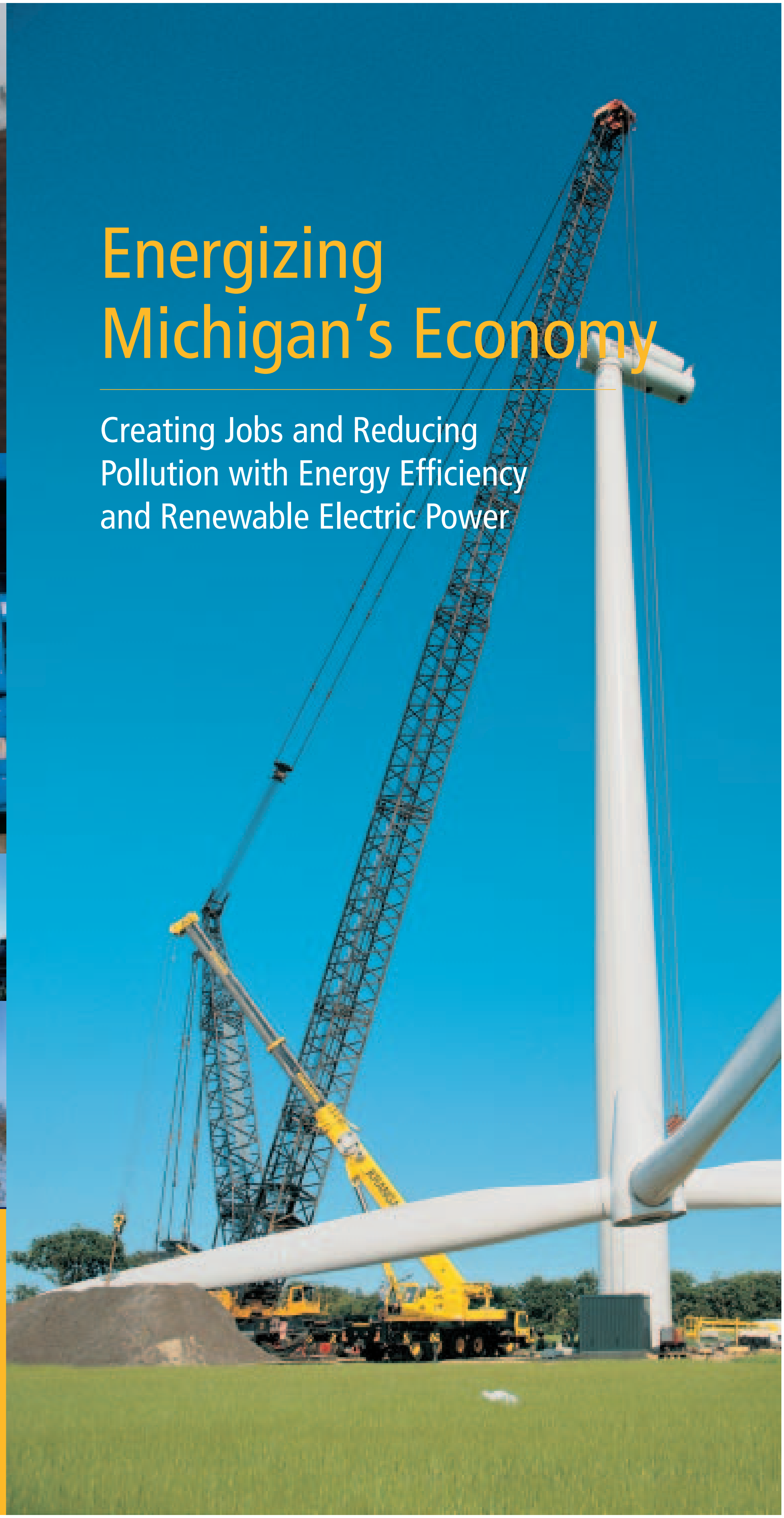


Energizing Michigan's Economy

Creating Jobs and Reducing Pollution with Energy Efficiency and Renewable Electric Power

Environment Michigan
Research & Policy Center

Energizing Michigan's Economy

Creating Jobs and Reducing Pollution with Energy Efficiency and Renewable Electric Power

Travis Madsen
Timothy Telleen-Lawton
Mike Shriberg

Environment Michigan
Research & Policy Center

February 2007

Acknowledgments

The economic model forming the basis of this report was originally designed by Skip Laitner and Economic Research Associates in Alexandria, Virginia. The authors are grateful for the firm's expert technical advice and ongoing assistance.

Environment Michigan Research & Policy Center is grateful for the additional perspective and input of Martin Kushler at the American Council for an Energy Efficient Economy, David Gard at the Michigan Environmental Council, Frank Zaski of the Sierra Club, David Pettit at PIRGIM, and several anonymous reviewers. Additional thanks go to Tony Dutzik of the Frontier Group for editorial assistance.

The generous financial support of the Energy Foundation made this report possible.

The authors alone bear responsibility for any factual errors. The recommendations in this report are those of Environment Michigan Research & Policy Center and do not necessarily represent the views of our funders or those who reviewed drafts of the report.

Environment Michigan Research & Policy Center is a 501(c)(3) organization. We are dedicated to protecting Michigan's air, water and open spaces. We investigate problems, craft solutions, educate the public and decision makers, and help Michiganders make their voices heard in local, state and national debates over the quality of our environment and our lives. For more copies of this report, see our Web site at www.environmentmichigan.org, or send $15 per copy to:

Environment Michigan Research & Policy Center
103 E. Liberty, Suite 202
Ann Arbor, MI 48104

For more information about Environment Michigan Research & Policy Center, please call our main office at (734) 662-9797, email us at center@environmentmichigan.org, or visit our Web site at www.environmentmichigan.org.

Cover Photos: *DOE/NREL, NEG Micon, and Bonus Energy A/S*
Layout: *Harriet Eckstein Graphic Design*

Table of Contents

Executive Summary

Michigan does not need and should not pay for new coal-fired or nuclear power plants to meet our electricity needs. Instead, our state should pursue a New Energy Future based on energy efficiency and home-grown renewable energy resources.

Such a New Energy Future would create jobs, save consumers money, stabilize energy prices, make Michigan more energy independent, reduce long-term economic and environmental risk from global warming pollution and ensure that more of Michigan's energy dollars stay in the local economy, as opposed to paying for coal, gas and uranium from out of state.

In this report, we use an economic and environmental model to compare the impacts of an innovative New Energy Future scenario (which eliminates growth in electricity demand through energy efficiency and generates 25 percent of electricity sales from renewable sources by 2025) with Governor Granholm's 21st Century Energy Plan (which makes a smaller commitment to efficiency and renewables), and with a business-as-usual scenario (which includes no efficiency or new renewables).

The New Energy Future scenario provides the strongest benefits for Michigan's economy and environment, and should form the central part of the state's energy plan.

Clean energy creates good jobs.

- The New Energy Future scenario would create 88,000 person-years of employment through 2020 (vs. business as usual), 60,000 more than the 21st Century Energy Plan. Moreover, the New Energy Future scenario would increase wages paid to Michigan workers by a cumulative total of $3.3 billion through 2020, $2.3 billion more than under the 21st Century Energy Plan. (All dollar figures are reported as undiscounted 2006 dollars.) While both plans would create more jobs and increase wages further than business as usual, the impact of the New Energy Future scenario would be about three times larger.

- Michigan spends more than $18 billion per year on imports of fuel from out of state, a tremendous drain on the state economy. Clean energy creates jobs by replacing expenditures for fuel with expenditures for labor and materials produced at home.

- Harnessing Michigan's well-developed industrial base to manufacture renewable energy and energy efficiency technologies for use and export would provide additional significant economic advantages.

Clean energy saves consumers money on electricity and gas bills.

- The New Energy Future scenario will save Michigan residents and businesses a total of more than $2.2 billion through 2020, while the 21st Century Energy Plan would yield $1.2 billion in savings (compared to business as usual). By enabling Michiganders to spend energy bill savings for needs other than energy, clean energy stimulates the local economy and creates jobs.

- The New Energy Future scenario makes a substantial commitment to energy efficiency and renewable energy, requiring a large influx of capital that yields larger benefits over the long-term.

Clean energy prevents pollution.

- During the year 2020, the New Energy Future scenario would reduce annual power plant air pollution by about 30 percent vs. business as usual.

- Through 2020, the New Energy Future scenario would prevent the emission of a cumulative total of:

  * 170 million metric tons of carbon dioxide, the leading global warming pollutant;

  * 260,000 tons of soot-forming sulfur dioxide;

  * 90,000 tons of smog-forming nitrogen oxides; and

  * 1,000 pounds of mercury, a neurological toxicant.

- These air pollution reductions are more than twice as much as the 21st Century Energy Plan would yield.

Clean energy shields Michigan from the economic and environmental risks of building new coal-fired power plants.

- If Michigan chooses to build new coal-fired power plants, it will increase the state's emissions of global warming pollution. Without a large reduction in emissions, global warming could dramatically impact the state over the next century—doubling or tripling the number of days in Detroit with highs of 90° F or warmer, reducing the volume of the Great Lakes, causing droughts, crop failures, extreme weather events, and more.

- The growing urgency of addressing global warming makes limits on carbon dioxide pollution a virtual certainty for the future. As these limits are set, coal-fired power will become more expensive. Utility companies and their shareholders may be forced to pay significant costs for pollution credits or for carbon capture and storage—damaging the state economy.

- Because energy efficiency and renewable energy emit no global warming pollution, they can help shield Michigan from these risks. And because renewable energy is not tied to finite fuel supplies, it can also shield Michigan from the economic risk of fuel price increases.

Michigan could eliminate the need to build any new coal-fired power plants by using energy more efficiently.

- By investing $225 million per year in an effective energy efficiency program, Michigan could eliminate growth in electricity demand, greatly reducing pressure to build any new coal-fired power plants (or other new fossil-fuel or nuclear facilities).

- In contrast, the 21st Century Energy Plan recommends an energy efficiency program funded at only $68 million per year. This program would allow Michigan's electricity demand to continue to grow at about 0.9 percent per year—failing to alleviate the need to build one or two new coal-fired power plants.

- Efficiency is the most cost-effective energy resource for Michigan. Efficiency programs save energy at half the cost of building, fueling and operating a new power plant. States with active energy efficiency programs typically achieve energy savings at an average cost of 3 cents per kWh or less, compared to a cost of energy of about 6 cents per kWh from a new power plant. The *Energy Efficiency Resource Assessment* in Michigan's 21st Century Energy Plan estimates that a large block of savings can be achieved for even less—2.57 cents per kWh.

Using local resources, Michigan could dramatically increase generation of renewable electricity.

- The technical potential for renewable energy generation in Michigan is large. On-shore wind energy, biomass and solar energy could together produce the equivalent of more than two-thirds as much electricity as Michigan currently uses per year.

- The potential of off-shore wind energy alone far exceeds Michigan's current electricity needs. Tapping into just a fraction of this potential, Michigan could launch a new industry and become a regional leader in renewable energy use and clean energy technology manufacturing.

- Renewable energy sources currently cost the same or slightly more than conventional power generation, but have major advantages in avoiding future fuel price increases and future environmental costs such as carbon taxes. Plus, costs are projected to decrease as demand for renewable energy ramps up, and fossil fuel prices continue to climb.

Policy Recommendations

Now is the time to move Michigan toward a clean energy future. Michigan has a once-in-a-generation chance to change course—from old and dirty fossil fuel-based energy to a more efficient economy powered by renewable energy. To make this future a reality, Michigan's leaders should:

- **Restart energy efficiency programs.** Michigan should aim, at minimum, to meet all future growth in demand for electricity with energy efficiency improvements. The state should require its utility companies to create and fund energy efficiency programs sufficient to reduce growth in electricity demand to zero. In addition, Michigan should update residential and commercial building codes, set stronger appliance efficiency standards, and implement a "Pay As You Save" (PAYS®) program to help extend the leverage of energy efficiency program funding and improve the penetration of energy efficient products into the marketplace.

- **Adopt a renewable energy standard of 25 percent by 2025.** Michigan should require utility companies to generate a large and growing share of their electricity from in-state renewable sources of energy, reaching 25 percent of sales by 2025. The standard should focus on truly renewable resources like wind, solar and clean biomass—and exclude toxic sources of energy like trash incineration.

- **Reject new coal-fired or nuclear power proposals.** By implementing strong energy efficiency and renewable energy programs, Michigan could eliminate the need for new coal-fired or nuclear power plants. State leaders should implement clean energy programs and priorities first, before considering irresponsible and expensive proposals for new generation.

Introduction

Michigan's economy needs an infusion of new energy. As of December 2006, fully 7.1 percent of Michigan's work force is out of a job, one of the worst unemployment rates in the country.[1]

Making up for the recent decline in the fortunes of the auto industry will be a long-term task. However, Michigan has the resources right here at home to make a strong start, and lay the foundation for a prosperous future.

The key is energy.

Michigan is almost entirely dependent on other states and countries for the oil, coal, natural gas and uranium that we use for fuel. In 2004, Michiganders were spending more than $18 billion per year on energy supplies from out of state—surely billions more after the fuel price increases triggered by hurricane Katrina and turmoil overseas.[2] This is a tremendous drain on the state's struggling economy—equivalent to more than 5 percent of gross state product, or more than $1,700 per person—and a huge boon for major energy-producing states like Wyoming, where personal incomes are growing faster than anywhere else in the country.[3]

At the same time, Michigan's over-dependence on fossil fuels exposes us to serious public health and environmental risks. Burning coal and oil has contaminated Michigan's rivers and lakes with mercury pollution and dirtied the state's air with dangerous soot and smog. It has also created massive amounts of global warming pollution, which has contributed to the warming of Michigan's climate—visible in the early blooming of cherry trees, reduced winter ice in the Great Lakes, and a northward shift in the range of plant and animal species.

If we extend our dependence on fossil fuels, we increase our vulnerability. As demand for natural gas and oil begins to exceed available supply, Michiganders will face rapidly increasing energy prices. Increased coal consumption could delay the day when Michiganders have clean and healthy air to breathe, and fish without mercury contamination. And increasing Michigan's use of fossil fuels will only worsen the impact of global warming—threatening the welfare of future generations, the ecosystems upon which life depends, and our standing in the global community.

Fortunately, Michigan has better solutions to its energy problems. Technologies exist that can dramatically reduce our consumption of energy, while at the same time drawing more of that energy from clean, renewable sources like wind, biomass and sunlight. Pursuing such a "New Energy Future" would begin to free Michigan from its dependence on fossil fuels, keep more energy dollars in-state, create jobs, allow the state to do its part to reduce global warming and safeguard future economic and national security.

Developing these resources will help Michigan build and diversify its economy into the 21st century. Utilizing efficiency and renewable resources would prompt the growth of a new manufacturing industry to supply the state with clean energy technologies. It would also help set up the state to capitalize on rapidly growing future regional and global demand for efficient products and renewable energy components.

Moving beyond solutions that worked in the past—like building more coal-fired power plants—can yield significant returns for Michigan. This report quantifies the benefits for Michigan's economy of investing in a serious program to improve the efficiency of electricity use and tap into the state's home-grown renewable energy resources.

Clean Energy Benefits Michigan's Economy

Electricity is a central part of Michigan's economy. It provides power for everything from lighting to powering industrial equipment to maintaining a comfortable environment in homes, shops, and offices across the state—making the modern economy possible.

Choices about how Michigan generates its electricity affect the economy. However, the impact is much broader than the price we pay for every kilowatt-hour (kWh). (See Appendix I for an explanation of electricity terms.) Simply choosing the energy options that deliver the cheapest short-term electricity rates—as some participants in the crafting of Michigan's 21st Century Energy Plan advocate—will not deliver the best results overall.

First, people and businesses value the services energy provides—not energy itself. Consumers benefit if they can get the same services—such as heating, lighting, or appliance use—at a lower total cost. Energy efficiency programs—even though they may require a slight increase in the per-kilowatt-hour cost of electricity—lower consumers' overall bills and reduce total future electricity system costs, thus saving everyone money in the long run.

Second, different energy sources send money to different parts of the economy—acting as either a drain or a stimulus to the state's overall economic health. For example, purchasing coal to run a power plant sends money out of state to pay for mining and transportation. In contrast, purchasing biomass from a Michigan farm to use in a power plant would keep more of the money local, and have a greater positive impact on the state economy. (See "Clean Energy is a Local and Growing Resource" on page 13.)

Also, developing the capacity to manufacture technology like wind turbines that are in demand elsewhere can provide a strong stimulus for the economy—much as the auto industry has done for Michigan over the years.

Finally, choices about energy sources have profound impacts on our health and our environment. For example, Michigan's reliance on old coal-fired power plants causes air pollution that takes a serious toll on public health—including nearly 1,000 premature deaths a year caused by soot pollution and extensive mercury contamination in Michigan lakes exposing children to the risk of developmental disability.[4] Continued reliance on fossil fuels has helped make the U.S. the world's leading contributor to global warming—which could increase average summer temperatures in Michigan by 7° to 10° F by the year 2100, doubling or tripling the number of days in Detroit with highs over 90° F and radically altering Michigan's landscape and natural resources.[5]

It is in this context that we must address the energy choices that Michigan now faces. If Michigan continues to go about business as usual, the state is likely to build several new coal-fired power plants to meet electricity demand, projected to grow at about 1.3 percent per year through 2020.[6] If Michigan adopts the governor's 21st Century Energy Plan, which includes a small commitment to energy efficiency and renewable energy (an efficiency program with initial funding of $68 million per year and a renewable energy standard of 10 percent by 2015), the state will need to build one or two new power plants, likely coal-fired, to meet future electricity needs.[7]

On the other hand, Michigan could transform how it produces and consumes energy, following a New Energy Future scenario. This strategy would increase Michigan's reliance on renewable forms of energy such as wind, biomass and solar power—reaching 25 percent of total electricity generation by 2025. It would also tap into Michigan's vast "strategic reserves" of energy efficiency—a resource that could cost-effectively eliminate growth in demand for energy for the foreseeable future.

The clean energy path is not unique. In fact, 18 other states already have strong energy efficiency programs and 22 states have a renewable energy standard. Many other developed countries have far surpassed these goals. However, Michigan is in a unique position because of our need to reinvent our economy and because of our tremendous potential for clean energy production and deployment.

In this report, we use an input-output model of the Michigan state economy to compare the impacts of three different energy strategies: business as usual, the governor's 21st Century Energy Plan, and a New Energy Future scenario. The model describes how changes in spending driven by the alternate policies affect the overall economy and the environment. (See the Methodology section on page 45 for more details.)

The results confirm the findings of a raft of earlier studies: implementing a robust

Table 1: Cumulative Net Impact of 21st Century Energy Plan and New Energy Future Scenario vs. Business as Usual (2007-2020)

Measure	21st Century Energy Plan	New Energy Future Scenario
Jobs Created (Person-Years of Employment)	28,000	88,000
Wages Paid	$1.1 billion	$3.3 billion
Increase in Gross State Product	$80 million	-$10 million
Net Consumer Savings on Energy	$1.2 billion	$2.2 billion
Avoided Global Warming Pollution (CO_2)	70 million metric tons	170 million metric tons
Avoided Smog-Forming NO_x Emissions	40,000 tons	90,000 tons
Avoided Soot-Forming SO_2 Emissions	120,000 tons	260,000 tons
Avoided Mercury Pollution	450 pounds	1,000 pounds

Note: All impacts are above and beyond the business-as-usual case. All dollar figures are expressed in 2006 values and are not discounted. Any apparent discrepancies between Table 1 and Table 2 are due to rounding. For a detailed explanation of the methodology behind the results, see page 45.

