Renewable Energy Prospects for Michigan, 2006-2020: MREP Inputs for MPSC Capacity Needs Forum

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Introduction

In its October 14, 2004 Order in Case No. U-14231, the Michigan Public Service Commission (MPSC or Commission) commenced "an investigation into the present and future capabilities of Michigan's electric power system to supply adequate levels of this key product at a reasonable price…" (Order, p. 3). The Commission directed its Staff "to work in conjunction with representatives of the electric power industry and other interested parties to…[p]ropose membership in a Capacity Need Forum (CNF) to be approved by the Commission… to review data and advise the Commission on resource addition policy matters" (Order, p. 4). Specific questions raised in the Commission Order included:

1. The anticipated short-, intermediate-, and long-term demand for power.
2. An analysis of the ability to meet projected demands from existing resources.
3. If additional resources are needed, an analysis of the potential resource options that are available within each of the timeframes, including, but not necessarily limited to: (a) technical considerations relevant to various options; (b) anticipated capital and operating costs; (c) relevant financing, ownership, and organizational considerations; (d) risks associated with various options; and (e) a discussion of any synergistic effects or the extent to which the choice of some options may enhance or foreclose others.
4. Recommendations. (Order, p. 4).

In reviewing the scope of power supply and demand-management options to be investigated through the CNF, the Commission stated:

> "The Commission is aware that alternative sources of generation capacity, such as qualifying facilities, merchant plants, and distributed generation must be considered in addition to the more traditional sources of supply provided by the state's public utilities. It is not starting this proceeding with the assumption that the future construction of base-load generation is the only solution to future resource shortfalls. The Staff should ensure that renewable resources and everyday efficiency measures are included in the investigation of the need for additional capacity. The work done by the Staff and others pursuant to the orders issued in Cases Nos. U-12915 and U-13843, which implement the legislative mandate set forth in MCL 460.10b(1) and MCL 460.10r(6) to promote renewable resource generation facilities, is exemplary and should be incorporated into the investigation. Given that the focus of the investigation is

> broader in scope than renewable resources, the previous Staff work related to renewable resources may be supplemented, but it need not be duplicated." (Order, p. 5).[1]

The purpose of this paper is to present estimates of Michigan's potential for renewable energy resource development over the next 15 years, based on assessments made by members of the Michigan Renewable Energy Program (MREP) Collaborative; established in response to the Commission's May 16, 2002 and May 18, 2004 Orders in Case No. U 12915.[2]

In 2004 and 2005, various MREP committees undertook efforts to analyze Michigan's renewable energy resource potential. Efforts to date have concentrated on biomass, solar, and wind energy options.[3] Table 1 presents a brief summary of the potential, as estimated by the various MREP Committees. The remainder of this report explains how these estimates were derived. Included for each major technology type is a discussion of the estimated costs and predicted benefits associated with developing each of these potential resources.

Table 1: Summary of Michigan Renewable Resource Potential, MREP Estimates for 2006-2020

	2006-2010			2011-2015			2016-2020		
Resource Type	Low	Med	High	Low	Med	High	Low	Med	High
Biomass									
Solar[1]									
Wind									
Total									

Sources: For Biomass see Table <crossreference>, for Solar see Table <crossreference>, and for Wind see Table <crossreference>.

Notes: [1] The solar category incorporates estimates of potential contributions from geothermal and micro-hydroelectric energy facilities. See the solar energy section of this report for details.

[1] Information on the Capacity Need Forum, including the October 14, 2004 Order in Case No. U-14231, is available on the Commission's Web site at http://www.cis.state.mi.us/mpsc/electric/capacity/cnf/.

[2] Information on the Michigan Renewable Energy Program, including Orders in Case No. U-12915, is available on the Commission's Web site at http://www.michigan.gov/mrep.

