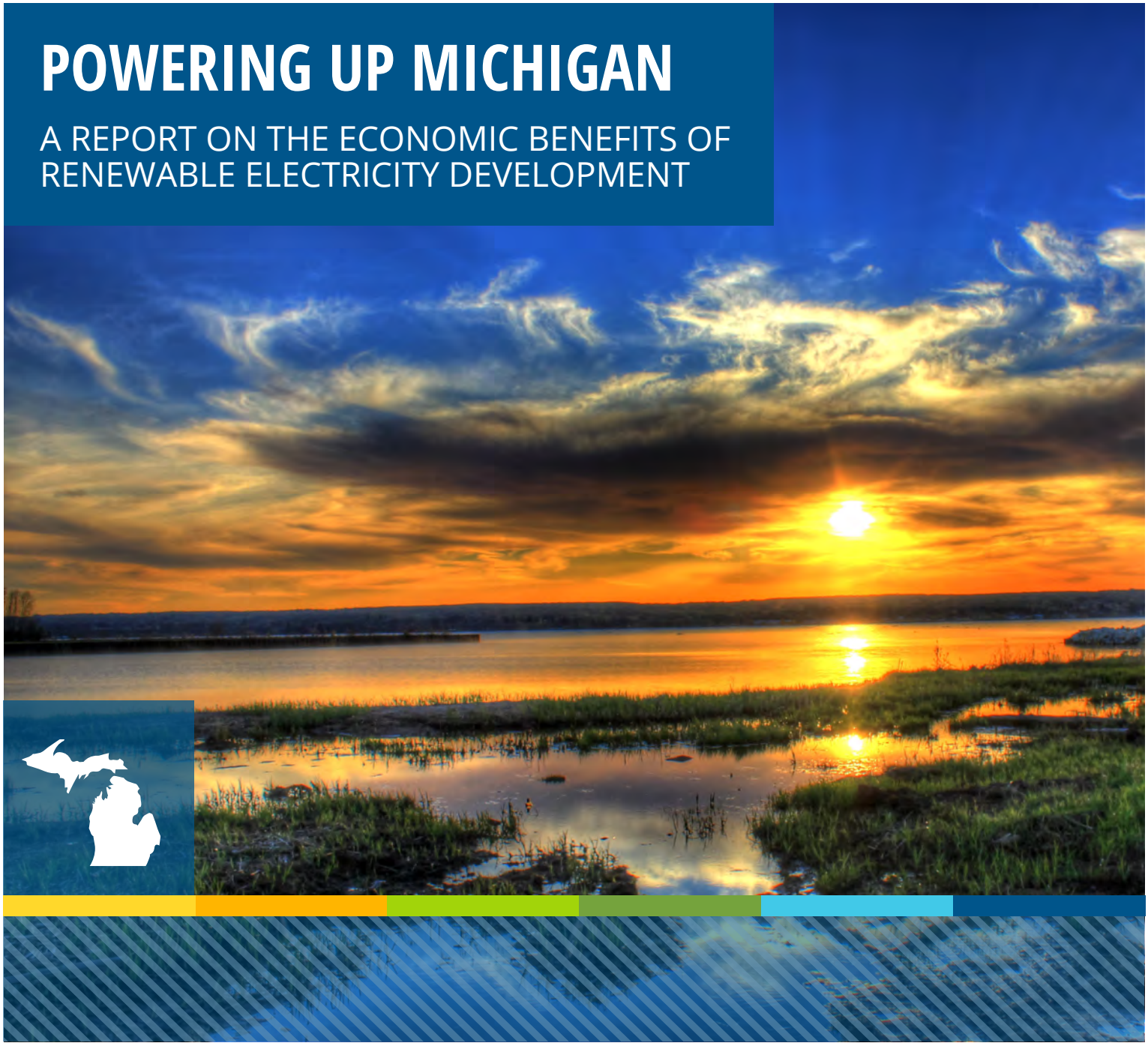
A Renewable America

POWERING UP MICHIGAN

A REPORT ON THE ECONOMIC BENEFITS OF RENEWABLE ELECTRICITY DEVELOPMENT



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JANUARY 2015

EXECUTIVE SUMMARY

Economic growth, energy independence, and new job creation are just a few of the many reasons that a significant majority of Americans consistently support developing renewable electricity.[1] Technological innovations continue to lower costs, and in recent years, several of the renewable electricity sectors have experienced significant growth, attracting billions in new private investment.

Solar, wind, hydropower, biomass, geothermal and waste-to-energy already provide more than 13 percent of U.S. electricity, and renewables are capturing an increasing share of the power grid every year.[2] In 2013, the major renewable electricity technologies provided well over 527 million megawatt hours of electricity to the utility grid – enough to supply the equivalent of over 43 million average American homes.[3] The renewable electricity industries also represent an important source of American jobs, directly employing over half a million people.

This report examines the current and potential economic benefits from developing renewable electricity in Michigan, finding that the state's existing deployment of renewable energy is already delivering significant economic benefits, as $2.2 billion has already been invested to bring new renewable energy projects online through 2013 in Michigan.