Table 2: Cumulative Net Impact of New Energy Future Scenario vs. 21st Century Energy Plan (2007-2020)

Measure	Additional Impact of New Energy Future Scenario over 21st Century Energy Plan
Jobs Created (Person-Years of Employment)	60,000
Wages Paid	$2.3 billion
Increase in Gross State Product	-$90 million
Net Consumer Savings on Energy	$1.1 billion
Avoided Global Warming Pollution (CO_2)	90 million metric tons
Avoided Smog-Forming NO_x Emissions	50,000 tons
Avoided Soot-Forming SO_2 Emissions	140,000 tons
Avoided Mercury Pollution	520 pounds

clean energy plan will create thousands of good-paying jobs and save Michiganders billions of dollars on their energy bills. (See "Clean Energy Policies Benefit the Economy" on page 14.)

Energy efficiency, wind, clean biomass, and solar energy technologies can provide a clean and sustainable supply of electricity for Michigan. At the same time, these technologies are also an economic development tool that Michigan can use to move its economy forward. Table 1 compares the 21st Century Energy Plan and the New Energy Future scenario to business as usual in terms of economic and environmental impacts. Table 2 compares the New Energy Future scenario directly with the 21st Century Energy Plan, showing the economic advantages of a stronger commitment to energy efficiency and renewables.

Clean Energy is a Local and Growing Resource

Michigan has no coal or uranium reserves. And, Michigan's oil and gas production is declining, while use is increasing. The average natural gas well operating in Michigan in 2005 produced 75 percent less gas per day than the average well in operation in 1990, despite improvements in extraction technology.[8] Michigan's natural gas production reached an all-time high in 1997, and has since entered a decline.[9]

In contrast, clean energy is a growing resource. As we learn more about how to use energy efficiently and more effectively tap into the vast and local resources of wind, biomass and sunlight, the quantity of energy available increases. Moreover, as technologies designed to save energy and renewable energy systems are deployed in larger numbers, the resulting economies of scale will bring about lower prices.

Clean Energy Policies Benefit the Economy

The results of this study confirm and compare favorably with other recent research. In fact, this study's results are conservative by comparison:

- In 2001, researchers at the University of Illinois's Regional Economics Application Laboratory determined that a regional plan to boost energy efficiency, renewable energy and combined heat and power would create 38,000 jobs in Michigan and increase the gross state product by $3.4 billion by 2020.[10]

- In January 2005, the American Council for an Energy Efficient Economy estimated that a five-year regional energy efficiency program could create over 11,000 jobs in Michigan.[11]

- The Union of Concerned Scientists estimates that a national renewable energy standard achieving 20 percent renewable energy by 2020 would increase employment in Michigan by 4,900 jobs—more than twice the expected impact from building more natural gas or coal power plants.[12]

- The Renewable Energy Policy Project estimates that national efforts to build large amounts of solar and wind energy facilities would create more than 9,000 manufacturing jobs in Michigan.[13]

- In an earlier report, Environment Michigan Research & Policy Center estimated that enacting a national renewable energy standard of 20 percent by 2020 and redirecting fossil fuel subsidies in the 2005 energy bill to energy efficiency and renewable energy programs would create 3,300 jobs per year in Michigan and increase the state's GSP by an average of $20 million per year from 2005 to 2020.[14]

Employment Gains

Investing in energy efficiency and renewable energy would bring jobs to Michigan. Compared to business as usual, the New Energy Future scenario would increase employment through the year 2020 by 88,000 person-years, 60,000 more than the 21st Century Energy Plan. The New Energy Future scenario would also increase wages paid to workers by a total of $3.3 billion through 2020, $2.3 billion more than the 21st Century Energy Plan. (See Table 3.)

Table 3: Employment and Wage Impact of New Energy Future Scenario

Measure	Impact over Business as Usual	Impact over 21st Century Energy Plan
Cumulative Employment Created (2007-2020)	88,000	60,000
Cumulative Wages Paid (2007-2020)	$3.3 billion	$2.3 billion

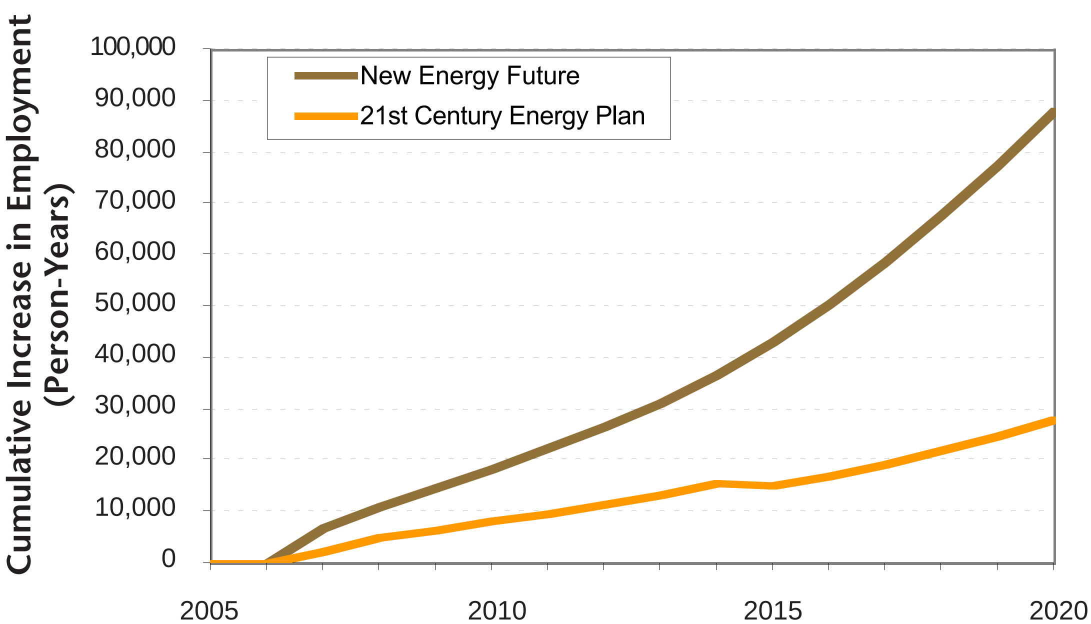
Michigan spends more than $18 billion per year on imports of fuel from out of state.[15] The state is almost completely dependent on imports—relying on other states or countries for 100 percent of its coal and uranium, 96 percent of its oil, and 75 percent of its natural gas.[16] This is a tremendous drain on our economy.

Clean energy creates jobs by replacing expenditures for fuel with expenditures for labor and materials produced at home. By keeping more energy dollars local, clean energy policies have a net positive impact on employment in the state.

Clean energy policies also produce more jobs than business as usual because they stimulate industries that are more efficient at creating jobs than other parts of Michigan's economy. For example, wind and solar energy direct more investment into construction than coal- or gas-fired plants. For every $1 million spent on construction in Michigan, 15.1 jobs are created. Alternatively, investing $1 million dollars in oil and gas extraction creates only 7.9 jobs, while putting $1 million into natural gas distribution creates only 3.8 jobs.[17]

Figure 1 shows the trajectory of net cumulative job creation due to investment in clean energy, above and beyond the business-as-usual case. Similarly, Figure 2 shows the cumulative impact on net wages paid to workers in Michigan. Both figures show that a deeper commitment to renewables and energy efficiency lead to greater employment and wage increases for Michigan. The increases in jobs and wages are driven by changes in spending patterns within the economy as a result of investment in energy efficiency and renewable energy programs.

Figure 1: Cumulative Net Employment Increase under New Energy Future and 21st Century Energy Plan (vs. Business as Usual)



Gambling on Coal

Investments in coal-fired power plants are not only less effective at creating jobs in Michigan than energy efficiency and renewables—they also impose serious economic risks for utilities, their shareholders, their customers and the state as a whole.

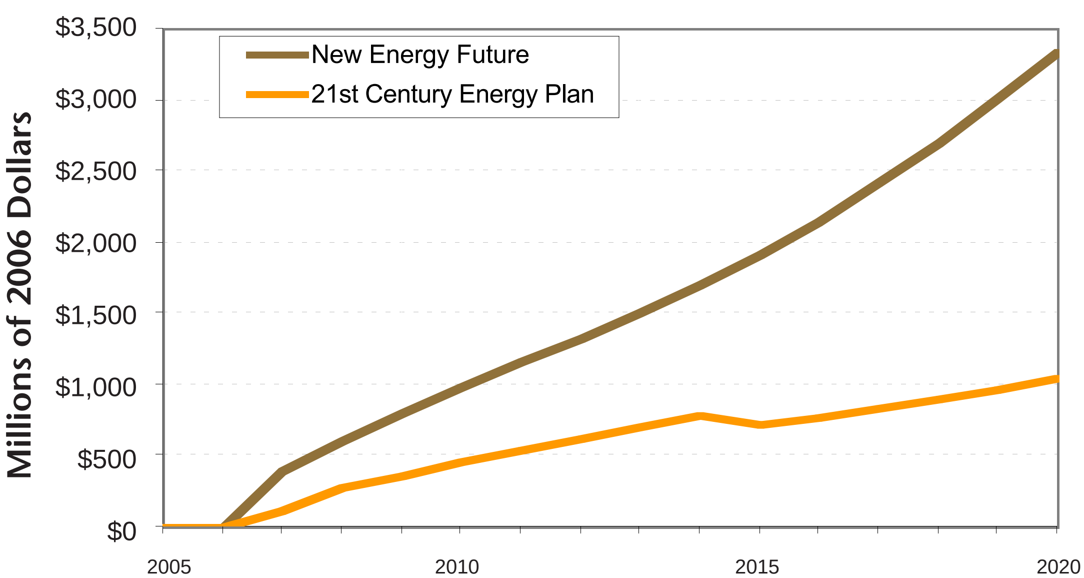
Any new coal-fired power plants will be built in the face of a clear scientific consensus that humans are causing global warming by burning fossil fuels. Regulations to limit and reduce global warming pollution are imminent—and they will make generating electricity from coal much more expensive.

There is growing consensus, even within the United States, that concerted action must soon be taken to curb global warming emissions. For example:

- In 2005, seven northeastern U.S. states reached an agreement on the Regional Greenhouse Gas Initiative (RGGI), a program designed to reduce carbon dioxide pollution from power plants.[18] Subsequently, Maryland adopted a law that joins Maryland to the RGGI pact and sets tougher emission limits on the seven dirtiest power plants in the state.[19]

Continued on page 17

Figure 2: Cumulative Net Wage Increase under New Energy Future and 21st Century Energy Plan (vs. Business as Usual)



Continued from page 16

- Governor Arnold Schwarzenegger of California (the state with the second-highest emissions of carbon dioxide) issued an executive order in 2005 setting a global warming pollution reduction target of 80 percent below current levels by 2050.[20] In September 2006, the state enacted a legally binding cap on emissions from the state's largest emitters.[21]

- In June 2005, the U.S. Conference of Mayors voted unanimously in favor of the Climate Protection Agreement, which matches the Kyoto Protocol's goal of reducing global warming pollution by 7 percent below 1990 levels by 2020.[22] The Conference represents 1,183 cities from all 50 states, including Detroit, Grand Rapids, Warren, Flint, Sterling Heights, Lansing, Ann Arbor, and more.

- Legislation is pending in the 2007 United States Congress that would significantly limit global warming pollution from power plants and other sources across the United States. The pending bills require pollution reductions as deep as 80 percent below 1990 levels by mid-century.[23]

Companies that choose to move forward with coal-fired plants in the face of this knowledge expose themselves, their shareholders and their ratepayers to a substantial economic risk. Owners of coal-fired power plants could be required to pay for the right to emit carbon dioxide into the environment—either through a carbon tax designed to reduce emissions or through the purchase of pollution permits. In either case, the cost of producing electricity from coal-fired power plants would increase and the value of those plants would decline relative to other, less carbon-intensive forms of generation.

Another possible scenario is that coal-fired power plant owners would be required to install equipment to capture and store carbon dioxide emissions from the plant. Such investments are likely to be very expensive. The Electric Power Research Institute (EPRI) estimates that energy from a conventional coal-fired power plant would cost 77 percent more with carbon capture and storage.[24] Even energy from an IGCC coal plant, the type of plant best suited for carbon capture, would cost over a third more with carbon storage. Moreover, carbon storage—on the scale at which it must be implemented to fight global warming—is an immature technology with serious questions about its future viability. As of 2006, there are only 21 demonstration projects in the world, and not one of them is large enough to store the lifetime emissions of even one power plant.[25]

In October 2006, the government of the United Kingdom released a report concluding that each metric ton of carbon dioxide released causes a minimum of $160 worth of damage to the world economy.[26] If these costs were included when investors and utilities were making decisions about how to spend their money, coal would immediately become too expensive to consider (with added costs close to 14 cents per kWh).

In contrast, clean energy options do not emit carbon dioxide and thus would shield Michigan from the economic risk of future regulation of global warming pollution.

Clean Energy Creates Skilled, High-Paying Jobs

Investment in renewable energy and energy efficiency directly creates quality jobs in manufacturing, construction and building trades, operation and maintenance, and finance.

Manufacturing

Michigan's well-developed industrial base makes it an ideal site for manufacturing energy efficient products and components for renewable energy systems.

Energy efficiency programs require technologies that use less energy, and companies employ people to design and manufacture those technologies. Opportunities for more energy efficient products encompass nearly the entire spectrum of manufacturing. Companies could produce energy efficient lighting systems, dishwashers, power supplies, windows, industrial motors, electronic controls and countless other energy-using products. By increasing demand for these types of products, energy efficiency programs can directly create manufacturing jobs.

For example, Michigan is home to Insulspan, a manufacturer of insulated panels used to make housing and buildings more efficient to heat and cool. The company employs about 100 people in Blissfield.[27]

Similarly, renewable energy systems require highly skilled manufacturing workers who design and build components of wind turbines, solar panels and other technologies.

Much of the work involved in creating a wind farm goes into manufacturing components, which include rotor blades, structural towers, hubs, transmissions, generators and assorted electronic controls. According to a survey of wind energy companies by the Renewable Energy Policy Project (REPP) in 2001, manufacturing 10 MW of wind turbines requires a year of labor from 32 full-time workers.[28] For example, Kaydon Corporation, based in Ann Arbor and with plants in Muskegon, manufactures precision bearings used in mid- to large-sized wind turbines. Kaydon is North America's leading supplier of wind turbine bearings that are required for critical pitch, yaw, and gearbox applications.[29]

Similarly, much of the work behind solar energy involves manufacturing. Building a photovoltaic panel requires creating cells from silicon and glass, installing wires and other electrical components, and assembling them into a unit. According to a 2002 analysis by University of California-Berkeley Professor Daniel Kammen, by the end of the decade, manufacturing a megawatt of solar photovoltaic panels will require nearly six full-time employees working for a year, given likely improvements in economies of scale and manufacturing technology.[30]

Michigan is home to two of the world's most important solar-related manufacturing companies: United Solar Ovonic and Dow Corning's Hemlock Semiconductor.

United Solar Ovonic operates the world's largest thin-film solar photovoltaic manufacturing facility in Auburn Hills. The facility uses a process analogous to printing a newspaper to layer very thin solar photovoltaic cells on a thin sheet of steel over a mile long, which is then assembled into panels. The company predicts that the scale and efficiency of this process will lower the cost of their solar panels far below conventional solar materials and reach cost competitiveness with fossil fuels.[31] As of the end of 2006, the company is capable of manufacturing 58 MW worth of solar capacity per year.[32] The company currently employs over 400 people in Michigan.[33]

To meet the rapidly expanding demand for solar panels, United Solar Ovonic plans to more than quadruple its manufacturing capacity by 2010.[34] The company selected Greenville, Michigan as the site for its third manufacturing plant.[35] The new 50 MW facility will create 200 direct jobs in Greenville, and pave the way for the potential for up to 1,000 additional jobs as the company continues to expand.[36]

Hemlock Semiconductor, based in

Hemlock and owned by Dow Corning, is the world's leading producer of polycrystalline silicon, a primary ingredient in solar panels. Hemlock expects the solar industry to grow by more than 20 percent per year over the next decade.[37] Driven by this growth, the company began an expansion of its headquarters facility at the end of 2005, increasing its manufacturing capacity by 50 percent.[38] The expansion will create approximately 150 full-time jobs and an equal number of contractor positions, plus employ 400 people during construction.[39] Upon completion of the project in 2008, Hemlock will employ about 500 people directly, and support 600 contractors.[40]

By increasing local demand for renewable energy and energy efficient products, Michigan could create and enhance the opportunity for new companies to locate facilities in Michigan while bolstering the state's existing clean energy businesses. The state has a well-developed industrial base and access to ports on the Great Lakes—assets that could attract manufacturers interested in tapping into the regional and global clean energy market. For example, the Spanish wind turbine manufacturing company Gamesa located its U.S. headquarters in Pennsylvania in part because of the state's commitment to renewable energy, as well as its strategic location.[41]

However, to take into account the fact that economic activity for manufacturing is not necessarily tied to Michigan, we assume that 80 percent of all expenses for clean energy programs, including energy efficiency programs, renewable energy financing and ongoing operation and maintenance, will be local. (See Methodology for more details.)[42]

Building Trades, Construction and Installation

Installation of energy efficiency measures and renewable energy facilities typically involves local construction firms and general contractors, boosting local economies.

Energy efficiency programs increase the demand for builders, general contractors and energy service companies to install and maintain energy efficiency measures. For example, architecture and design firms help plan energy efficient structures. Consulting firms help businesses meet building codes. Energy service companies provide a wide range of energy-related services, from identifying efficiency opportunities to facilities management. Engineering firms create technical solutions. Contractors provide installation and service for heating, ventilation, air conditioning, and refrigeration systems. All of these activities support jobs.

Similarly, wind farm installation also requires local workers. Large wind farms can need up to 300 workers on site during construction. These workers assemble turbines, erect towers, pour concrete, build roads, and lay cable.[43]

For example, Noble Environmental Power is building a wind farm in Huron County in Michigan's thumb. The project broke ground in 2006. In the first phase, the company is building 32 wind turbines, creating about 200 jobs during construction.[44] Over the next few years, the wind farm will expand to well over 100 turbines, creating additional jobs.[45]

Operation and Maintenance

The operation and maintenance needs of a wind farm or a biomass facility create permanent, high-quality local jobs ranging from servicing turbines to accounting.

