of manure digesters, woody and grassy biomass, and cellulosic ethanol
- Biochar development and applications. (Biochar is high-carbon charcoal. When buried, carbon is sequestered and soils are amended.)
- Natural carbon storage. All plants, living and dead, store carbon in their cellulose. Investigate ways to manage natural ecosystems and soils rich in plant detritus to maximize carbon storage.

- Encourage utilities to participate in federal Green Button data initiatives. These represent an industry-led effort to enable customers to easily access and securely download their energy usage data via a "Green Button" on electric utilities' websites. With this information, consumers can use a growing

array of new web and smartphone tools to make more informed energy decisions and investments, and even use apps for competing to save energy and lower their carbon emissions.[22]

Tracking our progress

To measure our progress toward cleaner and more resilient energy strategies, we recommend using a framework that monitors these factors:

- Reduction of carbon emissions;
- Financial savings based on the cost of energy, both in terms of rates and overall spending;
- New installation of solar, wind, thermal and bioenergy power;
- Quality of life, comfort, and convenience (the *happiness index*);
- Economic development across the state;
- Sustaining cultural values, traditions and ecological integrity.

In order for these measures to have value, specific benchmarks, targets, and goals are needed. Done well, these could provide a clear picture of our progress, help us learn and adapt strategies accordingly, and share advances with other states and regions.

We can do this

As our world faces climatic changes that threaten our health, safety, and the stability of natural systems that sustain us, Wisconsin can play a positive, solution-oriented role. Change creates opportunity, but that opportunity comes with the responsibility to pursue options that will sustain the people of Wisconsin, our environment, and our economy in a global context.

At a minimum, we can step up and find ways to reduce our own state's carbon footprint. We also have the ability to go much further by developing new technologies and breakthroughs in conservation, efficiency, and renewable energy that would not only benefit us, but could serve as resources and models for other northern regions of the world. We can also pursue urban design and transportation systems that can meet our 21st-century needs. We have research capacity, manufacturing know-how, and innovators who are already leading the way with forward-thinking strategies. We have world-class higher education in our state, and people who know how to tackle hard challenges.

At this critical juncture, our leaders from all walks of life in Wisconsin must fully examine the many steps it will take to embrace this challenge, and then to plunge in and take part. Many are already in the vanguard. Drawing on all these capacities, we are confident that Wisconsin can chart a new climate and energy path that will truly carry us forward.

Notes

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APPENDIX

How does Wisconsin compare with other states in the region?

Energy efficiency policy

All of our surrounding states have an Energy Efficiency Resource Standard (EERS) in place that requires a reduction in energy sales over a given period of time. Although, it is important to note that none of these standards are capped by funding, as is the case in Wisconsin. In order to meet the standards, utilities in these states promote energy conservation and efficiency practices among their customer base. For instance:

- Illinois's law ramps up to a requirement of 2% energy savings by 2015 and continues all the way 7.1% by 2019. [1]
- Minnesota requires its investor owned utilities to reduce total energy sales by 1.5% each year, beginning in 2010.[2]
- Michigan's 2008 EERS requires each utility to reduce their annual sales by 1% by 2012 and again each year until 2015.[3]
- Iowa's targets vary by utility, with average annual electricity savings of 1.4% and natural gas savings of 1.2% of retail sales by 2013.[4]

In contrast, Wisconsin's goal is lower—approximately 0.75 percent of sales in 2011, 2012, and 2013 for electricity. Moreover, the most recent Focus on Energy evaluation completed in November 2012 showed that our first year goal for 2011 was not met.

Building codes

Building energy codes and standards set minimum requirements for energy-efficient design and construction of new and renovated buildings. These codes affect energy use over the life of the building. Approximately 41 percent of energy consumed in the US in 2010 was used in buildings, so building codes are an important way to conserve energy and reduce energy demand, and thus emissions.[5]

Wisconsin has statewide building energy codes that follow the International Code Council's (ICC) International Energy Conservation Code (IECC) publications. These are periodically updated recommendations for energy performance of different types of buildings. Currently, under the state's Uniform Dwelling Code (UDC) for residential buildings, new one- and two-family dwellings must meet 2006 IECC guidelines (with a few amendments).[6] Wisconsin state law dictates that local residential building ordinances conform and not be any more or less restrictive than the UDC.[7] Commercial buildings are held to the more recent 2009 IECC recommendations.[8] The ICC has published updated code recommendations for 2012, but these have yet to be adopted at the state level.

For residential building codes, a full 28 states, including Iowa, Illinois, and Michigan, follow IECC 2009 or equivalent energy efficiency guidelines, which are more stringent than Wisconsin's.[9] However, for commercial buildings, only Maryland has yet to follow standards stricter than Wisconsin's (it uses IECC 2012 or equivalent guidelines), while 33 states follow the 2009 IECC or equivalent recommendations along with Wisconsin.[10]

Renewable energy policy[11]

State level renewable energy policies have become common across the nation. Indeed, all Midwest states have laws that address increased energy production from renewable technologies. In looking at our closest neighboring states, we can

see a snapshot of Wisconsin's progress towards diversifying its energy mix.