The state also has considerable untapped renewable electricity potential, and this analysis finds that developing these resources can deliver significant economic gains.

Renewable electricity is **driving economic growth** and creating jobs in communities across Michigan. The state is already home to more than an estimated 82,600 jobs in renewable power industries, energy efficiency and other conservation services.[4]

Renewable electricity offers an **affordable source of power**, as the cost of renewable electricity has declined dramatically in recent years. A recent report from the Michigan Public Service Commission concluded that the "levelized costs", or the overall competitiveness of different generating technologies, of all renewable technologies in Michigan are less than the levelized cost of a new conventional coal-fired facility.[5]

A **reliable source of power**, renewable electricity can displace the most expensive, least efficient power sources on the utility grid. For example, hydropower provided approximately 1,305,000 MWh of reliable electricity to Michigan in 2012; over 26 percent of all renewable generation in the state.[6]

While there are many examples of successful Michigan renewable electricity projects, this report features four case studies that are representative of the current and future potential for the state's renewable power industries. Utility-scale projects, including the Viking Energy biomass facility in McBain, the Kent County Waste-to-Energy facility, and the Apple Blossom Wind Farm in Huron County, as well as projects by large institutions, including General Motors, are featured in greater detail below. The case studies demonstrate that renewable energy is delivering low cost, reliable electricity, and creating jobs, while also saving businesses and other institutions money.

This report also builds on a scenario from the U.S. Department of Energy's (DOE) 2012 *Renewable Electricity Futures* study, which demonstrates that the U.S. is able to reliably and affordably meet 80 percent of its electricity use by 2050.

In a "**High Renewables**" scenario, Michigan has the potential to deploy as much as 19,497 megawatts of additional installed renewable electricity capacity by 2030 (enough to supply almost 48 percent of overall state electricity use). Michigan could nearly quintuple its renewable energy use from 2015 levels by 2030. Our report finds that this deployment would:

- Create over 160,000 additional local jobs and about $9 billion more in wages and benefits during construction.
- After construction and during its operation, this new renewable energy would create more than 5,000 additional annual jobs, approximately $276 million in annual wages and benefits, and about $425 million in annual tax revenue and $50 million in revenue to Michigan landowners per year.

Even in a "**Low Renewables**" scenario, characterized by low growth in electricity demand and 'Business-As-Usual' with no new policies, about 966 MW of additional renewable electricity capacity would be added by 2030. These additions would be driven by Michigan's Renewable Portfolio Standard (RPS) and the increasing competitiveness of renewable energy technologies. Our report finds that this deployment would:

- Create almost 7,800 jobs and over $440 million in wages and benefits during construction
- After construction and during operation, these new renewable electricity facilities would create more than 280 annual jobs, approximately $15.5 million in annual wages and benefits, and over $21 million in annual tax revenue and $2 million in annual land leasing revenue.

Finally, in June 2014, the U.S. Environmental Protection Agency (EPA) proposed a rule, known as the Clean Power Plan, to reduce carbon dioxide emissions from existing power plants. The rule aims to cut national emissions 30 percent from 2005 emissions by 2030, with an interim target of 25 percent on average between 2020 and 2029.[7] In developing emission reduction targets for each state, EPA assumed a certain level of renewable energy development, energy efficiency improvement, and increased natural gas use in each state.

The proposed rule calls for Michigan to reduce carbon dioxide emissions by 31 percent by 2030.[8] In our "High Renewables" case, renewable energy development would produce six times as much renewable energy as EPA projected.[9] Even in the "Low Renewables" case, Michigan would exceed the EPA assumption of renewable energy development thanks largely to the Michigan RPS. As demonstrated in greater detail below, these results imply that Michigan should be able to easily meet or exceed its emission reduction target.

MICHIGAN RENEWABLE ENERGY SUCCESS STORIES

Michigan is home to hundreds of companies that either produce renewable electricity or supply the components to build and maintain new projects. These companies employ thousands of workers and contribute billions to the state's economy. According to a recent report from the Michigan Public Service Commission:

> **"Conservatively, assuming installed cost of $2,000 per kW for new renewable energy projects, over $2.2 billion has been invested to bring 1,113 MW of new renewable energy projects online through 2013 in Michigan."[10]**

This section features an overview of current renewable electricity generation in Michigan and includes four examples that illustrate the benefits of renewable power development. Utility-scale projects including the Viking Energy biomass facility in McBain, the Kent County Waste-to-Energy facility, and the Apple Blossom Wind Farm in Huron County, as well as projects by large institutions, including General Motors, are featured in greater detail below.

More than 5 percent of Michigan's electricity generation currently comes from renewable sources, and the state is on pace to double its production to 10 percent by 2015:[11]

- 1,163 MW of Wind Power
- 22 MW of Solar Power
- 369.6 MW of Hydropower
- 403.6 MW of Biomass
- 84.8 MW of Waste-to-Energy

DRIVING ECONOMIC GROWTH

Renewable electricity is helping fuel Michigan's economy.