Wind farms need staff to operate and regularly service the turbines throughout their roughly 30-year lifetimes. A recent survey of large wind farms in Texas found that every 100 MW of capacity requires six full-time employees to operate, monitor, and service the turbines.[46] The first phase of the Noble Thumb Windpark in Huron County will create 10 full-time operation and maintenance jobs.[47]

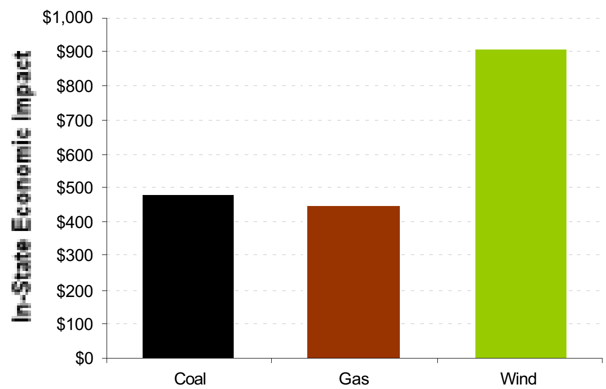
Spillover Effects

Each dollar spent on renewable energy creates impacts that ripple outward through

Renewable Energy Facilities Have Larger Direct Economic Impact than Coal or Gas-Fired Power Plants

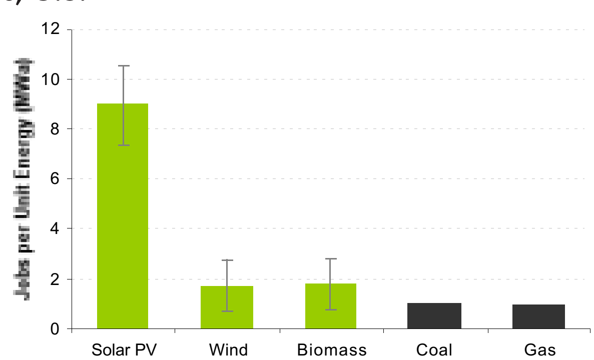
The National Renewable Energy Laboratory found that a wind farm in Michigan has about twice the direct economic impact of an equivalent coal or gas-fired power plant. (See Figure 3.) Much of the benefit stems from the fact that for gas or coal, more of the investment ends up leaving the state for fuel purchases. Additional benefits arise from the fact that wind facilities require more land than traditional power plants, and thus pay a proportionally larger share in property taxes. Wind facilities also provide more economic impact during construction than either coal- or gas-fired plants.

Figure 3: Direct Economic Impact of Equivalent Electric Generation from Wind, Gas and Coal Power Plants in Michigan[48]



Similarly, a variety of studies confirm that renewable energy generates more jobs per unit of energy produced than fossil-fuel technologies—even when looking at the U.S. economy as a whole.[49] (See Figure 4.) The data in Figure 4 include consideration of jobs all across the U.S. (like fuel processing), and not just in a single state.

Figure 4: Jobs per Unit of Energy from Renewable and Fossil Technologies, U.S.[50]



the local economy, extending far beyond the direct creation of jobs at energy facilities.

For example, workers at a manufacturing plant need raw materials and equipment. Their work in assembling turbines supports jobs in equipment manufacturing and component supply. Contractors at a construction site need concrete and heavy equipment, and their work supports additional jobs supplying these needs. In addition to these indirect jobs, workers spend some of their wages in the local economy, purchasing goods and services like groceries and housing, supporting additional workers.

Consumer Savings

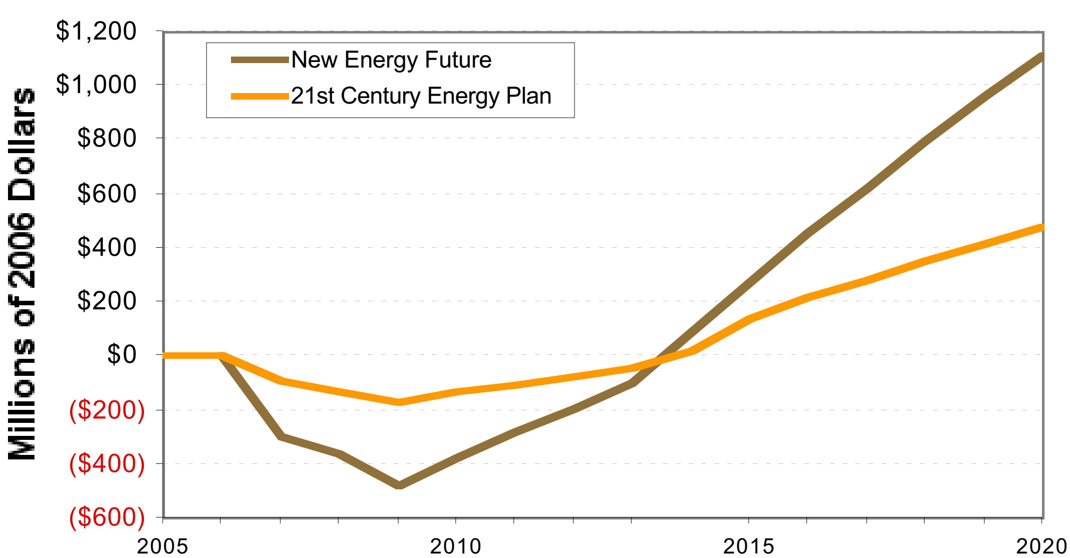
Clean energy saves consumers money on their electricity and gas bills, particularly in the long run. As a result, people have extra money to spend, which can stimulate Michigan's economy and create jobs. This effect accounts for much of the economic stimulus documented in this report.

Both the 21st Century Energy Plan and the New Energy Future scenario would save Michigan residents and businesses substantial amounts of money compared to business as usual. Under the New Energy Future scenario, cumulative consumer savings on energy through 2020 would total \$2.2 billion, while under the 21st Century Energy Plan, consumer savings would reach \$1.2 billion.

While the New Energy Future scenario requires a greater up-front commitment of resources, it also delivers greater benefits down the line. In 2020, the New Energy Future scenario would be delivering over \$1 billion in energy savings per year.

In 2014, the annual savings under the New Energy Future scenario would begin to exceed those available under the 21st Century Energy Plan. (See Figure 5, which shows the course of consumer savings, reflecting an initial investment in clean energy technology, followed by big dividends in the years to come as Michiganders are able to achieve more with less energy.) After 2018, the cumulative savings under the New Energy Future scenario would exceed the 21st Century Energy Plan, growing rapidly thereafter.

Figure 5: Net Annual Consumer Savings under New Energy Future and 21st Century Energy Plan (vs. Business as Usual)



Under the New Energy Future, the average Michigan residential electricity customer would be saving more than $85 per year on electricity in 2020, compared to the business-as-usual course.[65] Michigan's commercial and industrial electricity consumers would save money, too. In 2020, businesses and industry would altogether save more than $760 million on electricity bills under the New Energy Future. Under the 21st Century Energy Plan, savings in the year 2020 would be about 57 percent less—but still substantially greater than under business-as-usual conditions.

Much of the savings stem from energy efficiency programs, which help consumers use less energy—directly translating into smaller energy bills.

Energy efficiency and renewable energy have broader benefits for everyone who uses energy—through indirect effects on the price of energy. First, energy efficiency programs and renewable energy can reduce peak demand for electricity, reducing the

Renewable Energy Can Stimulate Rural Economies

Local Jobs

Renewable energy installation can create jobs in rural parts of the state. Wind farms in particular are often located in places where local economies depend on farming or resource extraction. Local jobs include construction and facility installation, operation and maintenance of the facility after it is constructed, and jobs induced by the additional money the workers spend in the local economy.

Landowner Royalties

Rural landowners who lease their property for a wind facility can create an additional source of income. Unlike the income from a typical harvest, payments from wind energy are steady and year-round. The Union of Concerned Scientists estimates a typical farmer or rancher with good wind resources could increase the economic yield of their land by 30-100 percent.[51]

Lease terms vary, but they typically represent 2.5 percent of gross revenue from electricity sales.[52] Assuming a contract price for electricity generated from wind power of 3 ¢/kWh, a single 1.5 MW turbine would bring the landowner $3,285 each year.[53] For example, the initial 32 wind turbines at the Noble Thumb Windpark in Huron County will generate hundreds of thousands of dollars in easement payments to local landowners over 20 years.[54] In the case of land owned by a local government, leasing income could be funneled into local schools and services.

Under the New Energy Future scenario, energy produced by on-shore wind farms in Michigan through 2020 could supplement rural landowner income by about $60 million, benefiting farmers, other private landowners, and local and state government.[55] In contrast, the 21st Century Energy Plan projects a smaller amount of wind development, which would yield on the order of $30 million in landowner income through 2020.[56]

Local Tax Income

Renewable energy equipment will raise the property tax base of a county, creating

Continued on page 23

need to use the most expensive sources of electricity (such as a peaking natural gas power plant), and protecting electricity consumers from the impact of fuel price spikes. As a result, these programs can have a stabilizing effect on the overall price of electricity.

Second, both energy efficiency and renewable energy reduce the demand for natural gas and ease the upward pressure on natural gas prices. As a result, people and industries that depend on natural gas will have slightly smaller bills than without natural gas conservation efforts. These savings can then be reinvested in other parts of the economy, rather than spent on high-priced fuel imported from out of state. This additional spending creates jobs throughout the economy.

Reduced natural gas prices are especially important for industries like Dow Chemical that require natural gas as a raw material to manufacture products. Dow, based in Midland, Michigan, understands that

Continued from page 22

a new revenue source for education and other local government services. For example, the Noble Thumb Windpark in Huron County will generate more than $6.5 million in property tax revenues over 20 years.[54]

Under Michigan law, renewable energy equipment will not be required to pay property taxes until 2013. However, communities may negotiate "host fees" in lieu of property taxes. In the case of a Michigan wind farm, one renewable energy developer estimated that the fee could be in the range of around $5,000 per turbine per year.[57]

The New Energy Future scenario would funnel over $800 million into local government coffers through 2020.[58] (While the state has not yet developed any rules governing offshore wind farms, we assumed that offshore facilities would be taxed in a manner analogous to on-shore facilities for this estimate.) In contrast, the 21st Century Energy Plan projects less renewable energy deployment in Michigan, yielding an estimated property tax impact on the order of $470 million.[59]

Renewable energy can provide more local tax income, distributed across more Michigan communities, than traditional fossil-fuel technologies. Coal-fired power plants pay a proportionally smaller share in property taxes than renewable energy, because they require less land.[60] The National Renewable Energy Lab estimates that wind would provide about double the tax income as coal-fired plants in Michigan on an energy equivalent basis.[61]

Energy Crop Production

Using tree trimmings for energy, or specifically growing a crop for energy on a plot of land, can also help advance the economies of rural parts of Michigan.

For example, the Oak Ridge National Laboratory estimates that planting and harvesting 188 million dry tons of switchgrass, an energy crop, would increase total U.S. farm income by $6 billion.[62] Michigan has at least 8 million acres of land suitable for growing switchgrass or woody crops like willow or poplar.[63] In contrast, for traditional energy technologies, Michigan has to import 100 percent of its coal and uranium, 96 percent of its oil, and 75 percent of its natural gas—sending valuable resources out of state.[64]

energy efficiency is an important part of a strategy to bring down gas prices and thus the cost of producing products.

Recent studies estimate that for every 1 percent reduction in national natural gas demand, natural gas prices fall by 0.8 percent to 2 percent below forecast levels.[67] Modeling the impacts of a hypothetical national renewable energy standard and energy efficiency effort in effect starting in 2003, the Lawrence Berkeley National Laboratory found natural gas bill savings with an estimated net present value as high as $73 billion through 2020.[68] The Midwest Natural Gas Initiative, coordinated by the Midwest Energy Efficiency Alliance (MEEA), has a goal of decreasing natural gas consumption by 1 percent per year for five years in eight Midwestern states. According to an analysis by the American Council for an Energy Efficient Economy, doing so will decrease wholesale natural gas prices by as much as 13 percent.[69] If the initiative is successful, the net economic savings to Michigan customers will be $745 million by 2010 along with creating an estimated 5,170 new jobs and $130 million in additional employee compensation.[70]

Reduced natural gas demand driven only by the state-level New Energy Future policy evaluated in this report would produce a more modest reduction in gas prices, producing savings in Michigan with a cumulative value on the order of $210 million between 2007 and 2020 (non-discounted, and excluding any electricity price reduction that could occur as a secondary result). In contrast, the 21st Century Energy Plan would produce non-electricity natural gas savings on the order of $90 million.

"We can't wait much longer for increased energy efficiency in this country."

— Peter Molinaro,
Vice President of Federal and State
Affairs, Dow Chemical, January 2005[66]

Economic Output

Economic output is often measured by Gross State Product (GSP). GSP represents the market value of all final goods and services produced within a state in a given period of time—or the sum of value added by all consumption, investment, government spending and exports, minus imports.

While GSP can capture some important trends in describing the economy, it is not necessarily a good measure of public welfare and prosperity. For example, rebuilding after a natural disaster could produce a lot of economic activity—but natural disasters typically cause more harm than good. Similarly, building a new coal-fired power plant requires a lot of capital investment and thus has a positive effect on GSP.

In contrast, strong energy efficiency programs transfer investment away from new coal-fired power plants and put some of that money back in Michigander's pockets—where it can have a real impact in people's daily lives.

The effect of energy efficiency programs on GSP depends on assumptions of the fraction of energy bill savings that will be re-spent within Michigan's economy, as opposed to spent out-of-state. If more energy bill savings stay within Michigan, the positive impact on GSP will be larger.

We assume that 80 percent of energy bill savings will be re-spent in the Michigan economy. Using this assumption, the New Energy Future scenario effectively results in no net change in GSP through 2020. In the first few years of the New Energy Future scenario, initial investments in renewables and efficiency programs will have a large net positive effect on GSP.

However, as efficiency programs begin to have an effect, they will reduce the overall amount of money going into the electric utility sector of Michigan's economy, reducing the overall amount of capital invested in new power plants, and thus lowering GSP. In comparison, the 21st Century Energy Plan, would increase Michigan's GSP by a cumulative net of $80 million through 2020 (vs. business as usual). (See Figure 6.)

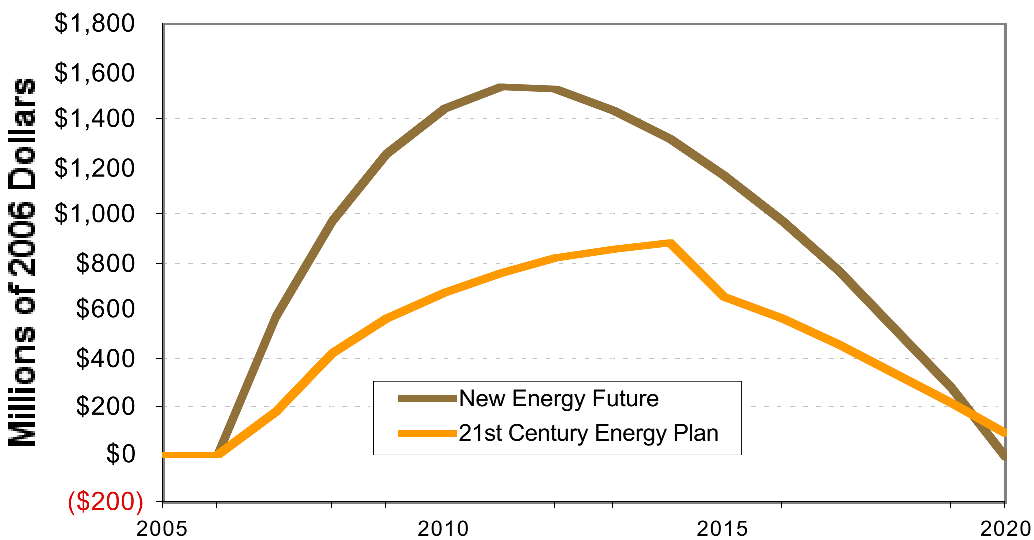
Other studies that include a larger geographic area (such as the entire Midwest or the U.S. as a whole) capture a higher fraction of re-spending and show large GSP benefits. (For examples, see *Clean Energy Policies Benefit the Economy* on page 14.) Should more than 80 percent of the money spent stay in Michigan, the GSP benefits of Michigan's clean energy policies would be greater.

To put this in perspective, these net changes in GSP are small compared to overall Michigan GSP. The U.S. Department of Energy forecasts that, under business-as-usual conditions, Michigan GSP will reach $567 billion by 2020. The change in GSP modeled in the 21st Century Energy Plan is relatively small—on the order of 0.01 percent of total GSP in 2020.

Michigan can work to increase its GSP by encouraging neighboring states to adopt their own clean energy strategies, and using incentives to develop Michigan into a regional manufacturing center for efficient technologies and renewable energy components. By harnessing its manufacturing base and shipping advantages to produce clean energy technology for other markets, Michigan can expand the economic benefits of clean energy.

For example, a 2001 report by the University of Illinois' Regional Economics Application Laboratory evaluated the economic impact of a Midwest regional strategy to eliminate growth in electricity demand and increase the use of renewable energy and efficient combined heat and power facilities. The report found that Michigan's GSP would increase substantially, growing $3.4 billion by 2020.[71]

Figure 6: Cumulative Net Impact of the New Energy Future Scenario and the 21st Century Energy on Gross State Product (vs. Business as Usual)



Reduced Pollution

In addition to economic benefits and monetary savings, investing in energy efficiency and renewable energy would reduce global warming and help create a cleaner, healthier future for Michigan. Following the New Energy Future scenario would significantly reduce emissions of carbon dioxide, the leading cause of global warming, as well as speed progress in reducing soot, smog and mercury pollution, which damage public health. Table 4 summarizes the pollution prevention impacts of the New Energy Future scenario and the 21st Century Energy Plan.

Reduced Global Warming Pollution

Global warming poses a serious challenge to Michigan's future. Scientists have concluded that pollution caused by human activity is driving a warming trend now apparent across the globe.