Renewable Portfolio Standards

A Renewable Portfolio Standard (RPS) is a policy that requires increased production of electricity from renewable resources over a certain time period. Wisconsin was the first state to adopt renewable energy portfolio standards in 1999 without restructuring the electrical utilities. Wisconsin's RPS was updated in 2005 and requires 10 percent of statewide energy to come from renewable energy sources by 2015.

In 2007, Minnesota created a 25 percent by 2025 RPS for all the state's utilities except Xcel Energy, which is required to generate 31.5 percent renewable energy by 2025. Just this year, Minnesota updated its law to include a 1.5 percent solar requirement for all investor owned utilities, a small-scale renewable energy requirement (known as a distributed generation carve out), and a goal of 10 percent solar energy by 2030 for the entire state.

Illinois passed its 25 percent by 2025 RPS in 2007. The law includes a percentage requirement for different technologies; for example, 1.5% of sales during the compliance year of 2025–2026 must be met by solar photovoltaics.

In 2008, Michigan passed an RPS of 10 percent by 2015. In addition, the state's two largest utilities, Detroit Edison and Consumers Energy, must build on-the-ground renewable energy capacity of 600 and 500 megawatt (MW), respectively, by the end of 2015.

While not entirely similar to an RPS, Iowa's Alternative Energy law was passed in 1983. The law requires the state's two investor-owned utilities to own or contract for a combined total of 105 MW of renewable energy; this goak was reached in 1999.[12]

Net Metering

Net metering policies are used by electricity consumers who own renewable energy systems and can produce energy as well as consume it. As electricity meters spin backwards and forwards, net metering helps to balance out times when consumers are taking energy from the grid with times that they are supplying it, by giving a credit for that excess energy production. The details of the given credit, as well as the size of the system allowed, are important factors for evaluating the strength of the policy.

In 1982, it became mandatory for Wisconsin utilities to provide net metering for systems that produce up to 20 kilowatts (kW) of electricity. Credit for excess electricity varies by utilities, but is often credited onto the next utility bill at the consumer's retail rate for electricity. In 2011, Xcel Energy was given approval to provide credits on an annual basis, which better allows for seasonal fluctuations in a system's performance.

Minnesota adopted its own net metering procedure in 1983. Its policy allows for systems up to 40 kW and gives the customer the option to receive the credit in the form of a direct payment or credit on the next bill. In 2008, Minnesota required Xcel Energy to provide a Community Solar Garden Program that allows consumers to subscribe to solar gardens and receive breaks on monthly bills based on the solar energy that is produced. This program is effectively a type of net metering sponsored by the utilities.

Michigan has a two-tiered net metering policy, with systems up to 20 kW receiving a credit at the retail rate on their next bill, and systems up to 150 kW receiving a lower rate that resembles avoided cost. Net metering is available to customers of Iowa's two investor owned utilities for systems up to 500 kW in size and provides a credit carried

forward indefinitely at the customer's retail rate for electricity. Illinois's net metering policies allow for systems up to 40 kW and credit to the next bill at the retail rate.

Feed-in tariffs[13]

A feed-in tariff is a policy that guarantees a payment to a renewable energy producer, usually in the form of long-term contracts. These policies are designed to incentivize renewable energy development by giving financial certainty to system owners.

Wisconsin has no statewide requirement to make feed-in tariffs available, and there are only a few examples of feed-in tariffs at work in the state. Madison Gas and Electric had a program that paid $0.25/kWh for electricity produced by solar photovoltaic systems, although the program's cap of 1 MW has been met and there is currently a waiting list for customers who want to join the program. River Falls Municipal Utility, a member of WPPI Energy, offers a $0.30/kWh tariff for electricity from solar photovoltaic systems. The cap on the program, currently at 30 kW, has been raised several times to accommodate demand.

Minnesota has a unique feed-in tariff program called "Made in Minnesota." Starting in January 2014, systems of 40 kW or less may apply for 10-year contracts. The renewable energy technology must be certified as made in Minnesota. The rate has yet to be determined, and it will be recalculated each year. The state also has various utilities with feed-in tariff programs.

Michigan has an Experimental Advanced Renewable Energy Program (EARP) in place that offers electricity buyback produced from solar photovoltaics with 15-year contracts. The program is capped at 3,000 kW, with 1,500 kW allocated for residential systems and 1,500 kW for non-residential systems. This program has numerous phases with multiple payment amounts that vary by each system.

Policy	Renewable Portfolio Standard	Net Metering	Feed-In Tariff	Energy Efficiency Standard: Electricity	Energy Efficiency Standard: Natural Gas	Building Codes
Wisconsin	10% by 2015	20 kW system size cap	1 limited program available	.75% goal	.5% goal	2006 IECC
Minnesota	25% by 2025	40 kW cap	Statewide solar	1.5% each year	1.5% each year	2006 IECC
Iowa	105 MW (Goal Met)	500 kW for two largest utilities	1 program available	1.4% average across utilities by 2013	1.2%	2009 IECC
Illinois	25% by 2025-2026	40 kW	No programs available	2% each year	8.5% cumulative savings by 2020	2012 IECC
Michigan	10% by 2015 Plus 1100 MW	20 kW and 150 kW	1 program at largest utility	1% each year	0.75% each year	2009 IECC

Table 2. Wisconsin and surrounding state Energy Efficiency Resource Standards (EERS)
Source: Database of Incentives for Renewables & Efficiency, 2013.

Notes

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