- The state is home to more than an estimated 82,600 jobs in renewable power industries, energy efficiency and other conservation services.[12]
- There are more than 210 in-state wind and solar companies and suppliers – varying from manufacturing and operations to construction and other support sectors.[13]
- Michigan's waste-to-energy facilities contribute $185.3 million in economic activity to the state.[14]

AFFORDABLE SOURCE OF POWER

The cost of renewable electricity has declined dramatically in the past few years. Renewable power purchase agreements are typically long-term, fixed cost agreements, helping protect ratepayers from price spikes associated with other energy sources. In many cases, renewable electricity is now cost competitive with traditional electricity sources. For example:

- Wind power costs have fallen over 50 percent in the last five years.[15]
- Solar installation costs have fallen nearly 40 percent since 2010.[16]
- A recent report from the Michigan Public Service Commission concluded that the "levelized costs", or the overall competitiveness of different generating technologies, of almost all renewable technologies in Michigan are less than the $133 MWh levelized cost of a new conventional coal-fired facility.[17]

RELIABLE SOURCE OF POWER

Renewable electricity can displace the most expensive, least efficient power sources on the utility grid.

- For example, hydropower provided approximately 1,305,000 MWh of reliable electricity to Michigan in 2012; over 26 percent of all renewable generation in the state.[18]

GENERAL MOTORS CHARGES UP IN MICHIGAN WITH DIVERSIFIED RENEWABLE POWER INVESTMENTS

> "We choose to invest in biomass, solar, and waste-to-energy because of the financial benefits to General Motors. We only purchase renewable energy that is on par or beats non-renewable energy options – that is the number one priority when we evaluate projects. Renewable energy delivers direct daily savings and offers us the ability to control energy costs in the future as a hedge. Investing in renewable energy offers an opportunity to educate our customers, employees and the community that these technologies are cost competitive with traditional power."
>
> ***ROB THRELKELD,***
> *MANAGER, RENEWABLE ENERGY, GENERAL MOTORS*

EXECUTIVE SUMMARY

The General Motors (GM) Detroit-Hamtramck facility, home of the Chevrolet Volt, is powered by solar and waste-to-energy, providing a total of 58 percent of the overall power needs at the assembly plant. The solar array alone will save the facility $15,000 per year. A total of $25 million has been invested to support on-site renewable energy projects at GM facilities in Eastern Michigan in the last two years. The company has set a corporate goal to promote the use of 125 MW of renewable energy by 2020 globally across its manufacturing facilities.

BACKGROUND AND CONTEXT

GM supports a diversified energy portfolio, as it does with its products. The company has set a corporate commitment to promote the use of 125 megawatts (MW) of renewable energy by 2020 globally across its manufacturing facilities. As of November 2014, GM has installed or sourced more than 65 MW of renewable energy globally – well on its way to meeting this ambitious target. In the United States, GM has installed 9.2 MW of solar across four states – California, Maryland, Michigan, and Ohio.

In Eastern Michigan, a total of $25 million has been invested to support in on-site renewable energy projects at GM facilities in the last two years. At GM's Detroit-Hamtramck assembly plant, where the company manufactures the Chevrolet Volt and the Cadillac ELR, the facility benefits from two sources of renewable energy: solar and waste-to-energy.

LOW-COST SOLAR WILL SAVE GM MONEY

The solar installation at the Detroit-Hamtramck facility will save the plant $15,000 per year in electricity costs.

DRIVING NEW INVESTMENT

GM has invested $25 million to support on-site renewable energy projects at its Eastern Michigan facilities in the last two years alone.

MAKING THE INVESTMENT

GM partnered with DTE Energy to install a 516 kW ground-mounted solar array, the largest in Michigan at the time (in 2011) with over 4,000 thin film solar panels across seven acres of land. The $3.3 million investment required a total of 35 jobs, including equipment, engineering, and construction. The array generates electricity capable of charging 150 Chevrolet Volts every day for a year – a total of 54,750 Volts - and will save the GM facility $15,000 per year.

More recently, GM partnered with Detroit Renewable Energy to turn municipal solid waste from Metro Detroit into process steam that will be used to heat and cool portions of the assembly plant. The $11 million investment required building an 8,000-foot steam pipe from the existing waste-to-energy facility to the GM assembly plant.

GM had previously utilized coal-fired boilers for energy needs including compressed air, chilled water and hot water – which have now been taken offline. The project allowed GM to avoid over $5 million in capital investment to retrofit the boilers from coal to natural gas. GM will receive 35 percent of the total steam generated by this waste-to-energy facility, representing a total of nearly 16 MW of renewable electricity.

The combination of solar and waste-to-energy will provide 58 percent of the power needs at the GM Detroit-Hamtramck assembly plant, making it the top GM facility in the world by percentage of renewable energy used.