The consensus view of the scientific community is that most of the global warming that has occurred is directly due to human activities, particularly the burning of fossil fuels. Fossil fuel combustion releases carbon dioxide, which traps solar radiation reflected from the earth's surface that normally would escape back to space. Carbon dioxide levels in the atmosphere are now increasing faster than at any time in the last 20,000 years, and are likely higher now than at any point in the last 20 million years.[72]

Average temperatures worldwide have risen by about 1.4° F in the past century and now are increasing at a rate of about 0.36°F per decade.[73] The 10 warmest years in the global record have all occurred since 1990, and 2006 was the warmest year to date in the lower 48 states.[74]

Already, warming-induced changes are visible in Michigan. Before 1980, Grand Traverse Bay froze during most winters (85 percent). However, since 1980 the bay is freezing over only approximately 20 percent of the time.[75] Spring is arriving sooner, cherry trees are blooming about a week earlier, and Canada geese are shifting their migration patterns.[76] Worldwide in the last half of the 20th century, 1,700 plant, animal and insect species shifted toward the earth's poles at an average rate of about 4 miles per decade.[77]

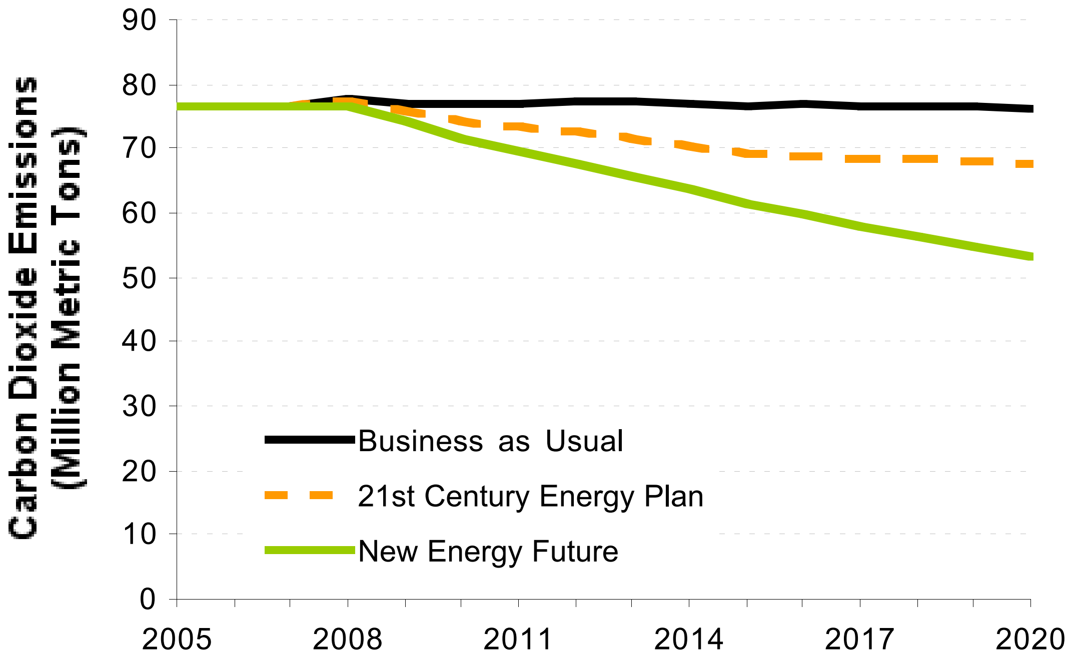
In Michigan, scientists predict that summer temperatures could be 7° to 10° F warmer than today by the year 2100.[78] The number of days in Detroit with highs of 90° F or warmer could double or triple (reaching 30 to 50 days per year).[79]

Warming on such a scale would have serious consequences for Michigan and the world. For example, a recent update to a Lake Erie management plan predicts global warming will lead to a steep drop in water levels over the next 64 years, a change that could cause the lake's surface area to shrink by up to 15 percent.[80] Worldwide, global warming could create hundreds of millions of refugees fleeing flooding or

Table 4: Cumulative Pollution Prevention Impact of the 21st Century Energy Plan and New Energy Future Scenario vs. Business as Usual (2007-2020)

Measure	21st Century Energy Plan	New Energy Future Scenario
Avoided Global Warming Pollution (CO_2)	70 million metric tons	170 million metric tons
Avoided Smog-Forming NO_x Emissions	40,000 tons	90,000 tons
Avoided Soot-Forming SO_2 Emissions	120,000 tons	260,000 tons
Avoided Mercury Pollution	450 pounds	1,000 pounds

Figure 7: Effect of the New Energy Future Scenario on Global Warming Pollution from Electricity Generation in Michigan



drought and permanently reduce global economic output by 20 percent per year, or roughly $7 trillion annually.[81]

The government of the United Kingdom recently estimated that each metric ton of carbon dioxide released causes a minimum of $160 worth of damage worldwide.[82] Left unchecked, global warming will impose serious costs on Michigan and the U.S. as a whole.

On average, each megawatt-hour of electricity generated in Michigan produces about 1,440 pounds of carbon dioxide.[83] Under business-as-usual conditions, Michigan's electricity sector will continue to emit substantial amounts of carbon dioxide pollution into the future.

In contrast, the New Energy Future scenario would reduce carbon dioxide emissions from electricity generation in Michigan by about 30 percent in 2020—preventing 22 million metric tons of carbon dioxide emissions in that year. The New Energy Future scenario would be more than twice as effective as the 21st Century Energy Plan in preventing global warming pollution in Michigan. (See Figure 7.)

Emissions cuts on this scale would put Michigan well on the road to doing its fair share to mitigate the worst effects of global warming—which will require cuts in carbon dioxide emissions on the order of 50 percent worldwide by 2050 (and up to 80 percent in the U.S. as the world's largest emitter).[84]

Reduced Soot and Smog

Coal and natural gas-fired power plants emit air pollution. For every megawatt-hour of electricity generated, the average Michigan power plant emits 6.5 pounds of soot-forming sulfur dioxide and 2.2 pounds of smog-forming nitrogen oxides.[85] Partially because of this pollution, 25 counties across Michigan do not meet health-based air quality standards for smog, and 7 counties in southeast Michigan do not meet standards for soot.[86]

Sulfur dioxide emissions from coal-fired power plants form fine soot particles in the atmosphere. When inhaled, these particles become lodged deep in the lungs where they cause a variety of health problems, including asthma, bronchitis, lung cancer and heart attacks.[87] Soot pollution from power plants is responsible for significant harm to public health in Michigan. According to a study by Abt Associates, a frequent consultant to the U.S. EPA, soot in Michigan cuts short the lives of nearly 1,000 people, and causes more than 24,000 asthma attacks and more than 140,000 missed work days due to respiratory illness annually.[88]

Fossil-fueled power plants also emit nitrogen dioxide, one of the primary ingredients in smog. Smog makes lung tissues more sensitive to allergens and less able to ward off infections.[89] It scars airway tissues.[90] Children exposed to smog develop lungs with less flexibility and capacity than normal. During high smog days, otherwise healthy people who exercise can't breathe normally.[91] Over time, smog exposure can lead to asthma, bronchitis, emphysema and other respiratory problems.[92]

Health problems imposed by soot and smog have serious economic consequences for Michigan. Beyond the loss of priceless years of healthy life, an unhealthy workforce is less productive.

Soot and smog pollution from power plants are projected to decrease in the coming years because of implementation of the Clean Air Act. However, the New Energy Future scenario will reduce soot and smog emissions even further:

- By 2020, the New Energy Future scenario would reduce smog-forming nitrogen dioxide emissions by nearly 11,000 tons per year vs. projected levels, a decrease of about one-third.

- It would also avoid over 30,000 tons of soot-forming sulfur dioxide emissions, also a reduction of about one-third vs. projected levels.

- These pollution reductions are more than double what would be achieved under the 21st Century Energy Plan.

Reduced Mercury Deposition

Mercury emissions from coal-fired power plants and other industrial sources are making the fish in our lakes, rivers and streams unsafe to eat. Burning coal releases mercury into the air that eventually contaminates rivers and lakes, where bacteria convert it to a highly toxic form that bioaccumulates in fish.

In early 2007, two new studies of mercury deposition in the Northeast confirmed that U.S. coal-fired power plants are the chief cause of mercury contamination "hot spots."[93] The studies show that "mercury deposition is five times higher than previously estimated by EPA" in the area surrounding a coal plant in southern New Hampshire.[94] Dr. Thomas Holsen of Clarkson University and one of the study authors remarked that "a significant fraction of the mercury emitted from coal-fired power plants in the U.S. is deposited in the area surrounding the plants." Dr. Charles Driscoll, another study author, noted that "biological mercury hotspots occur and … mercury emissions from sources in the U.S., as opposed to China and other countries overseas, are the leading cause." This new research suggests that coal-fired power plants in Michigan (as opposed to those from out of state) may have a greater role in mercury deposition in the state's waterways than previously suspected.

Mercury is a neurotoxin that is particularly damaging to the developing brain. In early 2004, EPA scientists estimated that one in six women of childbearing age in the U.S. has levels of mercury in her blood that are sufficiently high to put one in six babies born each year at risk of learning disabilities, developmental delays and problems with fine motor coordination, among other problems.[95]

In 2000, Michigan's coal-fired power plants emitted more than 2,600 pounds of mercury.[96] This pollution has led to elevated levels of mercury in the fish in Michigan's waters.

U.S. EPA tested fish across the country for mercury content in 1999. Every fish caught in Michigan contained mercury, with more than half exceeding the EPA "safe limit" for women of childbearing age.[97] Because of the danger of mercury exposure, the Michigan Department of Community Health has issued a fish consumption advisory for all inland lakes in Michigan. The department warns that children under 15 and women of childbearing age should not eat more than one meal per month of rock bass, perch, crappie, largemouth bass, smallmouth bass, walleye, northern pike or muskie from any of Michigan's inland lakes; and no one should eat more than one meal per week of these fish.[98]

On April 17, Gov. Granholm announced a new requirement for power plants to reduce mercury emissions by 90 percent by 2015, a step that, if implemented correctly, will clean up Michigan's waterways and protect the health of Michigan families. However, clean energy can reduce mercury emissions even further.

The New Energy Future scenario would prevent about 70 pounds of mercury emissions in 2020, while the 21st Century Energy Plan would prevent on the order of 30 pounds. Depending on how fast Michigan power plants comply with the 90 percent reduction rule, the cumulative mercury pollution prevention under each scenario through 2020 could be on the order of 1,000 pounds and 450 pounds, respectively.

Nuclear Power is too Expensive and too Dangerous to Consider

The chief executive of DTE (parent of Detroit Edison), Anthony Earley, has suggested that Michigan might need a new nuclear power plant to meet future electricity demand.[99] While nuclear power is able to generate electricity with relatively little air pollution, the problems with nuclear power, explored below, make it an inappropriate solution to the global warming and health-threatening pollution problems associated with coal.

- **Cost** – Nuclear power has proven to be expensive due to the high cost of building, maintaining and decommissioning nuclear reactors. But looking only at market costs obscures the more than $100 billion spent by U.S. taxpayers for research and development, protection against liability from accidents, and other subsidies for nuclear power.[100] Without these ongoing subsidies, the nuclear industry would likely not exist.

- **Accident risk** – In the short history of nuclear power, the industry has experienced at least two major accidents—at Three Mile Island and Chernobyl—that endangered the health of millions of people.[101] While the United States has thus far been spared an accident of the scale of Chernobyl, there have been numerous "near-misses." For example, in 2002, inspectors discovered a football-sized cavity in the reactor vessel head of the Davis-Besse nuclear reactor in Ohio. The damage was overlooked in previous inspections and went unnoticed for six years, despite similar damage occurring at other nuclear plants. According to a study performed by the Oak Ridge National Laboratory, the reactor vessel could have breached in as little as two months, potentially causing a core meltdown worse than Three Mile Island.[102]

- **Terrorism and sabotage** – In 2005, the National Academy of Sciences found that a terrorist attack aimed at the spent fuel storage pools at a boiling water reactor could cause a large radiation release.[103] The security record of nuclear power plants is far from reassuring. In tests at 11 nuclear reactors in 2000 and 2001, mock intruders were capable of disabling enough equipment to cause reactor damage at six plants.[104] A 2003 General Accounting Office report found significant weaknesses in the Nuclear Regulatory Commission's oversight of security at commercial nuclear reactors.[105]

- **Nuclear waste** – Spent nuclear fuel is one of the most dangerous substances ever created by mankind. It remains highly radioactive for hundreds of thousands of years and would cause extensive public health damage if released into the air after an accident or terrorist attack.

Continued on page 31

Continued from page 30

Nearly all U.S. nuclear reactors store waste on site, often in water-filled pools at densities approaching those in reactor cores. Should coolant from the spent-fuel pools be lost (as a result of earthquake, terrorist attack or human error), the fuel could ignite, spreading highly radioactive compounds across a large area. In 2005, the National Academy of Sciences warned that "[s]pent nuclear fuel stored in pools at some of the nation's 103 operating commercial nuclear reactors may be at risk from terrorist attacks."[106] One study estimated that such an event would result in between 2,000 and 6,000 additional deaths from cancer.[107] Evacuation costs could run into the tens of billions.

Michigan's four nuclear power plants have produced more than 1,600 metric tons of high-level radioactive waste.[108] In fact, in October 2005, a load of radioactive waste hung suspended on a stuck crane over a spent fuel pool at the Palisades nuclear reactor in Michigan. The Nuclear Regulatory Commission issued a small fine to Palisades for improperly managing the incident, increasing the risk that the load could have fallen and broken the storage container, releasing radioactive material into the air over the state.[109]

The federal government has proposed disposing of high-level waste at Yucca Mountain in Nevada. Even without the considerable safety issues raised by shipping the waste on public highways and the fact that Yucca Mountain can not safely contain the waste until it is no longer dangerous, this solution faces political obstacles that may well prove insurmountable.

- **Aging** – Continued operation of nuclear reactors beyond their initial projected 40-year lifespan could lead to unforeseen safety problems.[110] In 2001, the Union of Concerned Scientists identified eight instances in just the previous 17 months in which nuclear reactors were forced to shut down due to age-related equipment failures.[111]

For the last several decades, Michigan has relied upon nuclear power for more than 20 percent of its total electricity generation.[112] However, the operating licenses of the D.C. Cook nuclear reactors are scheduled to expire within the next 10 years, and the Fermi reactor is licensed through 2025.[113] These reactors should be shut down when their licenses expire, without extensions. In early 2007, the Nuclear Regulatory Commission approved a 20 year license extension for the Palisades nuclear reactor, past its originally scheduled expiration date of 2011.[114] Michigan leaders should protest the extension granted to Palisades—and Michigan should not build any new nuclear facilities. The potential costs of increased dependence on nuclear power are too large to justify.

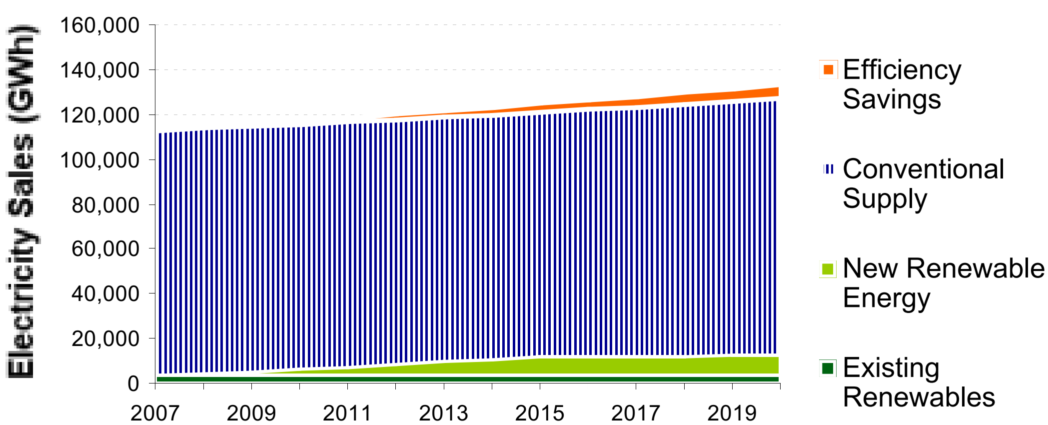
Michigan Can Meet its Electricity Needs with Efficiency and Renewables

Michigan has a vast strategic reserve of energy efficiency, plus ample potential to generate electricity from renewable sources of energy. Together, these resources are more than sufficient to make a new energy future for Michigan a reality.

Without action, experts predict that Michigan's need for electricity will grow by 1.3 percent per year for the next two decades.[115] By 2020, Michigan is expected to use over 23,000 additional gigawatt-hours (GWh) of electricity per year, with increased peak demand of more than 4,000 MW. To meet this demand, utility companies could choose to build several new coal-fired power plants.

If Michigan adopts a 21st Century Energy Plan that includes a small commitment to energy efficiency and renewable energy (specifically an efficiency program with initial funding of $68 million per year and a renewable energy standard of 10 percent by 2015), Michigan's electricity demand will

Figure 8: The 21st Century Energy Plan



continue to grow at about 0.9 percent per year, and the state will still need to build one or two new power plants, likely coal-fired, to meet future electricity needs.[116] (See Figure 8.)

However, instead of building new coal-fired power plants, Michigan could meet its energy needs with a visionary New Energy Future scenario. Starting with a well-designed energy efficiency program, Michigan could stabilize electricity demand and eliminate the need to build new coal-fired power plants. At the same time, Michigan could tap into its home-grown renewable energy resources, including wind and biomass energy, to ensure that 25 percent of the state's electricity comes from renewable sources by 2025. (See Figure 9.)

Energy Efficiency Can Eliminate the Need for New Coal

By investing in a well-designed energy efficiency program, Michigan can stabilize its demand for electricity and eliminate the need to build any new coal-fired power plants.

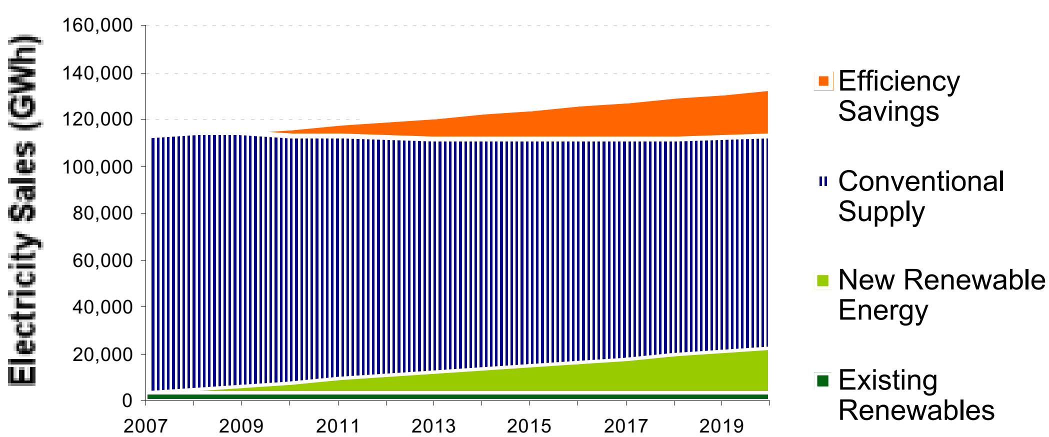
Energy Efficiency is Already a Key Part of the Economy

The most prevalent myth underpinning the energy debate across America is that a vigorous economy and sound standard of living can only be achieved through ever-increasing consumption of energy. The assumption that increasing energy consumption is a given leads to an errant focus on building additional generation.

However, using more energy is not the only option. Instead, we can reduce our consumption of energy dramatically—and we can do it without sacrificing our quality of life. America has already proven that it can be done.

In the late 1970s, improvements in energy efficiency—driven by a mix of higher energy prices and government programs such as tighter appliance and automobile efficiency standards—created conditions for both reduced energy consumption *and* robust economic growth. From 1979 to 1982, energy use in the U.S. declined each year, and energy consumption did not surpass its 1979 level again until 1988.[117] Over that nine-year period of 1979 to 1988, the nation's inflation-adjusted gross domestic product (GDP) increased by 30 percent.[118] Over the past two decades, America has consistently used less energy to produce

Figure 9: New Energy Future Scenario for Michigan



more economic wealth. In 1980, the U.S. used 15,000 BTU for every dollar in gross domestic product; by 2004, we were using only 9,300 BTU—a drop of more than one-third.[119]

Michigan Has Cost-Effective Potential to Use Electricity More Efficiently

The potential for additional energy efficiency improvements in Michigan is immense.

