Renewable Energy 8: *What is Michigan's long-term potential for more wind, solar, hydro, biomass, landfill gas, and other renewables sources?*

Executive Summary

1. The long-term potential for renewable energy can be defined in different ways. The "resource" or "technical" potential provide upper bound estimates whereas the "economic" and "market" potential are more limited, taking into consideration costs, various federal and state policies—particularly tax treatment—public attitudes, and other factors.

2. There are several studies and data sources addressing Michigan's potential for renewable energy, particularly wind energy. Few address market or economic potential or public attitudes and acceptance. Public Sector Consultants estimates that the market potential is around 1,800 MW (in addition to the capacity necessary to meet the current 10% RPS). This is based on proposed projects in response to utility requests for proposals for renewable generation, projects in MISO queue, market pricing info and trends, and discussions with industry experts. As with all estimates, there is uncertainty.

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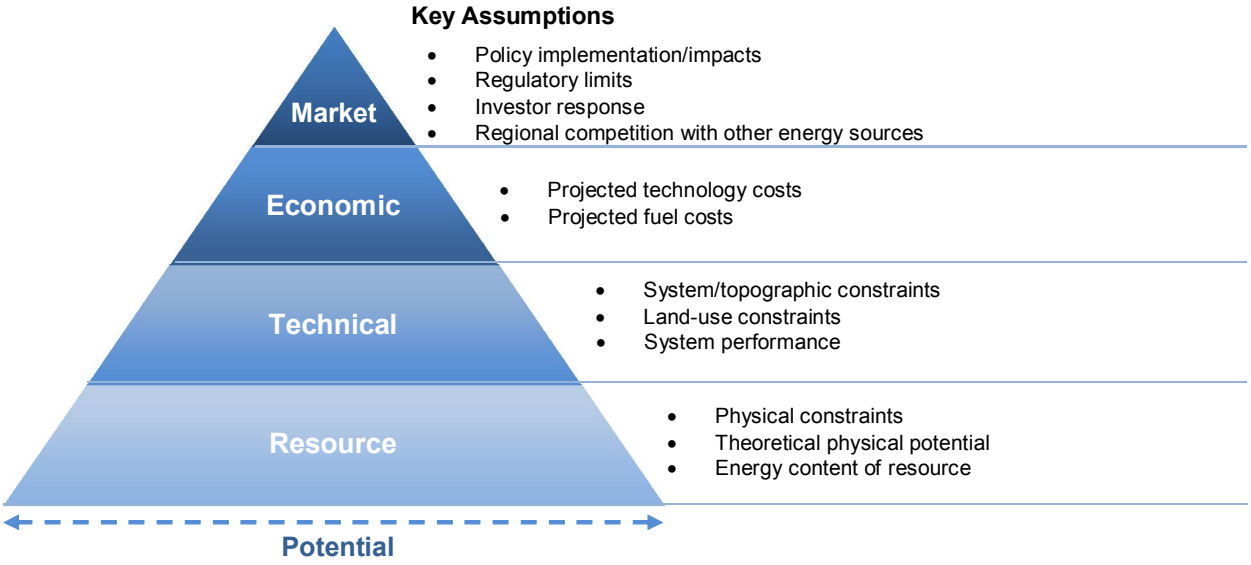
The National Renewable Energy Laboratory (NREL) has conducted numerous studies nationally, with estimates by state, of renewable energy potential. The NREL defines different types of "potential" according to the pyramid shown below in Exhibit 1.

EXHIBIT 1. NREL Renewable Energy Potential Definitions



SOURCE: National Renewable Energy Laboratory, Renewable Energy Technical Potential, 2012. Available at: www.nrel.gov/docs/fy12osti/51946.pdf

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These definitions are important to consider when evaluating different types of potential studies below.

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   Several studies and data sources address, directly or indirectly, the renewable energy potential in the state, as summarized in Exhibit 2 and discussed further below. Estimates range from about 1,800 MW to over 4 million MW. For reference, Michigan's *total* current generating capacity from all renewable and non-renewable sources is 29,831 MW. The estimates vary considerably due to different methodologies, timing, applicable technologies, and purpose. Most of the formal studies listed (NREL, Great Lakes Offshore Wind Council, Wind Energy Resource Zone Board) provide the technical potential, and do not fully consider market or economic potential or public attitudes and acceptance. In addition to these studies, there are other data sources, including the Midwest Independent Transmission System Operator (MISO) generation interconnection queue and responses to utility RFPs, which relate to the potential and actual trends with respect to renewable energy developments in the state.