VIKING ENERGY BIOMASS FACILITY BRINGS JOBS TO LOCAL ECONOMY IN MCBAIN

"The Viking McBain facility services many needs in the local economy from clean and reliable power generation to offering a market for waste wood forest products and recycled tires. Biomass is able to compete with old coal and natural gas powered generation and has room to expand in Michigan." –

TOM VINE
PLANT MANAGER

EXECUTIVE SUMMARY:

The Viking Energy biomass facility in McBain, Michigan has been supporting the local market for waste wood in this rural part of the state since 1989. Contributing more than $200,000 to local tax revenue annually and creating many skilled, full-time well- paying jobs, the Viking McBain facility is a crucial economic contributor to the regional economy, contributing more than $5 million per year. The facility produces more than 16 megawatts of electricity, and provides clean, reliable, and affordable electricity to more than 13,000 average Michigan households.

BACKGROUND AND CONTEXT

Built in 1989, the Viking McBain biomass facility is owned and operated by GDF-Suez North America, a multinational energy service company. The city of McBain has historically relied on the local timber and pulpwood industries. The processing of sawlogs and pulpwood generates significant quantities of bark and pulping waste materials. Thinning operations, in which the tops and branches of larger tress are removed, produces a substantial amount of waste wood materials. Timber companies have traditionally not been able to sell this otherwise unusable waste wood material.[19] Biomass energy facilities like Viking McBain have created a market that helps reduce landfill disposal of waste wood material and sustain the local forest-logging economy. In addition to waste wood material, the facility recycles more than 60 percent of the tires used in Michigan as tire-derived fuel. While biomass capabilities are regionally specific, when scaled appropriately, biomass is able to service many different needs in a regional economy.

MAKING THE INVESTMENT

The Viking McBain facility contributes more than $5 million annually to the local economy and employs 21 full-time workers, ranging from equipment operators, technicians and control room operators to maintenance, management and administration positions.[20] Strategically sited in order to take advantage of the local timber industry, the facility is appropriately sized to the ability of the local timber industry to meet its daily energy needs. To keep transportation costs low, waste wood resources must be within a small radius of the facility.

The project generates 16.2 megawatts of electricity - enough power for approximately 13,000 homes - which is sold through a long term power purchase agreement with Consumers Energy, the state utility provider. With lifetime availability of 97 percent and a capacity factor greater than 99 percent, the Viking McBain facility has proven that biomass delivers a reliable and stable energy source. The project was recognized in 2011 by the State of Michigan through the Clean Corporate Citizen program which recognizes local business that have demonstrated environmental stewardship and a strong environmental ethic.

TECHNOLOGY SPOTLIGHT: BIOMASS IN MICHIGAN

Biomass in Michigan supports an estimated 145 direct jobs and over 600 jobs in processing, handling, and transporting waste wood fuel. More than $50 million is spent on biomass fuel annually by Michigan's 6 biomass facilities. These facilities are located in small and rural communities and they are often the largest employer and tax contributor to the local economy. It is estimated that the biomass industry in Michigan contributes over $72 million per year to the state economy through taxes, payroll and the purchase of goods and services.[21] Roughly 20 percent of Michigan's renewable energy come from-forest based, wood by-products. This means cleaner air, affordable electricity, healthier forests, improved landfill longevity and strong and robust local job creation.

INCREASING LOCAL TAX REVENUE

The Viking Energy biomass facility contributes more than $200,000 in annual tax revenue to the local community.

REDUCING LANDFILL DISPOSAL

Biomass energy facilities like Viking McBain have created a market that helps reduce landfill disposal of waste wood material and sustain the local forest logging economy. In addition to waste wood material, the facility recycles more than 60 percent of the tires used in Michigan as tire-derived fuel.

HURON COUNTY ATTRACTS $200 MILLION INVESTMENT FROM APPLE BLOSSOM WIND FARM

EXECUTIVE SUMMARY:

Huron County will add an additional 100 megawatts (MW) of wind power to expand the already impressive 600 MW of installed wind capacity. The Apple Blossom Wind Farm is estimated to represent a total investment of $200 million once fully developed, and land lease payments to local farmers and land owners will average half a million per year. The project will generate enough electricity to power 24,000 average homes.

BACKGROUND AND CONTEXT

The Apple Blossom Wind Farm is under construction by Geronimo Energy, a utility-scale wind and solar energy developer based in Minnesota, with plans to begin operation in 2015. The "Thumb" region in eastern Michigan has strong wind resources with over 300 wind turbines already built at over ten locations. Among the reasons for locating the wind farm in Michigan, Charlie Daum, director of business development at Geronimo cited "favorable market forces, including a strong renewable portfolio standard, a robust and expanding transmission, an abundant wind resource, and most importantly, a welcoming community, made our decision to invest in Huron County very easy."[22]

NEW LOCAL INVESTMENT AND NEW REVENUE FOR LOCAL FARMERS

The Apple Blossom Wind Farm is estimated to draw a total investment of $200 million once fully developed, and land lease payments to local farmers and land owners are expected to average $1 million per year.

JOB CREATION

The project is expected to create 100 short-term construction jobs, and ten full-time positions when complete.