Michigan terminated its utility energy efficiency programs in 1996, prompted by the drive toward utility deregulation.[120] As a result, the state has passed up countless opportunities to tap into its reserves of energy efficiency over the past decade. Comparing Michigan with California gives some idea of what might be achieved. California leads the nation in effective implementation of energy efficiency. California was the first state to adopt energy efficiency standards for home appliances, has the nation's most stringent building energy codes, and has long had well-funded, aggressive programs for promoting energy efficiency.

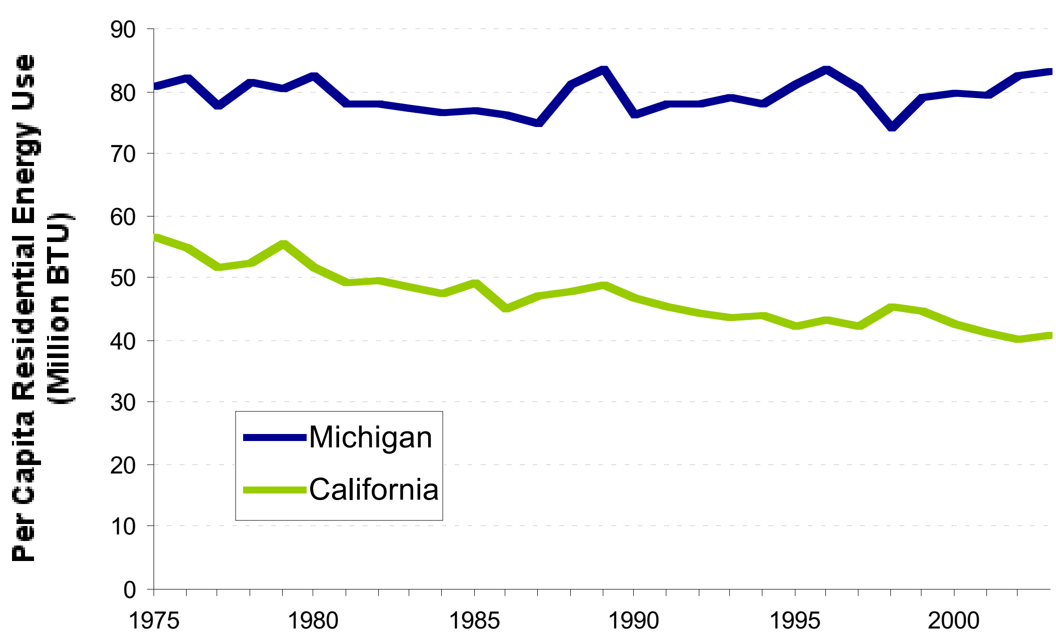
California's approach to energy efficiency has yielded results. For example, homes in California have become more efficient than perhaps anywhere else in the country. On a per capita basis, residential energy use in California declined by nearly 30 percent between 1975 and 2003. However, in Michigan, per capita residential energy use *increased* by 3 percent during the same period.[121] (See Figure 10.)

If Michigan had achieved the same per capita percentage reduction in residential energy use between 1975 and 2003 as California did, the state would have consumed more than 250 trillion BTU less energy in 2003. Moreover, total residential energy consumption in Michigan would have decreased by 20 percent.[122]

The gap between California and Michigan in per capita residential energy use represents a huge block of opportunity to reduce Michigan's overall energy consumption. Similar opportunities exist in the commercial and industrial sectors.

Members of the efficiency resource task force for Michigan's 21st Century Energy

Figure 10: Per-Capita Residential Energy Use in Michigan and California



Plan estimate that the state could cut demand growth by more than half with energy efficiency, saving 8,470 GWh after ten years of spending an average of $146 million per year.[123] By 2020, they estimate the state could reduce its energy demand by 9 percent vs. projected levels.[124]

However, analyses of achievable (not just cost-effective) potential for energy efficiency suggest that this is an underestimate. Reviewing a set of leading recent studies on achievable efficiency potential nationwide, the American Council for an Energy Efficient Economy concludes that the typical state could achieve energy savings of 24 percent below forecast levels within 20 years.[125] Other analyses suggest that there are enough cost-effective efficiency resources to reduce electricity demand by as much as 35 percent by 2020.[126] For example, a recent estimate of energy efficiency potential in Mountain West (where, like in Michigan, funding for efficiency programs has been relatively low) concluded that six states from Arizona to Wyoming could reduce projected electricity demand by 33 percent by the year 2020 (or close to 100,000 GWh/year).[127] The benefits of this approach would include net savings on electricity and fuel of $28 billion and avoid the need to build 34 power plants (500 MW).

In order to halt growth in electricity demand, Michigan would need to reduce demand for electricity by about 16 percent vs. projected levels in 2020.[128] Given Michigan's lack of investment in efficiency programs over the last decade, this level of savings should be achievable with a well-designed efficiency program.

Efficiency measures are much cheaper than generating and delivering electricity. In 2002, energy efficiency programs supported by public benefit funds in New England produced energy savings at an average lifetime cost of 2.4 cents per kWh.[129] Northeast Energy Efficiency Partnerships estimates that capturing all remaining achievable energy efficiency potential in New England would cost just 3.1 cents per kWh.[130] A study of potential efficiency measures in the Mountain West identified energy efficiency measures across all sectors of the economy that could result in electricity savings at an average cost of 2 cents per kWh (2000 dollars). The study concluded that the benefits of the efficiency measures exceeded their costs by more than 400 percent.[131] The Energy Efficiency Resource Task Force of Michigan's 21st Century Energy Plan estimates that over 8,000 GWh/year of energy savings in Michigan over the next ten years can be achieved at a lifetime cost of only 2.57 cents per kWh.[132] In comparison, the cost of generating and delivering electricity in Michigan is about 6 cents per kWh.[133]

Before Michigan canceled its utility energy efficiency programs, they were delivering similar results. In the early 1990s, efficiency programs in Michigan delivered savings at a cost of 1.5 to 2.6 cents per kWh—less than half of the cost of energy from new generation at the time.[134]

These estimates include only efficiency improvements that are *cost-effective* to the consumer in narrow economic terms—the inclusion of efficiency efforts that would be cost-effective to the state, factoring in environmental, public health and national security concerns, would likely be significantly higher. Moreover, the amount of energy efficiency that would be cost-effective to the consumer would increase significantly should fossil fuel prices continue to rise.

Energy Efficiency Programs Can Tap Into Michigan's Efficiency Potential

To tap into these resources, Michigan will need an effective energy efficiency program, in addition to policy changes that promote the penetration of efficient practices and technologies into the marketplace.

If consumers have access to products that use less electricity, they may be able to pay higher rates for the electricity those products consume and still emerge with lower overall bills. However, there are many well-documented market barriers that prevent consumers from taking advantage of these efficiency opportunities (including information barriers; split incentives between builders and homeowners and landlords and tenants, in which one buys the equipment and the other must pay operating costs; and the need to pay for improved energy efficiency up-front versus over time).

Efficiency programs are necessary to overcome these barriers. Well designed efficiency programs take these barriers head on—educating consumers, reducing split incentives, providing subsidies that reduce the up-front costs, and systematically driving the penetration of efficient technologies into the marketplace where they can make the greatest difference.

Supplemented with policy changes like appliance efficiency standards, updated building codes and related measures, efficiency programs can produce dramatic results. (See "Efficiency Vermont" on page 37.)

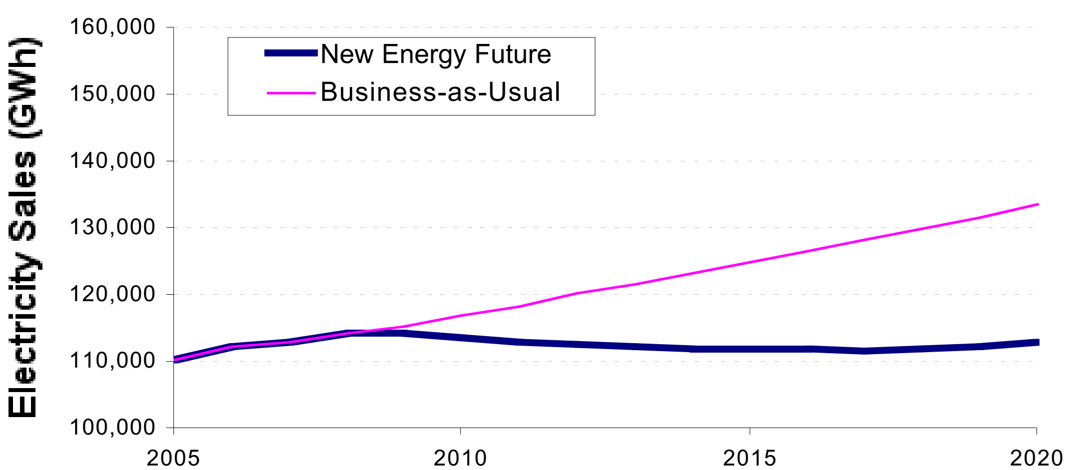
Assuming that Michigan can achieve energy savings at an average cost of 3 cents per kWh, and that efficiency measures have an average lifetime of 15 years, we estimate that the state will need to invest $225 million per year in efficiency programs in order to level off energy demand. (See Figure 11.) That investment could come directly through a utility-run energy efficiency program, or indirectly through policy changes like increased building and appliance efficiency standards. To put this level of spending in perspective, $225 million equates to about 3 percent of total electric utility revenue in Michigan, which is on par with spending levels in states with good energy efficiency programs.[135]

Michigan Can Generate Energy from Home-Grown Renewable Resources

After decades of anticipation, research and study, renewable energy has arrived and is ready to play a leading role in solving Michigan's energy problems. The state has enough cost-effective renewable energy resources to dramatically increase the amount of renewable electricity it generates and consumes.

In terms of raw potential, renewable resources in Michigan—including wind, biomass and solar power—could theoretically generate more electricity than the state currently uses. (See Table 5.)

Figure 11: Projected Effect of Funding Energy Efficiency Programs at $225 Million / Year



Efficiency Vermont

Efficiency Vermont provides a great example of a successful and well-designed efficiency program. Efficiency Vermont is the nation's first statewide energy efficiency utility, specializing in assisting homeowners and businesses to identify and take advantage of cost-effective energy saving opportunities with technical assistance and financial incentives.

Efficiency Vermont is funded by a surcharge on consumers' electricity bills. The funds are administered by an independent non-profit organization under contract to the Vermont Public Service Board, and all work undergoes independent financial and savings verification audits, ensuring that the public's money is being well spent.

In 2004, Efficiency Vermont worked with 12 percent of the state's electric ratepayers to complete efficiency investments that resulted in:[136]

- 58 million kWh of annual savings, achieved at 37 percent of the cost utilities would have paid to purchase that energy on the wholesale market and deliver it to customers; and

- Reducing growth in the state's energy needs by 44 percent and cutting summer peak energy demand by 9 MW.

The type of work Efficiency Vermont does is exemplified by the renovation of Enosburg Falls Middle and High School. Black River Design called on Efficiency Vermont to help optimize the energy efficiency of the project. Efficiency Vermont developed a design that capitalized on opportunities for cost-effective heating, ventilating, cooling and lighting—resulting in significant savings and a quality building. The school district spent $57,600, plus incentives from Efficiency Vermont totaling $62,000, and achieved annual energy cost savings of $32,600—a 56 percent return on the investment.

Table 5: Michigan's Renewable Energy Resources

Energy Source	Electricity Generation Potential (GWh / year)	Percent of Michigan's 2005 Total Energy Demand
Wind (Onshore, 50m, Excluding Class 3)	2,200	2%
Wind (Onshore, 50m, Including Class 3)	31,000	27%
Wind (Offshore)	150,000	130%
Biomass (Currently Available Stocks)	14,000	12%
Solar (PV panels on 7 percent of built-up land area)	38,000	33%

Wind

Until recently, the cost of renewable power has caused it to be rejected by utilities and regulators for most applications. Not any longer. In particularly windy areas of the country, wind power is already the cheapest electricity resource available.[137] For example, a recently constructed wind farm in Lamar, Colorado is producing electricity for less than 3.3 cents per kWh (with the benefit of the federal production tax credit).[138]

Michigan has significant wind energy resources on-shore. (See Figure 12.) The best areas for generating wind power on land can be found on islands, near the coasts, on the Thumb, and in the south central part of the state. While many of these areas may be excluded from wind development because of protected status, lack of accessible transmission infrastructure, or other reasons, Michigan's overall wind resource remains significant.

Based on an analysis of the wind resource at 50 meters elevation, immediately accessible areas with a resource of class 4 or greater could produce about 2,200 GWh per year.[139] However, modern wind turbine designs are now able to reach heights of 70 meters or higher, where the wind energy resource is typically greater. Michigan needs a more comprehensive analysis of the resource potential at these larger tower heights.

Again according to the analysis of potential at 50 meters, Michigan has wide areas with lower average wind speeds that should become commercially viable as technology improves. Including some of these areas (but excluding areas inappropriate for development) raises Michigan's on-shore wind energy potential to 31,000 GWh per year, or about 27 percent of Michigan's 2005 electricity consumption.[140] At a height of 70 meters or more, many of these areas should have higher wind speeds and be more immediately accessible with current wind turbine technology.

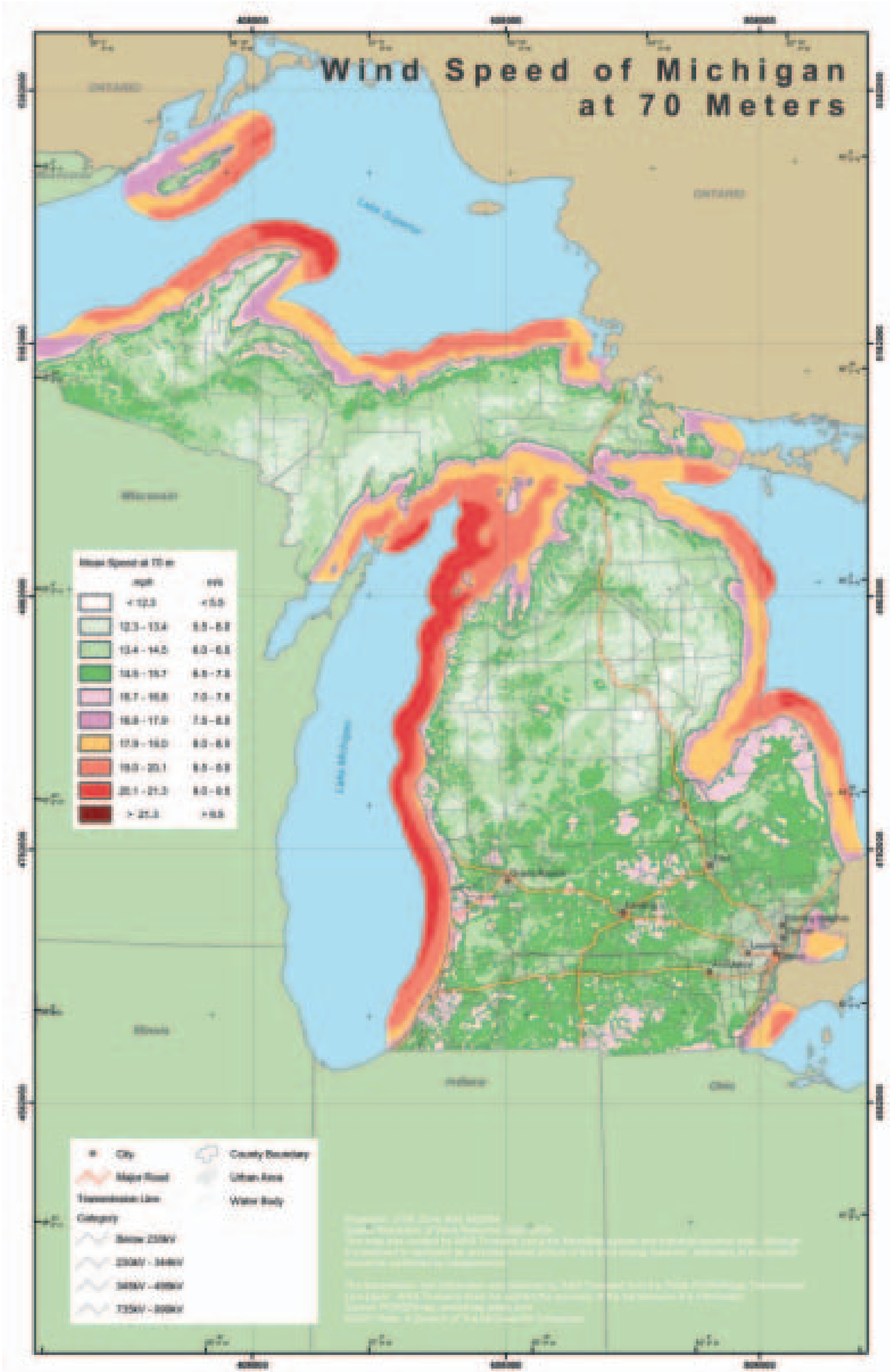
Michigan's best wind resources are located offshore, in the Great Lakes—including areas in Lake Michigan, Lake Huron and Saginaw Bay. (See Figure 12.) One estimate of Michigan's offshore wind resources (limited to currently identified areas at least 5 miles from shore, extending no further than 12 miles, and excluding protected areas) places offshore potential at 44 GW of wind turbines.[141] These facilities could produce around 150,000 GWh of electricity per year—more than the state of Michigan currently consumes in a year.[142] Estimates that include areas further out into the lakes, which are currently in process, could yield much larger resource potential.

While offshore wind energy technology is not as far along in development as onshore technology, it is growing in importance as a source of electricity worldwide. Offshore wind farms are already in operation in Denmark and other European countries, and several sites on the Atlantic and Gulf coasts are vying to become the first in America. In fact, a Canadian company based in Ontario has proposed a 710 MW wind energy project far offshore in Lake Huron.[143] If the project is approved, it could be operational during the year 2008. It would be one of the largest offshore wind energy projects in the world, and one of the largest wind farms in North America. According to the developer, Trillium Power, the project could spark the opening of new manufacturing plants in the region to supply wind turbines.[144]

Current technology makes shallow water the most cost effective location for offshore wind turbines, and new technologies are being developed to take advantage of wind in deeper waters. Although offshore wind energy in the Great Lakes could become viable much earlier, for the purposes of this analysis, we assume that offshore wind can begin to make a contribution to Michigan's electricity system starting in 2013.

Even though the wind doesn't necessarily blow all the time, wind power can make a valuable contribution to the overall electricity grid. Nations such as Denmark have

Figure 12: Michigan's Wind Energy Resources



shown that it is possible to obtain as much as 20 percent of their electricity supplies from the wind (and even more at certain times and places). And a recent study undertaken in Minnesota found that utilities can obtain up to one-quarter of their electricity from wind without harming grid reliability, and with only minor costs for absorbing the intermittent power.[145]

Biomass

Biomass energy also can help Michigan meet its energy needs. Already, biomass is the largest source of renewable energy in the U.S., due largely to the use of ethanol in motor fuel and production of electricity from forest product industry wastes.[146] It is estimated that energy crops could ultimately provide up to 14 percent of U.S. electricity (or 13 percent of motor fuel), while at the same time bolstering the health of rural economies.[147]

Michigan ranks 16th in the country in the availability of inexpensive biomass stocks, according to a survey of biomass resources across the country by the U.S. Department of Energy's Oak Ridge National Laboratory.[148] The study estimates that Michigan could divert over half a million dry tons of safely combustible biomass (including yard waste, pallets and other wood materials) from landfills every year, at a cost of $20 per dry ton or less. In addition, the study estimates that Michigan could obtain over 1 million tons of forest residues, over 1.5 million tons of mill residues from wood processing, over 4 million tons of waste plant material from farms, and could grow over 4 million tons of energy crops like switchgrass per year, with a delivered price of less than $50 per ton.