EXHIBIT 2. Data Points and Study Results on Renewable Energy Potential in Michigan

	MW	% Breakdown by Technology	Offshore wind included?	Type of Potential
NREL (2012)	4,042,000 MW	Solar PV 87% Onshore wind 1% Offshore wind 10% Biomass/other 1%	Yes	Technical
Great Lakes Offshore Wind Council (2009-2010)	~100,000 MW	Offshore wind 100%	Yes	Technical
Wind Energy Resource Zone Board (2009)	3,421–6,122 MW	Onshore wind 100%	No	Technical
21st Century Energy Plan (2007)	1,100–2,700 MW (plus 180 MW from combined heat and power)	Onshore wind Biomass	No	Economic/Market
MISO interconnection requests (April 2013)	2,539 MW	Onshore wind 83% Hydro 17%	No	Economic/Market
Public Sector Consultants estimate of market potential	1,800 MW	Onshore wind ~ 90% Biomass ~8-9% Landfill gas ~1%	No	Economic/Market

SOURCE: MPSC, 21st Century Electric Energy Plan, January 2007. National Renewable Energy Laboratory, U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis (July 2012). Available at: http://www.nrel.gov/docs/fy12osti/51946.pdf. Report of the Michigan Great Lakes Wind Council, September 1, 2009; see also Final Report, October 1, 2010. Midwest ISO Generation Interconnection Queue, March 20, 2013. Available at www.midwestiso.org. Public Sector Consultants (2013).

NREL

There are several studies by NREL that form "upper bound" estimates of renewable energy potential. The most current is *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis,* published in July

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2012. The NREL technical potential estimates for Michigan, in megawatts by technology type, are shown below.[1]

- Solar PV utility scale—3,478,000 MW
- Solar PV rooftop—22,000 MW
- Onshore wind—59,000 MW
- Offshore wind—423,000 MW
- Biopower—2,000 MW
- Enhanced geothermal—58,000 MW

In total, this is 4,042,000 MW, or 7.6 million gigawatt-hours (GWh) of electricity; this represents **over 70 times** the total retail electric sales in the state.[2] Based on this data, utility-scale solar PV represents 86% of overall potential with most of this on rural lands in Michigan with rooftop solar representing another 1%. Because solar PV does not need large contiguous areas, it is less constrained (therefore, higher potential) than other resource types such as offshore or onshore wind in studies like this one. Moreover, the solar potential is so high because this study does not consider the economics of the various resource options or other issues with implementation.

The NREL studies use geographic-based data sets on land characteristics and conflicting uses and available resources such as wind speeds and patterns to formulate the technical potential. They also consider technology performance to estimate the energy that can be produced and related capacity factors (e.g., wind turbine technical specifications applied to the applicable wind speeds). This approach involves extensive modeling but, as discussed above, does not consider economic or market factors or other practical considerations. NREL explains:

> These are technology-specific estimates of energy generation potential based on renewable resource availability and quality, technical system performance, topographic limitations, environmental, and land-use constraints only. The estimates do not consider (in most cases) economic or market constraints, and therefore do not represent a level of renewable generation that might actually be deployed.[3]

While the NREL considers conflicting land uses at a high level, there are limitations in the data and the studies do not consider the realities of siting, including setbacks and landowner and local government opposition. This is important in Michigan because there are many landowners involved in a single wind project (roughly 50 for utility-scale project covering 15,000–20,000 acres) compared to three or four landowners for a project in Texas, where there are large tracts of open land under common ownership.

[1] National Renewable Energy Laboratory, U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis (July 2012). Available at: http://www.nrel.gov/docs/fy12osti/51946.pdf. Technologies not included in graph with values of 0 or <1 GW for Michigan were: concentrating solar power (CSP), hydropower, and hydrothermal.
[2] Total retail electricity sales in 2010 were 103,649,219 MWh, or 103,649 GWh, according to EIA's Michigan electricity profile. See http://www.eia.gov/electricity/state/michigan/index.cfm.
[3] National Renewable Energy Laboratory, U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis (July 2012), p. iv. Available at: http://www.nrel.gov/docs/fy12osti/51946.pdf.