MAKING THE INVESTMENT

It is estimated that the Apple Blossom wind farm will bring in more than $200 million in investment, payroll, taxes and direct and indirect spending. Land lease payments to local farmers and land owners will total an average of half a million dollars a year, providing a steady and important revenue stream. Energy produced at Apple Blossom wind farm will provide Huron County with a large source of tax revenue each year, benefitting the school district, fire departments and townships. The project will create 100 short term construction jobs and 8 to 10 full-time positions when it is completed. Once constructed, the 100 megawatts of wind will generate enough electricity to power 24,000 Michigan homes, displacing over 216,000 tons of carbon emissions per year.

TECHNOLOGY SPOTLIGHT: MICHIGAN WIND POWER

Reviving Michigan's proud manufacturing legacy, the state is home to 121 companies that produce, manufacture, and supply wind turbine components, employing an estimated 4,000 people. New investment in wind energy has brought old manufacturing plants back to life in Michigan.[23]

KENT COUNTY TRANSFORMS WASTE INTO ENERGY TO PRODUCE RENEWABLE ELECTRICITY

> "Waste-to-energy facilities are net greenhouse gas (GHG) reducers meaning that for every ton of trash burned, waste-to-energy facilities reduce net GHGs by more than one ton, when compared to a traditional landfill. In addition, waste-to-energy facilities maintain the strictest emissions controls and are always investing in new technologies to reduce emissions further."
>
> ***DOUG WOOD,***
> *DIRECTOR, KENT COUNTY DEPARTMENT OF PUBLIC WORKS*

EXECUTIVE SUMMARY

The Kent County Waste-to-Energy (WTE) Facility in Grand Rapids has 40 full-time employees with an estimated annual payroll of $4.5 million. The plant processes 625 tons-per-day of municipal solid waste – representing 25 percent of the volume of waste generated by the county – generating 16 megawatts of electricity.

BACKGROUND AND CONTEXT

The Kent County WTE facility began commercial operation in February of 1990, servicing the solid waste management needs of the 600,000 residents of Kent County including the cities of Grand Rapids, Kentwood, and Wyoming. The project is owned by the county and operated by Covanta Kent, Inc. Processing 625 tons of municipal waste daily, the facility recovers energy from approximately 183,000 tons of municipal waste a year, representing 25 percent of the volume of waste generated by the county. The Kent County facility generates 16 megawatts (MW) of power, sold through a long-term power purchasing agreement with Consumer's Energy.

Kent County considers WTE an economically and environmentally appealing option in meeting the county's municipal solid waste needs. Taking up just nine acres, the Kent County WTE facility produces more energy in less space than the average landfill. On average, a WTE facility can produce one MW of electricity on just 0.7 acres, whereas a landfill-methane capture system would require 27 acres. The Kent County facility is located just 1.5 miles from downtown Grand Rapids, making it a much preferred low-profile alternative to a municipal dump landfill.

MAKING THE INVESTMENT

Waste-to-energy facilities require large upfront capital investments. Each new facility generates approximately $1 billion in total direct and indirect spending with an estimated 700 to 1,000 construction jobs created over the average two and a half year construction time span.[24] The Kent County project was financed through municipal bonds, paid back through revenue generated from disposal fees and the sale of electricity to Consumer's Energy.

The facility has 40 full-time employees ranging from repair and maintenance technicians to plant operators, with an average annual salary of $85,000 a year and an annual payroll of $4.5 million.

The Kent County WTE facility has been able to maintain a 90 percent boiler availability rate highlighting the reliability of waste-to-energy facilities to meet base-load requirements. In order to accommodate greater volume and generate more electricity, the Kent County facility was designed for future expansion. The county will be considering expansion options in the near future.

Technology Spotlight: Waste to Energy

Nationwide, the waste-to-energy sector employs approximately 5,400 Americans with direct labor earnings estimated at $459 million in wages, salaries, and benefits. The 84 waste-to-energy facilities in the U.S. generated approximately 14.5 million megawatt hours of electricity in 2012, enough to power 1.3 million U.S. homes.[25]

JOB CREATION

The Kent County WTE facility has 40 full-time employees with an estimated annual payroll of $4.5 million.

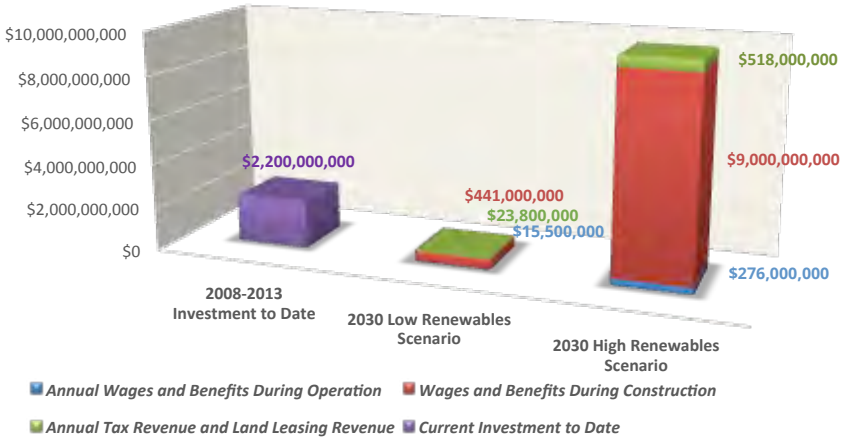
REDUCING LANDFILL DISPOSAL TO PRODUCE RENEWABLE ELECTRICITY

The plant processes 625 tons-per-day of municipal solid waste – 25 percent of the volume of waste generated by the county – generating 16 megawatts of electricity.