If Michigan were to use all of this biomass for clean electricity production, it would generate 14,000 GWh/yr, more than 12 percent of current electricity consumption in the state.[149] Biomass that produces toxic emissions should not be considered renewable. (See Appendix on page 50.)

Solar

The sun's energy can directly provide electricity for home or business use through the use of solar photovoltaic (PV) panels. As is the case with wind power, energy from solar PV systems is intermittent. Homes and businesses with PV systems use them to generate electricity when the sun is shining, selling any extra electricity back into

Using the Sun for Heat and Light

In addition to providing electricity, solar energy can also provide heat and light—the most cost-effective way to tap into the sun. Solar technologies can be as simple as designing a building to achieve maximum exposure to sunlight during the winter or using a fiber-optic cable to pipe concentrated daylight into a building. In addition, roof-mounted solar collectors allow solar energy to be captured and used to heat household water (or for commercial and industrial use). Typically, solar hot water systems pre-heat tap water before adding it to a standard hot water heater. As a result, the systems can reduce electricity or fossil fuel use for water heating by about two-thirds.[160]

In addition to photovoltaics, Michigan should pursue these other forms of solar energy to help solve its energy problems.

the grid, and then using electricity from the grid to obtain power at night. But solar PV is a particularly valuable contributor to the overall electric grid since it provides power at times when demand is highest (when the sun is shining and air conditioning use is high) and when electricity is the most expensive to produce.

For most Americans, however, PV systems remain relatively expensive compared to buying electricity from the grid. While PV installations have increased at a steady clip in recent years, at the end of 2005, there was only 479 megawatts of PV capacity installed in the United States.[150]

The good news, however, is that the cost of PV systems has declined at an average rate of about 4 percent per year over the last 15 years.[151] And the cost is likely to keep going down as the industry gets larger and achieves economies of scale. Recognizing this, countries like Germany and states like California have recently made strong commitments to solar power, helping to subsidize the cost of PV systems now in anticipation that PV will become cost-competitive in the near future. California alone has targeted 3 gigawatts (GW) of solar PV capacity over the next decade as part of its "million solar roofs" program.[152]

The solar industry has set a goal of having just over 100 gigawatts (GW) of PV systems installed by 2025.[153] Should the industry achieve that goal, the United States would be generating more than 220 million megawatt-hours of solar power by 2025.

The economics of solar PV panels as a direct electricity generation source are not nearly as favorable as the economics of wind, but that is rapidly changing. As with wind power, the cost of solar PV has dropped dramatically in recent years—over the last two decades, the cost of solar panels has declined from about $20 per Watt to as low as $3.50 per Watt today.[154] (However, due to rapidly expanding demand, manufacturing capacities are strained and prices for silicon wafers have risen about 10 percent in the first half of 2006.[155] Further investment in solar technology and manufacturing capacity will be required to expand the industry and eventually bring prices back down—as is happening in states that are actively expanding their solar markets.[156])

Moreover, residential and commercial PV provides unique economic value because of its status as a distributed resource—meaning that PV installations can reduce the need for additional investments in electricity transmission and distribution infrastructure. The city of Austin, Texas estimates that solar power is worth 10.4 to 11.7 cents per kWh when added to its system.[157]

Michigan, although not located in the sunniest part of America, still has significant solar energy potential. A solar system in Michigan would produce approximately 80 percent of the energy of the same system located in Florida.[158]

In Michigan, solar photovoltaic panels can make a large contribution to electricity supply. The simplicity of photovoltaic panels makes them easy to install on rooftops throughout urban areas; they are the only electric generators without moving parts, and like wind they have no fuel supply to maintain. If solar panels were installed on rooftops to cover 7 percent of built up areas in Michigan, they could produce 38,000 GWh per year, or about a third as much as electricity Michigan used in 2005.[159]

Policy Recommendations

Investing in energy efficiency and renewable energy would give a boost to Michigan's economy, create tens of thousands of jobs and increase wages, all while reducing pollution.

Therefore, the Michigan Legislature, Governor Granholm and the Michigan Public Service Commission should ensure that efficiency and renewables play a prominent role in the state's energy future. Michigan is at a turning point and in 2007 our state must seize this opportunity to invest in clean energy. Specifically, the state should:

Ramp Up Energy Efficiency Programs

Michigan should aim to meet all future growth in demand for electricity with energy efficiency improvements. To achieve this goal, Michigan should:

- **Restart utility-funded energy efficiency programs.** The state should require its utility companies to create and fund energy efficiency programs sufficient to reduce growth in electricity demand to zero. In order to achieve this goal, the state should create a secure funding mechanism, providing on the order of $225 million per year for efficiency activities, with a corresponding specific energy (MWh) and demand (MW) savings targets of about 1.3 percent per year. Michigan should treat energy efficiency as a resource comparable to new power plants in utility planning. With a true least-cost approach for Michigan energy consumers, energy efficiency should be the priority energy resource.

- **Establish appliance efficiency standards.** Michigan can and should enact energy efficiency standards for residential and commercial appliances where the federal government has failed to do so. Michigan may also petition the federal government for a waiver to implement stronger energy efficiency standards for appliances subject to federal regulation. At least 10 residential and commercial appliances—ranging from commercial boilers to DVD players—are potential targets for immediate adoption of efficiency standards.[161]

- **Upgrade building codes.** Building codes are a crucial leverage point in reducing Michigan's energy consumption. State building codes regulate the construction of residential and commercial buildings and generally include standards to ensure minimum levels of energy efficiency. Unfortunately, Michigan's building codes are out-of-date and bogged down in court cases. Our residential code is less stringent than the 1992 Model Energy Code while our commercial code is the outdated ASHRAE/IESNA 90.1-1999.

  Many other states are achieving far greater efficiency in buildings by regularly updating statewide energy codes to ensure that the code incorporates the latest efficiency opportunities. Michigan should give state officials the clear authority to update building codes to end the legal challenges from special interests. Then, Michigan should, at a minimum, adopt the 2006 International Energy Conservation Code (IECC) Residential Building Code and the ASHRAE 90.1-2004 standard. A number of states have gone further by promoting construction of homes meeting the federal Energy Star standard, which are certified to be at least 15 percent more efficient than homes built to the 2006 IECC. In Iowa, 42 percent of new homes met the Energy Star standard, and in New Jersey, Nevada and Texas, more than 30 percent of new homes met the higher standard in 2005.[162] In contrast, fewer than 3 percent of new homes in Michigan earned the Energy Star efficiency rating. To achieve greater savings, the state should adopt residential and commercial building codes equal to or better than Energy Star performance.

- **Implement and expand the EDGE2 Recommendations:** The Economic Development and Growth through Environmental Efficiency (EDGE2) process, painstakingly put together by a stakeholder group and the Department of Environmental Quality, resulted in a series of common-sense recommendations to reduce energy consumption. These steps, including creating an energy sustainability council and launching a public awareness campaign, should be implemented and then strengthened to include steps such as joining the Midwest Natural Gas Initiative and wider distribution of home energy efficiency materials. The Midwest Natural Gas Initiative alone would decrease natural gas consumption by 1 percent per year for five years in eight Midwestern states, reducing wholesale natural gas prices by as much as 13 percent and saving Michigan customers $745 million by 2010 and creating over 5,000 jobs.[163]

Enact a Renewable Energy Standard

Michigan should aim to generate a large and growing percentage of our electricity from clean and renewable energy resources. To achieve this goal, Michigan should:

- **Create a renewable energy standard of 25 percent by 2025.** Renewable energy standards (RES, also referred to as renewable portfolio standards) require that a certain percentage of the electricity supplied to consumers comes from renewable resources. Renewable energy standards help to increase the confidence of investors and renewable energy developers, promoting investment under stable market conditions that will support long-term demand for renewables. The 23 states (plus the District of Columbia) that currently have an RES generate the bulk of the wind energy in the U.S. By adopting an RES, Michigan can encourage greater investment in home-grown resources.

The first key to designing a RES is to set the right target. Increasing renewable power generation by at least 1 percent per year is a realistic goal that many states are already reaching. Experience in other states shows that the longer the time-frame and the more visionary the goal, the greater the long-term investment and economic development. Given Michigan's considerable renewable energy resources and current renewable generation level of 3.5 percent, reaching a target of 25 percent by 2025 is an achievable goal. The 21st Century Energy Plan of 10 percent renewables by 2015 is a step forward, but falls short of tapping Michigan's full potential for local renewable resources.

The second key to designing an RES is defining what is "renewable" and what is not. Michigan should not allow polluting fuels such as incineration to receive credit as "renewable" sources of energy. (See page 50 for a definition of clean biomass.)

The third key to a successful RES is an enforcement provision that ensures compliance. For example, a utility failing to meet the standard in a given year should pay at least $55 for every MWh below the standard. Fees should be put into a renewable energy fund to promote the development of renewable energy or energy efficiency resources in Michigan.

Finally, an RES should include an in-state renewable energy credit system, which prioritizes investment in local resources over investment out-of-state.

Methodology

Environment Michigan Research & Policy Center developed a Michigan-specific energy and economic model to project the economic and pollution reduction impacts of improving energy efficiency and deploying renewable energy technologies. The model employs input-output economic principles and is based on statistics that describe the production and exchange of goods and services within the various sectors of the Michigan economy, as provided by the Minnesota IMPLAN Group, Inc. (MIG), with all dollar results reported as the equivalent of 2006 values.[164] When selecting assumptions, we attempted to choose conservative values, and the results are generally consistent with a large number of state-level studies that have been carried out previously.[165] This approach allows a meaningful comparison of baseline projections of energy consumption and prices with changes driven by clean energy policies.[166]

Establishing the Default Path

We first established a baseline forecast for energy development in Michigan from 2007 to 2020. This default path served as the point of comparison with the 21st Century Energy Plan and the alternate New Energy Future scenario.

The projections for future energy demand in Michigan come from the November 2006 update of the Capacity Needs Forum to the Michigan Public Utilities Commission.[167]

Forecasts for electricity prices, natural gas consumption, coal consumption, power plant heat rates and power plant environmental performance were established using the most recent statistics from the U.S. Energy Information Administration (EIA) for Michigan's electricity sector, forecast to 2020 using the trajectory set in the regional tables of EIA's Annual Energy Outlook 2006.[168] For example, EIA forecasts a 0.1 percent annual growth rate for coal consumption in the East North Central region, which, when applied to Michigan, yields a forecast for the quantity of coal the state will consume in the future.

Macroeconomic forecasts for Michigan under the business-as-usual path, including GSP, employment and wages, were calculated from EIA's *Annual Energy Outlook 2004*, scaled to Michigan using the state and U.S. economic forecasts published by Woods and Poole Economics, Inc.[169]

Describing the 21st Century Energy Plan

We modeled the impact of the 21st Century Energy Plan as described in *Michigan's 21st Century Electric Energy Plan*, published by the Public Service Commission on 31 January 2007. Key assumptions include:

- An energy efficiency program with initial spending of $68 million per year, carried through from 2007 to 2020 (in constant 2006 dollars)—achieving energy savings on the order of 7,000 GWh in the year 2020.[170] This is a generous assumption because the 21st Century Energy Plan does not recommend guaranteed funding beyond the first year.

- A renewable energy standard of 10 percent by 2015, using 50 percent wind and 50 percent biomass technologies as described in the *Resource Assessment for Renewables*. (See Figure 13.)[171]

- Generation costs for renewables, again based on the description contained in the *Resource Assessment for Renewables*, as shown in Table 6.[172]

- All other assumptions were the same as under the New Energy Future scenario, described below.

Describing the New Energy Future Scenario

We model the impact of an energy efficiency program on electricity demand assuming the following:

- Program spending will be $225 million per year in constant 2006 dollars, from 2007 to 2020;

- Spending will consist of 15 percent for administrative expenses and the remainder will be equally divided among residential, industrial and commercial sectors;

Table 6: Generation Costs for Renewables under the 21st Century Energy Plan[173]

Generation Costs	21st Century Energy Plan
Investment ($/kW)	$1,375
O&M ($/kWh)	$0.009
Fuel Cost ($/kWh)	$0.000
Capacity Factor	0.417
Heat Rate (Btu/kWh)	n/a
Learning Rate per year	0.980
Initial Cost ($/kWh)	$0.064
Air Emissions Rate	0%

- The program will save 1 kWh of electricity for every 3 cents of investment (2006 dollars), and the measures will last for 15 years;[174]

- Efficiency program spending will drive additional consumer investment, and overall the efficiency measures chosen will have a payback period of 3-4 years;[175]

- The rate of investment effectiveness will decline by two percent per year, assuming that the most effective investments would be made first.

We developed a plausible scenario for renewable energy deployment that would be driven by a renewable energy standard requiring 20 percent of Michigan's total electricity consumption on an annual basis to come from new renewable resources by 2020, on course for the state to reach a target of 25 percent renewables by 2025.

There are a variety of technologies that could be used to meet this requirement. This scenario assumes that:

- Michigan starts at a base level of 3 percent renewable electricity generation in 2007.

- On-shore wind energy resources will be developed relatively quickly until production reaches about 4,000 GWh per year, then increase more slowly as developers move further into class 3 resources. In 2020, on-shore wind energy will produce about 8,500 GWh.

- Offshore wind energy will begin contributing in 2013 and quickly reach one-third of renewable energy production required under the clean energy standard.

Figure 13: Modeled 21st Century Energy Plan Renewable Energy Standard

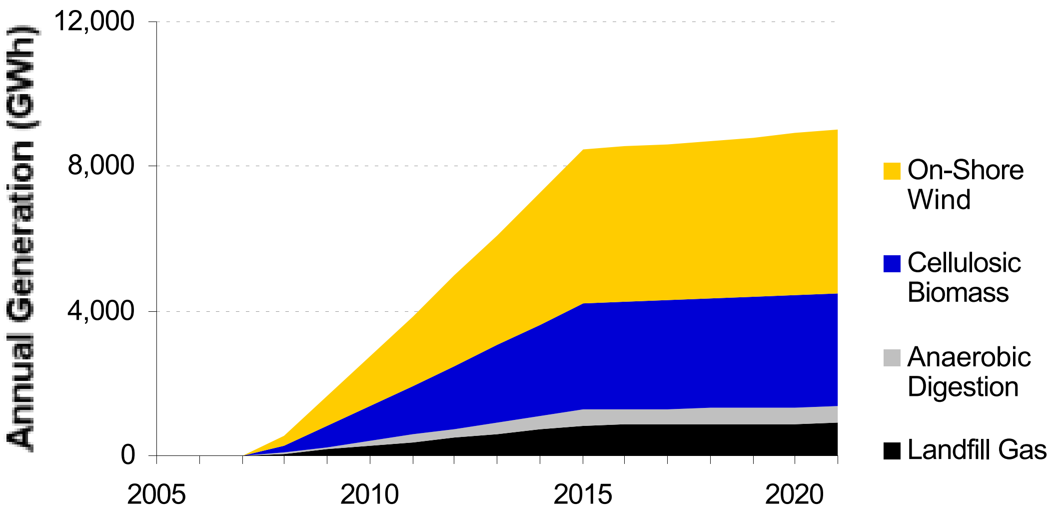
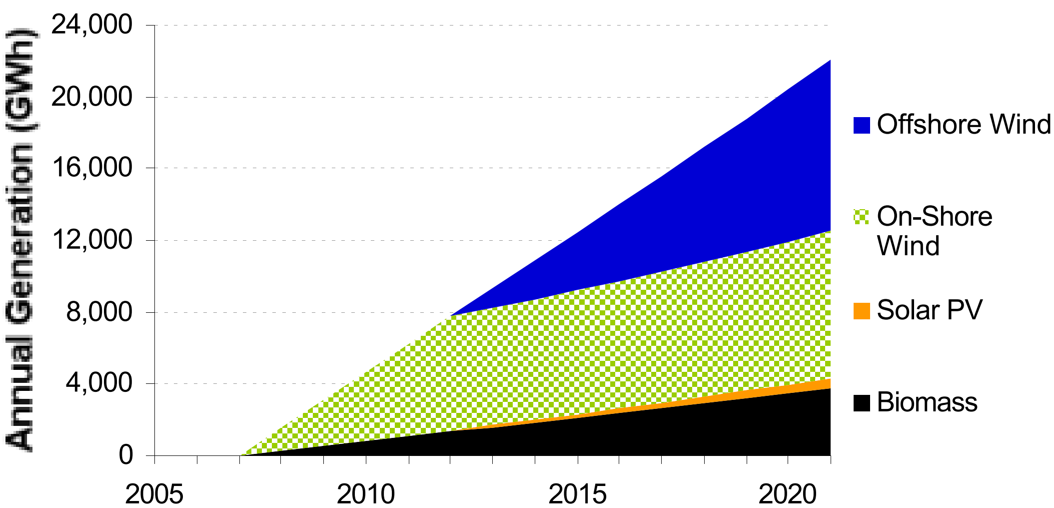


Figure 14: A Possible Michigan Renewable Energy Scenario



- Biomass generation will account for 17 percent of the required renewable energy, reaching output of about 3,900 GWh in 2020.

- Solar technologies will supply less than 3 percent of the required energy;

- Capital costs and operation, maintenance and fuel costs of each technology will decline as the technologies mature.[176]

Figure 14 graphs the development of a mix of technologies stimulated by the clean energy standard.

Modeling the Impact of Clean Energy Development in Michigan

Energy efficiency improvements and renewable energy deployment would require a change in technology investments, energy prices, energy expenditures, and government programs. We estimated these expenditures for the 21st Century Energy Plan and for the New Energy Future scenario based on the anticipated level of spending for energy efficiency and based on the capital, operations, maintenance and fuel costs for renewable energy technologies. We then mapped the change in expenditures and prices into the IMPLAN-derived state energy and economic model to estimate macroeconomic impacts as compared to the baseline "business-as-usual" scenario. Finally, we compared the output of the model under the 21st Century Energy Plan and under the New Energy Future scenario. For a more complete description of how the model was created, see the short working paper, "Modeling State Energy Policy Scenarios," available from Environment Michigan Research & Policy Center.[177]

Key Assumptions

Key assumptions used in the economic modeling are as follows:

Generation Costs:

Generation costs for renewable energy under the New Energy Future scenario and for coal fired power plants under the business-as-usual case are outlined in Table 7. We assume a higher cost for renewable energy under our scenario compared to the 21st Century Energy Plan based on the fact that the New Energy Future scenario aims for a deeper renewable energy penetration, which would require using resources (like offshore wind energy) that are likely

Table 7: Generation Costs under the New Energy Future Scenario

Generation Costs (in 2001 dollars)	Renewable Energy Under 20 Percent by 2020 Target[179]	New Coal Plants[180]
Investment ($/kW)	$1,713.00	$1,385.00
O&M ($/kWh)	$0.021	$0.013
Fuel Cost ($/kWh)	$0.003	$0.017
Capacity Factor	0.443	0.8
Heat Rate (Btu/kWh)	n/a	8,864
Learning Rate per year	0.98	0.98
Initial Cost ($/kWh)	$0.088	$0.059
Air Emissions Rate	0%	100%

Equation 1:

[Intercept] * (Number of years since 2003)^[Year] * [National Demand]^[Quantity] / [Deflator]

Table 8: Price Dynamics Coefficients for Natural Gas[182]

	Intercept	Year	Quantity	Deflator
Natural Gas	0.0052	-0.1485	2.0817	1.0101

to be higher on the state's renewable energy resource cost-curve. We estimated the costs of the New Energy Future renewable portfolio based on technology cost estimates by DOE, assuming that capital costs and operation, maintenance and fuel costs of each technology will decline as the technologies mature.[178]

Local Impacts:

To take into account the fact that all economic activity for manufacturing is not necessarily tied to Michigan, we assume that 80 percent of all expenses for renewable technology, including financing and ongoing operation and maintenance, will be local. We also assume that 80 percent of investment will happen in Michigan and 80 percent of energy bill savings will be respent in the Michigan economy.