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Great Lakes Offshore Wind Council

In response to an executive order issued by Governor Granholm, the Great Lakes Offshore Wind Council was formed and developed estimates of offshore wind energy potential. The study considered numerous social, physical, and ecological factors such as distance from shore (visual impacts), bathymetry (depth), shipping channels, and migratory bird pathways. Depth is very important because it affects the technical and economic feasibility of offshore projects. Only 7,874 square miles of Michigan's 38,448 square miles of Great Lakes bottomlands are at depths at or below 30 meters, the practical limit for turbine placement based on experience in Europe. At 30 meters, the potential for offshore wind energy in Michigan was nearly 100,000 MW, but the council acknowledged that permitting, siting, and other factors could significantly affect this estimate. The council also considered the renewable potential at depths of 45 meters since there was a piloted project at this depth in Europe.[4] The economic feasibility of offshore wind in Michigan was not considered.

Wind Energy Resource Zone Board

On behalf of the Wind Energy Resource Zone (WERZ) Board created under PA 295, Michigan State University used a methodology similar to that of the NREL to estimate the total energy and capacity of onshore wind energy in areas with the highest potential in the state. For the four "highest potential" areas in the state, the estimated total wind capacity ranged from 3,421 to 6,122 MW. This can best be described as a technical potential study, and it exceeds what is needed under the current RPS in addition to all the projects currently in the queue. While the board found that utility-scale wind energy was commercially viable technology and examined proposed projects in the interconnection queue, it did not review in detail the economics of the wind potential under its various scenarios.

21st Century Energy Plan

The 21st Century Energy Plan, issued in 2007 by the chairman of the Michigan Public Service Commission (MPSC), estimated the potential for renewable energy in the range of 1,100–2,700 MW. This was based on modeling for biomass[5] and utility-scale onshore wind resources. The plan emphasized the need to revisit these estimates, stating:

> Forecasting in this area is particularly problematic, in light of the rapid pace of technological advancements and policy changes that will affect renewables. It is thus important to revisit renewable resource modeling on a regular basis, and to expand the renewable portfolio when appropriate.[6]

MISO Generation Interconnection Queue

There is 2,539 MW of renewable generation active in the MISO generation interconnection queue. This is composed of 25 renewable projects (primarily wind) that are being studied to determine impacts on the electric grid and any necessary improvements to reliably deliver the power from such sources. With the exception of six projects (70 MW each for a total of 420 MW) related to the Ludington pumped storage upgrade, the remaining amount (~2,100 MW) consists of proposed wind projects.[7] Inclusion in the queue

[4] Report of the Michigan Great Lakes Wind Council, September 1, 2009; see also Final Report, October 1, 2010.
[5] Biomass consisted of three major sources: (1) combustion of cellulose-containing biomass such as wood and cornstalks; (2) anaerobic digestion of wastewater treatment plant waste, and cattle, swine and poultry waste; and (3) combustion of landfill gas.
[6] MPSC, 21st Century Energy Plan, January 2007, p. 26.
[7] One project, a 20 MW wind project, remains "active" in the queue and is included in these estimates and Appendix 1 but is already in service with a temporary generation interconnection agreement.

does not mean the project will be built but it is an indication of market potential and interest from project developers. Up-to-date information on the queue is available on MISO's website and a summary of Michigan projects in the queue as of March 13, 2013, is included in Appendix 1.

Public Sector Consultants Estimate of Market Potential

Public Sector Consultants estimates the market potential is roughly 1,800 MW (in addition to the capacity necessary to meet the current 10% RPS). This is based on proposed projects in response to utility requests for proposals for renewable generation, projects in MISO queue, market pricing info and trends, and discussions with industry experts. The total is broken down as follows:

- Onshore wind—approximately 1,600 MW
- Biomass—approximately 150 MW
- Landfill gas—approximately 15 MW

These estimates are subject to change. Several policy and economic factors will influence the level of interest by renewable energy developers going forward such as:

- The state's RPS policy
- Federal tax incentives
- Generation interconnection processes and related cost allocation
- Overall market conditions, including financing trends and wholesale energy prices and market rules affecting renewable projects
- Technology
- Public attitudes and acceptance

There is uncertainty related to all of these factors. For example, while there have been significant advancements in wind energy technology, there may be a point where that tapers off. Turbine sizes have grown considerably over the past several years, thereby increasing the energy output of wind turbines. But turbines can only be so high and blades so long before there are siting difficulties, such as Federal Aviation Administration restrictions. Conversely, there may be new materials developed or advancements in the efficacy and cost performance of wind energy, energy storage, or other technologies that expand the market potential for renewable energy over time. In addition, Michigan's greatest wind resources are offshore, and there is no offshore wind in this estimate given that it is not commercially viable in the near term.

In conclusion, there is a significant difference between the technical and market potential for renewable energy in Michigan. Market potential is still an estimate subject to change but more grounded in reality, recognizing economic and siting constraints. Even the best estimates of market potential are subject to economic, policy, public acceptance, and other factors so all estimates should be used with the appropriate level of caution.