MICHIGAN'S RENEWABLE FUTURE

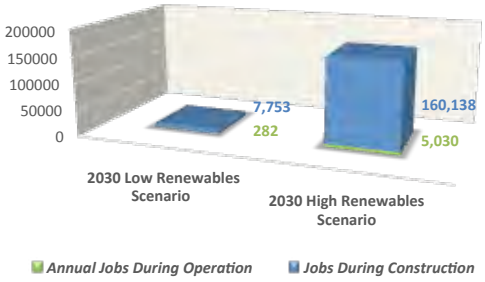
Our key findings are summarized below (see Methodology section for data sources and methods used and Appendix for consolidated data table).

Current Investment and Potential Future Opportunities for Renewable Electricity in Michigan



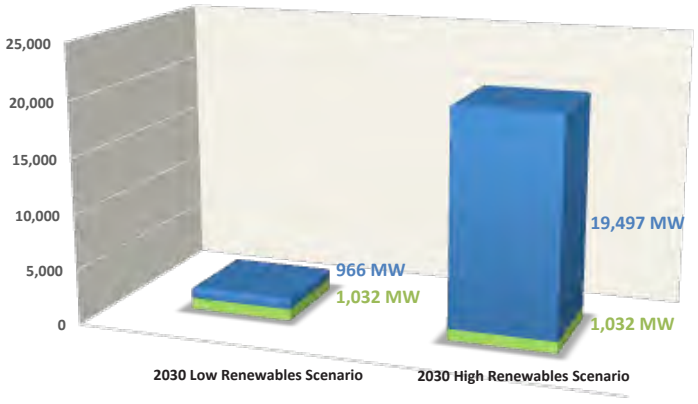
Michigan's existing deployment of renewable energy is already delivering significant economic benefits, as $2.2 billion has already been invested to bring new renewable energy projects online through 2013 in Michigan. In a "High Renewables" scenario, the state has the potential to attract $9 billion more in wages and benefits during construction.

Jobs During Construction and Operation



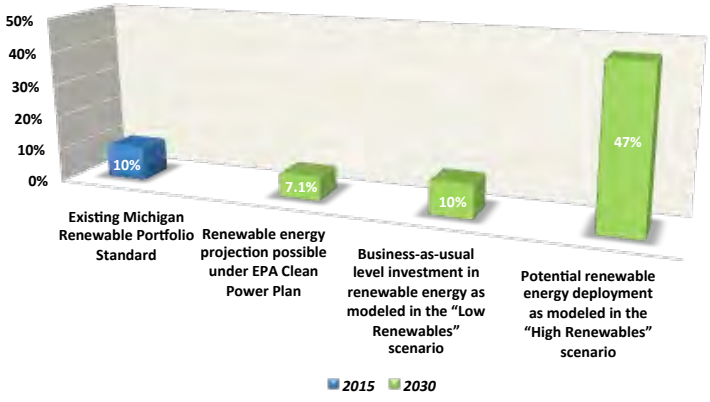
In a "High Renewables" scenario, Michigan has the potential to create over 160,000 additional local jobs during construction and more than 5,000 additional annual jobs committed to operations and maintenance.

Additional Installed Capacity (MW)



In a "High Renewables" scenario, Michigan could nearly quintuple its renewable energy use from 2015 levels by 2030.

Potential Renewable Electricity Capacity



In our "High Renewables" case, renewable energy development would produce six times as much renewable energy as EPA projected.

MICHIGAN'S RENEWABLE ELECTRICITY DEVELOPMENT POTENTIAL FAR EXCEEDS THE PROPOSED CLEAN POWER PLAN

The EPA Clean Power Plan calls for Michigan to reduce carbon dioxide emissions by 31 percent by 2030.[26] EPA based Michigan's target on cuts through the following measures:

- A 5.1 percent reduction through increased efficiency of coal plants
- An 11.5 percent reduction through increased use of low-emitting natural gas combined cycle plants where excess capacity is available
- A 4.1 percent reduction through the use of more zero-emitting power sources such as renewable energy and nuclear power, and
- A 10.5 percent reduction through energy efficiency improvements to reduce electricity demand.[27]

Michigan has a great deal of flexibility in developing its compliance plan, and may choose these or other carbon reduction strategies. A state could select a different balance among the approaches than EPA used to set the proposed emission reduction target.