Consumer Savings and Price Dynamics

Consumer savings estimates consisted of avoided electricity purchases—simply the amount that would have been spent to purchase electricity in the absence of efficiency savings—and the effect of reduced energy demand on energy prices.

We assumed that efficiency programs would have the effect of reducing upward pressure on the price of electricity, natural gas and coal, which are set by a regional and national market. Based on estimates of how much natural gas and electricity would be saved compared to the base case forecast, we predicted change in national demand. In turn, the change in national demand was translated into an estimate of the effect on electricity and natural gas prices in Michigan.

Natural gas prices were calculated using the coefficients listed in Table 8 and Equation 1.[181]

Electricity price impacts were calculated by estimating displaced utility related investment and operating/maintenance costs in the efficiency scenario compared to the base case.

To the extent that other states adopt energy efficiency programs and renewable energy standards and reduce their fuel demand, it will have positive impacts on Michigan's economy. The effect of policies established in other states or at the federal level are not modeled in this report.

Finally, it should be noted that the full effects of the efficiency investments are not accounted for. Savings beyond 2020 (the last year of the modeling timeframe) are not incorporated into the analysis. Nor does the model include other commercial productivity benefits which are likely to stem from the efficiency investments, such as improved product quality, lower capital and operating costs, increased employee productivity, or capturing specialized product markets.[183] To the extent these "co-benefits" are realized in addition to the energy savings, the economic impacts would be amplified beyond those reported here.

Appendices

Definition of Clean Biomass

Some technologies categorized as "biomass" are actually toxic and should be avoided, including waste and tire incineration. Environment Michigan Research & Policy Center defines clean biomass as:

A. Any plant-derived organic matter available on a renewable basis;

B. Non-hazardous plant matter waste material that is segregated from other waste materials and is derived from:

   1. an agricultural crop, crop by-product or residue resource;
   2. waste such as landscape or right-of-way tree trimmings or small diameter forest thinnings, but <u>not including:</u>
      a. municipal solid waste,
      b. recyclable post-consumer waste paper,
      c. painted, treated, or pressurized wood,
      d. wood contaminated with plastic or metals, or
      e. tires;

C. Gasified animal waste;

D. Digester gas;

E. Biogases and biofuels derived, converted or processed from plant or animal waste or other organic materials; or

F. Landfill methane.

Any biomass combustion must meet the best available control technologies for emissions. Preference should be given for gasified biomass technologies.

A Note On Electricity Units

Megawatts (MW) are the standard measure of a power plant's gener-ating capacity, or the amount of power it could produce if operating at full speed. Utilities measure their ability to supply demand on the grid at any one time in terms of MW. One MW equals 1,000 kilowatts (kW). One thousand MW equals one gigawatt (GW).

Power plant output and electricity consumption over a fixed length of time are measured in terms of megawatt-hours (MWh). For example, a 50 MW power plant operating at full capacity for one hour produces 50 MWh of electricity. If that plant operates for a year at full capacity, it generates 438,000 MWh of electricity (50 MW capacity x 8,760 hours/year). To give a sense of scale, an average household uses about 10 MWh of electricity each year.

Most plants do not operate at full capacity all the time; they may be shut down for maintenance or they may be operated at only part of their maximum generating potential because their power is not needed or their power source (such as wind) is not available. The actual amount of power that a plant generates compared to its full potential is reported as its capacity factor. Thus a 50 MW plant with a 33 percent capacity factor would produce 144,540 MWh of electricity in a year (50 MW x 8,760 hours/year x 33% capacity factor).

Key Economic Multipliers for Michigan

Table A1: Type 1 Multipliers for the Michigan Economy[184]

Sector	Type I Multiplier Employment (Per $MM of Final Demand)	Type I Multiplier Compensation (Per Dollar of Final Demand)	Type I Multiplier Value-Added (Per Dollar of Final Demand)	Labor Productivity Growth (Percent/Yr)
Agriculture	22.9	0.300	0.493	1.54%
Oil and Gas Extraction	7.9	0.194	0.570	2.66%
Coal mining	9.9	0.257	0.477	2.66%
Other Mining	9.0	0.403	0.640	2.66%
Electric Utilities	3.8	0.212	0.763	2.80%
Natural gas distribution	3.8	0.182	0.468	3.40%
Construction	15.1	0.524	0.696	2.00%
Manufacturing	7.4	0.349	0.563	2.30%
Wholesale trade	9.9	0.482	0.862	1.50%
Transportation and Public Utilities	12.7	0.537	0.781	2.80%
Retail Trade	24.5	0.567	0.852	1.50%
Services	14.9	0.475	0.844	0.40%
Finance	9.9	0.388	0.799	1.50%
Government	19.3	0.827	0.974	0.40%

Notes

1 Michigan Department of Labor and Economic Growth, *Michigan Fast Facts*, accessed at www.milmi.org on 17 January 2006; John Gallagher, "Michigan's September Unemployment Rate 7.1%," *Detroit Free Press*, 18 October 2006.

2 Martin Kushler, American Council for an Energy Efficient Economy, *Michigan's Energy Crisis: Time to Get Serious*, Presented to the 2005 Michigan Energy Conference, 20 October 2005. A large portion of the energy trade deficit is for transportation fuel.

3 Gross State Product: U.S. Department of Commerce, Bureau of Economic Analysis, *News Release: Gross Domestic Product by State, 2005*, 26 October 2006; Personal Income: Dennis Cauchon, "Incomes Up Most in Energy States; Ties to U.S. Government Boost Other Growth Areas," *USA Today*, 4 May 2006.

4 Deaths: Abt Associates, *Power Plant Emissions: Particulate Matter-Related Health Damages and the Benefits of Alternative Emission Reduction Scenarios*, June 2004; Every inland lake in Michigan is subject to an advisory that women of childbearing age and children under 15 limit eating of some larger fish, including walleye: John Flesher, "Polluted Lake Example of Slow Progress in Water Quality Agreement," *Associated Press State and Local Wire*, 19 December 2006.

5 George Kling, Union of Concerned Scientists, *Confronting Climate Change in the Great Lakes Region*, April 2003.

6 Demand growth: Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for CNF Update*, 15 November 2006.

7 Need for coal-fired power: Mark Hornbeck, "By 2015, State Needs New Power Facility; Michigan May Let Utilities Raise Rates for Customers to Pay for up to $2 Billion Plant," *Detroit News*, 1 February 2007. Recommendations of the 21st Century Energy Plan: J. Peter Lark, Michigan Public Service Commission, *Michigan's 21st Century Energy Plan*, 31 January 2007; See also: Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for CNF Update*, 15 November 2006; Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for Energy Efficiency*, 15 November 2006; Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for Renewables*, 15 November 2006.

8 Production: Energy Information Administration, U.S. Department of Energy, *Natural Gas Navigator: Natural Gas Gross Withdrawals and Production, Michigan*, 2 January 2007; Number of Producing Wells: Energy Information Administration, U.S. Department of Energy, *Natural Gas Navigator: Number of Producing Gas and Gas Condensate Wells*, January 2007.

9 Production: Energy Information Administration, U.S. Department of Energy, *Natural Gas Navigator: Natural Gas Gross Withdrawals and Production, Michigan*, 2 January 2007.

10 Regional Economics Application Laboratory for the Environmental Law & Policy Center, *Job Jolt: The Economic Impacts of Repowering the Midwest: The Clean Energy Development Plan for the Heartland*, 2001.

11 American Council for an Energy Efficient Economy, *Examining the Potential for Energy Efficiency to Help Address the Natural Gas Crisis in the Midwest*, January 2005.

12 Union of Concerned Scientists, *Renewing America's Economy*, September 2004.

13 Renewable Energy Policy Project, *Solar PV Development: Location of Manufacturing Activity*, January 2005; Renewable Energy Policy Project, *Wind Turbine Development: Location of Manufacturing Activity*, January 2005.

14 PIRGIM Education Fund, *Redirecting Michigan's Energy: The Economic and Consumer Benefits of Clean Energy Policies*, February 2005.

15 See Note 2.

16 Ibid.

17 Multipliers derived from: Minnesota IMPLAN Group, *2001 Data for the State of Michigan*, Stillwater, Minnesota, 2004. See Appendices for a full list of multipliers.

18 Regional Greenhouse Gas Initiative, *States Announce RGGI Agreement: Memorandum of Understanding*, 20 December 2005.

19 Environment Maryland, *Governor Signs Healthy Air Act*, (Press Release), 6 April 2006.

20 Mark Martin, "Governor Acts to Curb State's Gas Emissions; Goals Put Him at Odds with Many in GOP," *San Francisco Chronicle*, 2 June 2005.

21 Marc Lifsher and Jordan Rau, "State on Verge of Greenhouse Gas Restrictions," *Los Angeles Times*, 31 August 2006.

22 Gregory J. Nickels, Mayor, City of Seattle, *U.S. Mayors Unanimously Endorse Nickels' Climate Protection Agreement*, (Press Release), 13 June 2005.

23 Senator Bernie Sanders, *Senator Sanders Introduces the Global Warming Pollution Reduction Act*, (Press Release), 16 January 2007.

24 Assuming natural gas fuel prices of $5/MBtu, Pittsburgh #8 coal at $1.50/MBtu, capacity factors of 80 percent and cost of CO2 transportation and sequestration at $5/metric ton: Stu Dalton, Electric Power Research Institute, *Cost Comparison: IGCC and Advanced Coal*, Presented at the Roundtable on Deploying Advanced Clean Coal Plants, Washington D.C., 29 July 2004.

25 Steve Specker, Electric Power Research Institute, *Generation Technologies in a Carbon-Constrained World*, presented at the Resources for the Future Policy Leadership Forum, Washington D.C., 30 March 2006.

26 United Kingdom, HM Treasury, *Stern Review on the Economics of Climate Change*, 30 October 2006.

27 Michigan Department of Labor and Economic Growth, *Michigan Jobs from Energy Efficiency and Renewable Energy*, 6 March 2006.

28 Renewable Energy Policy Project, *The Work That Goes Into Renewable Energy*, November 2001.

29 Kaydon Corporation, *Wind Energy Bearings*, accessed at www.kaydonbearings.com/wind_energy.php on 12 January 2007.

30 Daniel Kammen and Kamal Kapadia, *Employment Generation Potential of Renewables to 2010*, 2002.

31 United Solar Ovonic, *Fact Sheet: Uni-Solar Manufacturing Plant, Auburn Hills, MI*, 11 August 2005.

32 United Solar Ovonic, *Solar: Overview*, accessed at www.ovonic.com/eb_so_solar_overview.cfm on 15 January 2007.

33 The recent 30 MW factory expansion, a duplicate of an earlier factory in Auburn Hills, employs 625 people: See Note 27.

34 See Note 32.

35 United Solar Ovonic, *United Solar Ovonic Bringing High-Tech Manufacturing Facility, 200 New Jobs to Greenville*, (Press Release), 23 March 2006.

36 See Note 32.

37 Dow Corning, *Demand in Solar Energy Industry Drives $400 Million Hemlock Semiconductor Expansion*, (Press Release), 15 November 2005.

38 Ibid.

39 Ibid.

40 Ibid.

41 Pennsylvania Department of Environmental Protection, *DEP Secretary McGinty Receives Alternative Fuels and Renewable Energy Leadership Award; Cited for Accelerating the Commercialization of Alternative Fuels and Renewable Energies*, (Press Release), 6 December 2006.

42 For example, Gary Westerholm of McKenzie Bay International estimates that about three-quarters of the parts used in its WindStor product will be manufactured in

Michigan: Tom Stanton, Michigan Public Service Commission, Renewable Energy Program, Personal Correspondence, 4 January 2007.

43 Texas SEED Coalition and Public Citizen, *Renewable Resources: The New Texas Energy Powerhouse*, September 2002.

44 Noble Environmental Power, *Thumb Windpark*, (Factsheet), 2005.

45 Noble Environmental Power, Personal Correspondence, 16 January 2007.

46 See Note 43.

47 See Note 44.

48 S. Tegen, National Renewable Energy Laboratory, *Comparing Statewide Economic Impacts of New Generation from Wind, Coal and Natural Gas in Arizona, Colorado and Michigan*, Technical Report NREL/TP-500-37720, May 2006.

49 Reports using a variety of methods and conditions all reach the same conclusion. See Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, University of California, Berkeley, *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* 13 April 2004.

50 Ibid.

51 M. Brower, et al., Union of Concerned Scientists, *Powering the Midwest: Renewable Electricity for the Economy and the Environment*, 1993.

52 Lease payments range between 2% to more than 10% of yearly gross revenues, depending upon competing land uses (National Wind Coordinating Committee, *The Effect of Wind Energy Development on State and Local Economies*, Wind Energy Series #5, January 1997, available at www.nationalwind.org); an assumed lease payment of 2.5% is common (see National Wind Coordinating Committee, *The Effect of Wind Energy Development on State and Local Economies*, Wind Energy Series #5, January 1997; AWEA, Texas SEED Coalition and Public Citizen, *Renewable Resources: The New Texas Energy Powerhouse*, September 2002).

53 AWEA estimates that Pennsylvania farmers could earn $2000-$3000 per turbine per year, possibly assuming smaller capacity turbines. AWEA, *Wind Energy Is Good for Pennsylvania's Economy*, downloaded from www.awea.org/pennsylvania/documents/economy_pa.PDF, 15 February 2004.

54 See Note 44.

55 Calculated using assumptions described in text and renewable energy deployment scenario described in the Methodology section at the end of the report. Dollar figure not discounted.

56 Projected assuming that 50 percent of the 21st Century Energy Plan will be met with on shore wind farms, per: Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for Renewables*, 15 November 2006; and using assumptions described in text.

57 See Note 48.

58 Tax income is reported in non-discounted 2006 dollars, representing total payments from 2007 through 2020. The value reported here follows from the renewable energy development scenario described in the methodology section and the following assumptions: We assume a host fee of $3,333 per MW per year, or about $5,000 per 1.5 MW wind turbine per year, through 2012. Beginning in 2013, we assume that Michigan's standard property tax system will apply. We assume that each facility depreciates on a linear schedule over a 25 year useful life, that 50 percent of market value is the state equalized value, and that the average property tax rate is 4 percent of the equalized value per year. See Citizen's Research Council of Michigan, *Outline of the Michigan Tax System: General Property*, 31 May 2006.

59 Estimated using the methodology outlined in note 58, plus a renewable energy technology deployment trajectory for the 21st Century Energy Plan estimated based on our modeled renewable energy production, with 50 percent of production coming from onshore wind with a 28 percent capacity factor, 35 percent from cellulosic biomass with an 80 percent capacity factor, 10 percent from landfill gas with a 90 percent capacity factor, and 5 percent from anaerobic digestion with an 80 percent capacity factor; plus cost estimates per: Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for Renewables*, 15 November 2006.

60 See Note 48.

61 Ibid.

62 Daniel G. De La Torre Ugarte, Marie E. Walsh, Hosein Shapouri, and Stephen P. Slinsky. Oak Ridge National Laboratory, *The Economic Impacts of Bioenergy Crop Production in U.S. Agriculture*, 1999. Online at bioenergy.ornl.gov/papers/wagin/index.html.

63 Michigan Department of Consumer and Industry Services, Biomass Energy Program,

Energy Crops and their Potential Development in Michigan, August 2002.

64 See Note 2.

65 Assuming equal distribution of energy savings in residential, commercial and industrial sectors.

66 Justin Blum, "Energy Department Slow to Mandate Efficiency," *Washington Post*, 22 January 2005.

67 Ryan Wiser, Mark Bolinger and Matt St. Clair, U.S. Department of Energy, Lawrence Berkeley National Laboratory, *Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency*, LBNL-56756, January 2005.

68 Ibid.

69 R. Neal Elliot and Ann Monis Shipley, American Council for an Energy Efficient Economy, *Impacts of Energy Efficiency and Renewable Energy On Natural Gas Markets: Updated and Expanded Analysis*, 2005.

70 Martin Kushler, Dan York and Patti Witte, American Council for an Energy Efficient Economy, *Examining the Potential for Energy Efficiency To Help Address the Natural Gas Crisis in the Midwest.* ACEEE Report U051, 2005.

71 See Note 10.

72 Faster: Working Group I, Intergovernmental Panel on Climate Change, *IPCC Third Assessment Report – Climate Change 2001: Summary for Policy Makers, The Scientific Basis*, 2001; 20 million: Working Group I, Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis*, 2001, Chapter 3.

73 1.4 degrees: National Aeronautics and Space Administration, Goddard Institute for Space Studies, *2005 Was Warmest Year in Over a Century*, (Press Release), 24 January 2006; 0.36: Associated Press, "Global Temperature Highest in Millennia: Global Temperature Highest in Thousands of Years, Researchers Tell Science Journal," *ABC News*, 25 September 2006.

74 1990s: Working Group I, Intergovernmental Panel on Climate Change, *IPCC Third Assessment Report – Climate Change 2001: Summary for Policy Makers, The Scientific Basis*, 2001; 2006: National Oceanic and Atmospheric Administration, *NOAA Reports 2006 Warmest Year on Record for U.S.*, (Press Release), 9 January 2007; 2005 and 1998 were the previous record-holders: National Aeronautics and Space Administration, Goddard Institute for Space Studies, *2005 Was Warmest Year in Over a Century*, (Press Release), 24 January 2006.

75 Michigan Environmental Council and National Environmental Trust, *Season Creep: Warming Climate Leads to Shifting Michigan Seasons*, (Press Release), 22 March 2006.

76 Ibid.

77 Associated Press, "Global Temperature Highest in Millennia: Global Temperature Highest in Thousands of Years, Researchers Tell Science Journal," *ABC News*, 25 September 2006.

78 See Note 5.

79 Ibid.

80 "Climate Change Experts Predict Drop in Lake Erie Water Levels," *U.S. Water News Online*, August 2006.