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Appendix 1

Proposed Projects in Michigan in MISO Generation Interconnection Queue (March 20, 2013)

MISO Project Number	MISO Queue Date	Project Transmission Owner (TO)	County	Point of Interconnection	Max Summer Output (MW)	In-service Date	Fuel Type	Study Status
G934	1/24/2012	METC	Gratiot	METC Nelson Road 345kV substation	150	10/1/2010	Wind	SPA - Parked
G997	12/7/2010	ITCT	Huron	Wyatt - Harbor Beach 120kV	50	12/31/2012	Wind	SPA - Parked
J075	10/5/2009	ITCT	Huron	Bauer - Rapson 345 kV	150	5/15/2014	Wind	DPP - System Impact Study
J119	3/17/2010	ATC	Chippewa	Pine River 69 kV Substation	61.2	7/31/2012	Wind	SPA - Parked
J161	8/31/2010	ITCT	Tuscola	Bauer - Rapson 345 kV	155	4/15/2014	Wind	DPP - System Impact Study
J185	11/15/2010	ITCT	Huron	METC Cosmo - Harvest Wind 120kV	100	9/30/2013	Wind	DPP - System Impact Study
J186	11/15/2010	ITCT	Huron	METC Baker - Rapson 345kV Substation	200	9/30/2013	Wind	SPA - Parked
J190	12/21/2010	METC	Ottawa	Kenowa 345kV Substation	100	12/15/2012	Wind	SPA - System Impact Study
J199	2/8/2011	METC	Gratiot	METC Slate Substation 345 kV	120	9/1/2013	Wind	DPP - System Impact Study
J201	7/16/2012	METC	Bay	ITC Manning 138kV Substation	20	9/1/2012	Wind	DPP - System Impact Study (Project In Service (with Temporary GIA)
J202	2/16/2011	ITCT	Bay	ITC Atlanta - Tuscola 115 kV	101	9/1/2012	Wind	DPP - System Impact Study
J203	2/16/2011	METC	Sanilac	ITC Bennett - Kilgore 120 kV	200	9/1/2012	Wind	SPA - System Impact Study
J225	9/19/2011	METC	Eaton	Charlotte - Delhi 115 kV	100	9/30/2015	Wind	SPA - Parked
J226	9/27/2011	METC	Mason	Ludington Substation	70	5/24/2014	Hydro	DPP - System Impact Study
J227	9/27/2011	METC	Mason	Ludington Substation	70	5/22/2015	Hydro	DPP - System Impact Study

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MISO Project Number	MISO Queue Date	Project Transmission Owner (TO)	County	Point of Interconnection	Max Summer Output (MW)	In-service Date	Fuel Type	Study Status
J228	9/27/2011	METC	Mason	Ludington Substation	70	5/27/2016	Hydro	DPP - System Impact Study
J229	9/27/2011	METC	Mason	Ludington Substation	70	5/26/2017	Hydro	DPP - System Impact Study
J230	9/27/2011	METC	Mason	Ludington Substation	70	5/25/2018	Hydro	DPP - System Impact Study
J231	9/27/2011	METC	Mason	Ludington Substation	70	5/24/2019	Hydro	DPP - System Impact Study
J235	11/15/2011	ITCT	Huron	future 345 kV Thumb loop where Moore Rd intersects the 345 kV line	110	6/30/2013	Wind	DPP - System Impact Study
J245	5/21/2012	METC	Tuscola	ITC Thumb Loop	100	11/1/2013	Wind	SPA - Parked
J246	5/21/2012	METC	Gratiot	Nelson Road - Goss 345 kV	7.2	10/1/2013	Wind	SPA - Parked
J247	5/21/2012	METC	Sanilac		150	10/1/2012	Wind	SPA - Parked
J264	11/16/2012		Shiawassee	St. Johns - Cornhill 138 kV line	120	10/15/2014	Wind	SPA - Parked
J267	1/14/2013		Tuscola	Karn-Garfield 138 kV line	125	5/15/2014	Wind	SPA - Parked
J268	1/14/2013		Genesee	Thelford substation	725	6/30/2017	Gas	SPA - Parked
J271	3/11/2013		Montcalm	Renaissance Energy Facility	499	9/1/2015	Gas	Feasibility Study
J275	3/14/2013		Midland	100 E Progress Place, Midland, MI 48640	700	10/1/2015	Gas	Feasibility Study

Total – all sources	4,463 MW
Total – renewable only	2,539 MW