Analysis from the Union of Concerned Scientists (UCS) demonstrates that even under a conservative growth scenario, states can achieve twice the renewable energy proposed by the EPA. According to UCS analysis, the Clean Power Plan does not sufficiently consider existing renewable energy deployment rates or the falling costs of renewable energy.[28] Another recent analysis based on modeling by ICF International, a business management consulting firm, concludes that the EPA utilized outdated renewable energy cost considerations, including "levelized costs for both wind and solar energy that are 46 percent above current average costs". The recent price drops in renewable energy will likely make the proposed rule less expensive to meet, and provide even greater opportunity for renewable energy development.[29]

Our analysis shows that Michigan could meet the entire EPA emissions reduction target through the increased use of renewable energy.

Indeed, Michigan also has the potential for significant renewable electricity development far beyond what is likely under the proposed standards. Developing those resources would attract substantial investment to the state and create thousands of new jobs.

Renewable energy projection possible under EPA Clean Power Plan	**7.1% by 2030**
Business-as-usual level investment in renewable energy as modeled in the "Low Renewables" scenario	**10% by 2030**
Existing Michigan Renewable Portfolio Standard	**10% by 2015**
Potential renewable energy deployment as modeled in the "High Renewables" scenario	**47% by 2030**

In the proposed Clean Power Plan, the EPA proposed a 2030 target emissions rate for each state. This target is based on EPA estimates of how each state could leverage a mix of measures, including adding new renewable electricity generation. States are not required to achieve EPA's renewable projections in order to comply with the proposed Clean Power Plan, or they may exceed them if cost-effective for the state. For Michigan, EPA projects 7.1 percent renewable energy generation under the proposed rule by 2030.

In accordance with the proposed rule, states will continue to drive significant carbon dioxide emissions reductions by investing in renewable electricity technologies. For example, according to the EPA, every ton of municipal solid waste processed at a waste-to-energy facility reduces lifecycle GHG emissions by one ton of carbon dioxide equivalents.

Michigan already meets the EPA proposed target and is on track to exceed it before 2030, due to its existing state Renewable Portfolio Standard of 10 percent by 2015.

The "High Renewables" scenario modeled here and in the NREL *Renewable Electricity Futures* study would significantly exceed the EPA proposed target.

RESEARCH METHODOLOGY

PURPOSE OF STUDY

David Gardiner and Associates (DGA) conducted this study for the Wind Energy Foundation and the A Renewable America campaign to assess the overall opportunity for renewable energy-based economic development in Michigan.

METHODOLOGY

DGA modeled the economic effects of a renewable electricity future in 2030 for Michigan based on two trajectories from the 2012 National Renewable Energy Laboratory (NREL) Renewable Electricity Futures (REF) study, the most comprehensive analysis of high-penetration renewable electricity in the United States to date.[30] That study involved a collaboration of more than 100 experts from 35 institutions representing national energy labs, academia, utilities, grid operators, industry, financial institutions, environmental groups and renewable energy businesses. It found that the United States could reliably meet at least 80 percent of its electricity needs from renewable energy resources by 2050, at a cost comparable with other scenarios for reducing harmful carbon dioxide (CO_2) and other power plant pollutants.

DGA features a "Low Renewables" and a "High Renewables" scenario based on updated 2014 results of the NREL Regional Energy Deployment System (ReEDS) model, completed by authors of the original REF study.[31]

- The "Low Renewables" scenario in this study is based on the "Low Demand Baseline" in the REF study. It assumes that electricity demand grows very slowly, and that no new renewable energy policies are enacted. Existing federal policies are assumed to expire as scheduled.
- The "High Renewables" scenario in this study is based on the REF "Core 80% RE scenario '80% RE-ITI'". It assumes that policies are enacted to achieve 49 percent of total contiguous U.S. electricity generation from renewable sources in 2030 and 80 percent in 2050, without specifying which of many policies could enable achieving that goal. It also assumes low electricity demand growth, and only incremental technology improvement (ITI) that reflects partial achievement of the future technical advancements that may be possible for each technology.

DGA did not utilize the scenario from REF that assumed a higher rate of "Evolutionary Technology Improvement", or scenarios that assumed "No Technology Improvement" or that assumed various potential constraints on renewable energy development, such as inadequate available renewable resources, inadequate transmission, or inadequate flexibility technologies, such as energy storage, needed to balance electricity demand with supply.[32] DGA also did not utilize REF scenarios with high energy demand, which would have produced higher levels of renewable energy development.

ReEDS calculates the mix of renewable energy and other technologies in each state that could meet the national renewable energy goals at the lowest total system cost.

DGA then calculated the economic development impacts of the five major renewable electricity technologies (biomass, geothermal, hydroelectric power, solar, and wind) using the NREL Jobs and Economic Development Impact (JEDI) model, with its generic default cost assumptions. JEDI was initially designed to estimate economic impacts of renewable energy to state economies, and later refined to focus on specific renewable energy projects. It includes both direct employment in the projects and their supply chains, and indirect and induced employment including wages and benefits spent in the state or local region.