81 See Note 26.

82 Ibid.

83 1,440: Energy Information Administration, U.S. Department of Energy, *Michigan Electricity Profile 2004 Edition*, DOE/EIA-0629, June 2006. Figure includes electricity generated by nuclear power plants.

84 Malte Meinshausen, "What Does a 2° C Target Mean for Greenhouse Gas Concentrations? A Brief Analysis Based on Multi-Gas Emission Pathways and Several Climate Sensitivity Uncertainty Estimates," in Hans Joachim Schnellnhuber, ed., *Avoiding Dangerous Climate Change*, Cambridge University Press, 2006.

85 See Note 83.

86 Michigan Department of Environmental Quality, *Attainment/Non-Attainment Information*, downloaded from www.michigan.gov on 31 October 2006.

87 C. Pope et al., "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution," *Journal of the American Medical Association* 287: 1132-1141, 2002; A. Peters et al., "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction," *Circulation* 103: 2810-2815, 2001; J. Samet et al., The United States Health Effects Institute, *The National Morbidity, Mortality, and Air Pollution Study, Part II: Morbidity and Mortality from Air Pollution in the United States*, Research Report Number 94, June 2000; Joel Schwartz, "Particulate Air Pollution and Chronic Respiratory Disease," *Environmental Research* 62: 7-13, 1993; D. Abbey et al., "Long-

term Ambient Concentrations of Total Suspended Particles, Ozone, and Sulfur Dioxide and Respiratory Symptoms in a Nonsmoking Population," *Archives of Environmental Health* 48: 33-46, 1993; Joel Schwartz et al., "Particulate Air Pollution and Hospital Emergency Room Visits for Asthma in Seattle," *American Review of Respiratory Disease* 147: 826-831, 1993; J. Schwartz et al., "Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children," *American Journal of Respiratory Critical Care Medicine* 150: 1234-1242, 1994.

88 See Note 4, "Deaths."

89 M. Gilmour et al., "Ozone-Enhanced Pulmonary Infection with *Streptococcus Zooepidemicus* in Mice: The Role of Alveolar Macrophage Function and Capsular Virulence Factors," *American Review of Respiratory Disease* 147: 753-760; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine* 21: 1-48, 2000.

90 M. Lippman, "Health Effects of Ozone: A Critical Review," *Journal of the Air Pollution Control Association* 39: 672-695, 1989; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine* 21: 1-48, 2000.

91 W. McDonnell et al., "Pulmonary Effects of Ozone Exposure During Exercise: Dose-Response Characteristics," *Journal of Applied Physiology* 5: 1345-1352, 1983.

92 R. McConnell et al., "Asthma in Exercising Children Exposed to Ozone: A Cohort Study," *The Lancet* 359: 386-391, 2002

93 Charles Driscoll, David Evers and Thomas Holsen, for the Hubbard Brook Research Foundation, *New Scientific Studies Identify Causes of Mercury Pollution Hotspots*, (Press Release) 9 January 2007.

94 Ibid.

95 Kathryn R. Mahaffey, Robert P. Clickner, and Catherine C. Bodurow, "Blood Organic Mercury and Dietary Mercury Intake: National Health and Nutrition Examination Survey, 1999 and 2000," *Environmental Health Perspectives* 112 (5), 562-570, April 2004; Kathryn R. Mahaffey, U.S. EPA, *Methylmercury: Epidemiology Update*, presentation before the Fish Forum, San Diego, January 2004.

96 U.S. Environmental Protection Agency, *E-Grid Database*, Version 2.01, May 2003.

97 U.S. PIRG Education Fund and Clear The Air, Reel Danger: Power Plant Mercury Pollution and the Fish We Eat, August 2004.

98 Michigan Department of Community Health, *2004 Michigan Family Fish Consumption Guide*, 2004.

99 Alejandro Bodipo-Memba, "State Pondering Nuclear Power; Opponents on Guard as Officials Assess Future Needs," *Detroit Free Press*, 3 September 2006.

100 Cumulative subsidies for nuclear power over the period 1947-1999 have been estimated at $145.4 billion, based on Marshall Goldberg, Renewable Energy Policy Project, *Federal Energy Subsidies: Not All Technologies Are Created Equal*, July 2000.

101 Swiss Agency for Development and Cooperation, *Chernobyl.info*, downloaded 20 January 2004.

102 John Mangels and John Funk, "Davis-Besse Could Have Blown Top in 60 Days," *The Plain Dealer*, 5 May 2004.

103 Matthew L. Wald, "Study Finds Vulnerabilities In Pools of Spent Nuclear Fuel," *New York Times*, 7 April 2005; Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, National Research Council, National Academy of Science, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, 6 April 2005.

104 Union of Concerned Scientists, *Nuclear Reactor Security*, downloaded from www.ucsusa.org/clean_energy/nuclear_safety/page.cfm?pageID=176, 24 July 2003.

105 U.S. General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened*, September 2003.

106 National Academy of Sciences, *Spent Fuel Stored in Pools at Some U.S. Nuclear Plants Potentially at Risk from Terrorist Attacks: Prompt Measures Needed to Reduce Vulnerabilities*, (Press Release), 6 April 2005.

107 National Academy of Sciences, Board of Radioactive Waste Management, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, National Academies Press, 2005.

108 Nuclear Management Company, *Nuclear Waste Disposal: State Facts – Michigan*, (Fact Sheet) 2002.

109 Nuclear Information Resource Service, *High-Level Atomic Waste Mishap at Palisades Nuclear Reactor Risks Radioactive Inferno with Casualty Potential of Thousands of Deaths Downwind*, (Press Release), 20 March 2006.

110 David Lochbaum, Union of Concerned

Scientists, *U.S. Nuclear Plants in the 21st Century: The Risk of a Lifetime*, May 2004.

111 David Lochbaum, Union of Concerned Scientists, Testimony before the Clean Air, Wetlands, Private Property and Nuclear Safety Subcommittee of the U.S. Senate Committee on Environment and Public Works, 8 May 2001.

112 See Note 83.

113 Nuclear Regulatory Commission, *Facility Info Finder – Michigan*, accessed at www.nrc.gov on 4 January 2007.

114 Nuclear Regulatory Commission, *NRC Renews Operating License for Palisades Nuclear Power Plant for an Additional 20 Years*, Press Release, 17 January 2007.

115 Michigan Public Service Commission, *Resource Assessment for CNF Update*, 15 November 2006; an update of: *Michigan Capacity Need Forum: Staff Report to the Michigan Public Service Commission*, Appendix D: Demand Work Group, January 2006.

116 See Note 7.

117 U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2003*, 7 September 2004, Table 1.1.

118 U.S. Department of Commerce, Bureau of Economic Analysis, *National Economic Accounts: Gross Domestic Product*, downloaded from www.bea.doc.gov/bea/dn/home/gdp.htm, 2 March 2005.

119 In constant 2000 dollars. U.S. Department of Energy, Energy Information Administration, *International Energy Annual 2004*, July 2006.

120 See Note 2.

121 Residential net energy consumption for California, Michigan and the United States was obtained from U.S. Department of Energy, Energy Information Administration, *State Energy Consumption, Price and Expenditures Estimates* database, downloaded from www.eia.doe.gov/emeu/states/_seds.html, 27 November 2006. Population estimates for California obtained from California Department of Finance, Demographic Research Unit, *California Population Estimates, with Components of Change and Crude Rates, July 1, 1900-2005*, March 2006. Michigan population estimates compiled from: U.S. Census Bureau, Population Distribution Branch, *Intercensal Estimates of the Resident Population of States*, downloaded from http://www.census.gov/popest/estimates.php on 13 December 2006; U.S. population estimate from U.S. Census Bureau, *Statistical Abstract of the United States 2006*, downloaded from www.census.gov/compendia/statab/tables/, 10 October 2006.

122 Based on multiplying Michigan per capita residential net energy consumption in 1975 by the percentage reduction in per-capita residential net energy consumption in California from 1975 to 2002 per sources described in footnote 121.

123 Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for Energy Efficiency*, 15 November 2006.

124 Ibid.

125 Steven Nadel, Anna Shipley, and R. Neal Elliot, American Council for an Energy Efficient Economy, *The Technical, Economic, and Achievable Potential for Energy Efficiency in the U.S.—A Meta-Analysis of Recent Studies*, From the Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, 2004.

126 Bruce Biewald, David White, et al, Synapse Energy Economics, *A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the U.S. Electricity System*, 11 June 2004.

127 Howard Geller et al, Southwest Energy Efficiency Project, *The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest*, November 2002.

128 See Note 115.

129 Richard Sedano, Regulatory Assistance Project, *Economic, Environment and Security Effects of Energy Efficiency and Renewable Energy: A Report for EPA and the New England Governors' Conference*, NEEP Policy Conference, 24 May 2005.

130 Optimal Energy, Inc. for Northeast Energy Efficiency Partnerships, *Economically Achievable Energy Efficiency Potential in New England*, May 2005.

131 See Note 127.

132 See Note 123.

133 Ibid.

134 See Note 2.

135 Based on 2004 revenue: See Note 83.

136 Efficiency Vermont, *Working Together for an Energy Efficient Vermont: Efficiency Vermont 2004 Preliminary Report*, subject to audit, downloaded from www.efficiencyvermont.com on 28 July 2005, final report available September 2005.

137 U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2006*, January 2006, Figure 61.

138 Colorado Public Utilities Commission, *Initial Commission Decision Approving Stipulation and Settlement Agreement*, Decision No. C02-1122, 2 October 2002.

139 Dennis Elliott, National Renewable Energy Laboratory, *Michigan Wind Energy Resources*, Presented to the Michigan Wind Working Group Meeting, Lansing Michigan, 5 October 2004. The analysis excludes urban areas, watery areas, land with a slope of more than 20 percent, 50 percent of non-ridge crest forestland, and with a 3 km buffer around all excluded land but water. It looks at the wind resource 50 meters above ground. Analysis assumes the following capacity factors: class 3 = 0.2, class 4 = 0.25, class 5 = 0.323, class 6+ = 0.4.

140 Predictions of the course of improvement of wind energy technology can be found here: U.S. Department of Energy and the Electric Power Research Institute, *Renewable Energy Technology Characterizations*, December 1997. Wind potential figures: Dennis Elliott, National Renewable Energy Laboratory, *Michigan Wind Energy Resources*, Presented to the Michigan Wind Working Group Meeting, Lansing Michigan, 5 October 2004. The analysis excludes urban areas, watery areas, land with a slope of more than 20 percent, 50 percent of non-ridge crest forestland, and with a 3 km buffer around all excluded land but water. It looks at the wind resource 50 meters above ground. Analysis assumes the following capacity factors: class 3 = 0.2, class 4 = 0.25, class 5 = 0.323, class 6+ = 0.4. Michigan's 2005 electricity demand was around 114,000 GWh: Michigan Public Service Commission, *Michigan Capacity Need Forum: Staff Report to the Michigan Public Service Commission*, Appendix D: Demand Work Group, January 2006.

141 44 GW: Scott Pryor, Mark Shahinian and Matt Stout, University of Michigan, *Offshore Wind Energy Development in the Great Lakes: A Preliminary Briefing Paper for the Michigan Renewable Energy Program*, April 2005. This estimate reflects only the wind resources identified in current wind maps (up to 12 miles offshore) and excludes specific protected areas plus all areas less than 5 miles from the shoreline.

142 GWh production figure assumes a capacity factor of 0.4, consistent with a mix of class 5 to class 6 wind areas. Michigan's 2005 electricity demand was around 114,000 GWh: Michigan Public Service Commission, *Michigan Capacity Need Forum: Staff Report to the Michigan Public Service Commission*, Appendix D: Demand Work Group, January 2006.

143 Jennifer Pritchett, "Power Project on Hold," *Kingston Whig-Standard*, 7 December 2006.

144 Ibid.

145 American Wind Energy Association, *Groundbreaking Minnesota Wind Integration Study Finds up to 25 Percent Wind Can Be Incorporated into Electric Power System*, Press Release, 13 December 2006. Wind industry analysts suggest it is possible to have up to 40 percent wind power as part of a smoothly functioning electricity grid. See, for example, Randall S. Swisher, "Bringing Wind Energy Up to 'Code,'" *Public Utilities Fortnightly*, June 2004. Swisher, executive director of the American Wind Energy Association, a wind industry trade group, contends that the technical limits to the integration of wind into electricity grids is approximately 40 percent of annual energy use.

146 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Biomass Basics*, downloaded from www.eere.energy.gov/biomass/biomass_basics.html, 3 March 2005.

147 Union of Concerned Scientists, *Growing Energy on the Farm: Biomass Energy and Agriculture*, downloaded from www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=129, 3 March 2005.

148 Marie E. Walsh, et al, Oak Ridge National Laboratory, *Biomass Feedstock Availability in the United States: 1999 State Level Analysis*, updated January 2000.

149 Assuming biomass heat content according to U.S. Department of Energy, Energy Information Administration, *Renewable Energy Trends 2004*, Table 10: Average Heat Content of Selected Biomass Fuels, August 2005; and a power plant heat to electricity conversion efficiency of 40 percent.

150 Photovoltaic Power Systems Programme, International Energy Agency, *Installed PV Power as of the End of 2005 in Reporting IEA PVPS Countries*, downloaded from www.iea-pvps.org/isr/01.htm on 9 January 2007.

151 Solarbuzz, *Fast Solar Energy Facts*, downloaded from www.solarbuzz.com/FastFactsIndustry.htm, 8 September 2006.

152 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *California Approves Legislation for Million Solar Roofs Plan*, 23 August 2006.

153 Based on interpolation between 2020 and 2030 target figures from Solar Energy Industry Association, *Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond*, September 2004.

154 "$20 per peak Watt" from U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Building Science Consortium's PV Primer*, downloaded from www.eere.energy.gov/buildings/building_america/pdfs/db/35206.pdf, 17 November 2004. "About $3.50 today" based on low price for individual module in Solarbuzz price survey, www.solarbuzz.com/ModulePrices.htm, downloaded 17 November 2004. Lower prices are available for modules purchased in larger quantities.

155 "Silicon Wafer Prices Increase Again," *Techweb*, 8 May 2006.

156 Nanosolar, Inc., *Nanosolar to Build 430 MW Solar Cell Factory*, (Press Release), 21 June 2006.

157 Clean Power Research and Austin Energy, *The Value of Distributed Photovoltaics to Austin Energy and the City of Austin*, 16 March 2006.

158 Based on a comparison of annual average solar radiation intensities in each state: U.S. Department of Energy, Energy Efficiency and Renewable Energy, *State Energy Alternatives*, 24 October 2006.

159 Michigan's solar radiation intensity is about 4250 watt-hours per square meter per day (U.S. Department of Energy, Energy Efficiency and Renewable Energy, *State Energy Alternatives*, 24 October 2006). Michigan's built-up land area was 3,461,000 acres in 2000 (U.S. Department of Agriculture, Natural Resources Conservation Service, *1997 Natural Resources Inventory: Michigan NRI Data: Trends in Urban Development*, 2001). We assumed that solar PV technology can achieve a 12 percent light to electricity conversion efficiency and a 20 percent capacity factor.

160 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Solar Hot Water and Space Heating & Cooling*, downloaded from www.eere.energy.gov/RE/solar_hotwater.html, 8 September 2005.

161 American Council for an Energy-Efficient Economy, Appliance Standards Awareness Project, *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, March 2006.

162 Energy Star, *Energy Star Qualified New Homes Market Indices for States*, downloaded from www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex, 18 August 2006.

163 See Note 69.

164 See Note 17.

165 See e.g., Argonne National Lab and Environmental Protection Agency, Engines of *Growth: Energy Challenges, Opportunities, and Uncertainties In the 21st Century*, January 2004, available at www.4cleanair.org/members/committee/ozone/EnginesofGrowth.pdf; Environment California, *Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California*, July 2003; Kammen, D., and Kapadia, K., University of California, Berkeley, *Employment Generation Potential of Renewables to 2010*, 2002; Hewings, G., Yanai, M., Learner, H., et al., Environmental Law and Policy Center, *Job Jolt: The Economic Impacts of Repowering the Midwest*, 2002; Tellus Institute, *Clean Energy: Jobs for America's Future*, October 2001; Union of Concerned Scientists, *Renewing Where We Live: A National Renewable Energy Standard Will Benefit America's Economy*, 2002 and 2003; Skip Laitner and Marshall Goldberg, for Land and Water Fund of the Rockies, National Renewable Energy Laboratory and Arizona State Energy Office, *Arizona Energy Outlook 2010, Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy*, July 1997.

166 For an overview of how this methodology might be typically applied, see Laitner, S., Bernow, S., and DeCicco, J., "Employment and Other Macroeconomic Benefits of an Innovation-Led Climate Strategy for the United States." *Energy Policy*, Volume 26, Number 5, April 1998, pp. 425-433. For an example of a study that applies this same modeling exercise within a state level analysis, see, Nadel, S., Laitner, S., Goldberg, M., Elliott, N., DeCicco, J., Geller, H., and Mowris, R., American Council for an Energy Efficient Economy, *Energy Efficiency and Economic Development in New York, New Jersey, and Pennsylvania*, Washington, DC, 1997.

167 See Note 115.

168 Energy Information Administration, U.S. Department of Energy, *Michigan Electricity Profile*, June 2006; Energy Information Administration, U.S. Department of Energy, *Annual Energy Outlook 2006 with Projections to 2030* Supplemental Tables: (East North Central), February 2006.

169 Woods & Poole Economics, *Michigan: 2004 Data Pamphlet*, Washington, DC, 2004.

170 J. Peter Lark, Michigan Public Service Commission, *Michigan's 21st Century Energy Plan*, 31 January 2007.

171 Michigan Public Service Commission, 21st Century Energy Plan, *Resource Assessment for Renewables*, 15 November 2006.

172 Ibid.

173 Ibid.

174 Very close to data from actual energy efficiency programs in New England: see Richard Sedano and Catherine Murray, Regulatory Assistance Project, *Electric Energy Efficiency and Renewable Energy in New England: An Assessment of Existing Policies and Prospects for the Future*, May 2005.

175 Based on statistics for the federal Energy Star program: Amy Wolfe and Marilyn Brown, Oak Ridge National Laboratory, *Scenarios for a Clean Energy Future: Appendix E-1*, November 2000.

176 U.S. Department of Energy and the Electric Power Research Institute, *Renewable Energy Technology Characterizations*, EPRI Topical Report No. TR-109496, December 1997.

177 *Modeling State Energy Policy Scenarios*, a working document prepared for U.S. PIRG by Economic Research Associates, Alexandria, VA, January 2005.

178 See Note 176.

179 Ibid.

180 See Note 115.

181 Energy Information Administration, U.S. Department of Energy, *Annual Energy Outlook 2004 with Projections to 2025*, Supplemental Tables, January 2004.

182 Ibid.

183 Office of Technology Assessment, *Industrial Energy Efficiency*, Congress of the United States, Washington, DC., September 1993, page 65. For a more complete discussion on this point, see, Skip Laitner, *Energy Efficiency as a Productivity Strategy for the United States*, Economic Research Associates, Alexandria, VA, June 1995; and Joseph J. Romm, *Lean and Clean Management: How to Boost Profits and Productivity by Reducing Pollution*, Kodansha American, Ltd., 1994.

184 See Note 17.