The JEDI model is not a macroeconomic model, and does not calculate any offsetting reduction in employment in other parts of the economy, such as extracting fossil fuels. Many previous studies have found, however, that renewable energy technologies yield more employment per dollar or per megawatt than fossil fuel technologies, and thus lead to net increases in employment.[33]

DGA has also not calculated the economic benefits of other investments needed to enable the "High Renewables" scenario, such as upgrades to transmission and distribution systems, or the development of energy storage or other flexibility resources. ReEDS calculates that the "High Renewables" scenario would also be accompanied by 2,165 MW of electricity storage technologies by 2030.

While distributed generation solar photovoltaics are exogenous to the ReEDS model, which focuses primarily on utility-scale solar opportunities, the REF study utilized a separate model to represent rooftop solar PV deployment.

The REF study and JEDI model do not include specific estimates for waste-to-energy technology. We include an estimate of the technical potential for waste-to-energy expansion in the key findings section of the report, based on a recent study from Columbia University.[34] The growth assumptions for waste-to-energy in this report are based on the percent of municipal solid waste (MSW) used at waste-to-energy facilities in Europe (which process 25 percent of MSW using waste-to-energy facilities, as opposed to 7.6 percent in the United States). Unlike the ReEDS modeling for other technologies, that estimate is not based on any assessment of the economic competitiveness of waste-to-energy relative to other electricity generation technologies. Other studies, such as the U.S. Energy Information Administration Annual Energy Outlook, have found that significant expansion of waste to energy is unlikely under business-as-usual or with modest renewable energy or greenhouse gas reduction policies. Expanded use of waste-to-energy is possible under policies favorable to that technology, however.

APPENDIX

Total Renewable Electricity (Biomass, Geothermal, Hydroelectric, Solar, and Wind)	2030 High Renewables Scenario	2030 Low Renewables Scenario
Additional Installed Capacity	19,497 MW	966 MW
Local Jobs During Construction	160,138	7,753
Wages and Benefits During Construction	$9 billion	$441 million
Annual Jobs During Operation	5,030	282
Annual Wages and Benefits During Operation	$276 million	$15.5 million
Annual Tax Revenue and Land Leasing Revenue	$518 million	$23.8 million
Wind (185 MW in 2010)	2030 High Renewables Scenario	2030 Low Renewables Scenario
Additional Installed Capacity	16,698.5 MW	791.8 MW
Local Jobs During Construction	73,434	3,471
Wages and Benefits During Construction	$3.9 billion	$186 million
Annual Jobs During Operation	3,641	171
Annual Wages and Benefits During Operation	$193.3 million	$9 million
Annual Tax Revenue and Land Leasing Revenue	$375.3 million	$18 million
Biomass (438 MW in 2010)	2030 High Renewables Scenario	2030 Low Renewables Scenario
Additional Installed Capacity	25.4 MW	25.4 MW
Local Jobs During Construction	49	49
Wages and Benefits During Construction	$4 million	$4 million
Annual Jobs During Operation	38	38
Annual Wages and Benefits During Operation	$2 million	$2 million
Hydroelectric Power (408 MW in 2010)	2030 High Renewables Scenario	2030 Low Renewables Scenario
Additional Installed Capacity	2,535 MW	148.8 MW
Local Jobs During Construction	72,135	4,233
Wages and Benefits During Construction	$4.3 billion	$251 million
Annual Jobs During Operation	1,244	73
Annual Wages and Benefits During Operation	$74.3 million	$4.3 million
Annual Tax Revenue and Land Leasing Revenue	$99.5 million	$5.8 million
Solar (0.3 MW in 2010)	2030 High Renewables Scenario	2030 Low Renewables Scenario
Additional Installed Capacity	238 MW	N/A*
Local Jobs During Construction	14,519	N/A*
Wages and Benefits During Construction	$792 million	N/A*
Annual Jobs During Operation	106	N/A*
Annual Wages and Benefits During Operation	$6.2 million	N/A*
Annual Tax Revenue and Land Leasing Revenue	$43 million	N/A*

*** Both scenarios estimate an extremely limited deployment of geothermal in Michigan.**

*** NREL assumed no growth for distributed generation solar PV in the Low Renewables scenario.**

Separately, this report also reviewed the technical potential for waste-to-energy in Michigan.

Waste-to-Energy (84 MW in 2014)	2030 Additional Capacity Potential
	236 MW

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Page 13 Kent County Covanta Waste-to-Energy Facility.
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ABOUT THE ORGANIZATIONS

A RENEWABLE AMERICA

A project of the Wind Energy Foundation, a 501c3 nonprofit organization, *A Renewable America* provides education about the many benefits of American-made renewable electricity. A Renewable America raises public awareness of how each of the six major U.S. renewable electric technologies – biomass, geothermal, hydro, solar, waste-to-energy, and wind power – are already providing a substantial amount of clean, affordable, and reliable electricity. For more information, visit www.arenewableamerica.org.

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The Wind Energy Foundation is a 501c3 nonprofit organization dedicated to raising public awareness of wind as a clean, domestic energy source through communication, research, and education. The Foundation is also committed to supporting ongoing research that furthers the continued growth of wind energy. For more information, visit www.windenergyfoundation.org.

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