[3] According to Michigan's Customer Choice and Electricity Reliability Act [2000 PA 141; MCL 460.10g(1)(f)], "'Renewable energy source' means energy generated by solar, wind, geothermal, biomass, including waste-to-energy and landfill gas, or hydroelectric." MREP has not yet undertaken analysis of geothermal or hydroelectric resources. For the purposes of this report, geothermal and hydroelectric energy systems may be considered to be among the technologies included in the analytical approach that is used to estimate solar energy potential (see <crossreference>). The MREP collaborative process remains open to all interested parties, including those who wish to explore geothermal and hydroelectric resources.

Biomass – MREP Estimates of Resource Potential, 2006-2020

Insert text which explains the technologies considered (and/or feedstocks considered). Draw as much as possible from MREP draft report, and/or consider including in MREP report whatever gets used for this report.

Dulcey and Don Johns working on this section. Stanton will consolidate into report next week.

Conclude with tables, something like this:

Table 2: MREP Cost Estimates for Biomass Energy Conversion

⮟⮟List different technologies or feedstocks here, e.g. ⮟⮟	⮟⮟List here the assumptions that were used to develop the cost estimates. If necessary, create multiple columns and characterize the different categories with column headings. ⮟⮟
Biodiesel	
Wood waste	
Agricultural wastes	
Landfill Gas	
Wastewater treatment plants	
Total	
Notes:	

Table 3: MREP Estimates of Michigan Biomass Energy Potential, 2006-2020

⮟List different technologies or feedstocks here, e.g. ⮟⮟⮟	2006-2010	2011-2015	2016-2020
Biodiesel			
Wood waste			
Agricultural wastes			
Landfill Gas			
Wastewater treatment plants			
Total			
Notes:			

Solar – MREP Estimates of Resource Potential, 2006-2020

Same kind of thing as Biomass section.

Wind – MREP Estimates of Resource Potential, 2006-2020

Information on the estimated availability of wind energy in Michigan was developed for Michigan's Wind Working Group[4] in 2004 and early 2005, under a program sponsored by the U.S. Department of Energy, with the assistance of experts at the National Renewable Energy Laboratory (NREL) and with the financial support of Michigan's State Energy Office.[5]

The first major step in analyzing Michigan wind energy potential for this study was the production of new wind maps for Michigan. Maps of Michigan wind speed and wind power density were developed. <explain more details from previous write-ups>. New maps of Michigan wind speed and wind power density measured at 50 meters above the surface were verified <explain how>. Figures 1 and 2 are examples of the kinds of maps that were developed in this effort. Figure 1 shows wind power density at 50 meters and Figure 2 shows unverified estimates of wind power density at 100 meters.

The next steps, completed by NREL staff, included using geographic information systems to identify and calculate the area, measured in square kilometers, of onshore land and nearby offshore areas for each wind power class, for each of the three Michigan regions being evaluated by the CNF.[6] Specific assumptions were made about land and offshore areas to be excluded from analysis.[7] The areas that remained after removing exclusions were tabulated, and those results are shown for onshore areas in Table 4 and offshore in Table 5. Once those land area estimates were completed, then wind generation capacity estimates (measured in nameplate MW) were separately calculated for the onshore and offshore areas not excluded, based on the generally conservative assumption that 5 MW of wind generator nameplate capacity could be installed, per square kilometer.[8] The results of these calculations are presented for onshore areas in Table 6 and offshore in Table 7.

In the final steps needed to complete this analysis, members of the MREP Collaborative, WWG, and CNF Other Generation Committee reviewed all of the data presented in Tables 4

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[4] The Michigan Wind Working Group (WWG) was first organized in <year> under the auspices of the state Energy Office. The WWG serves as MREP's Wind Committee. <complete basic information about WWG and link to WWG web page>

[5] A majority of the work involved in developing this Michigan wind energy potential study was completed by staff from the National Renewable Energy Laboratory, in response to specific information requests from the Michigan Wind Working Group and Capacity Need Forum. Major contributors from NREL included Dennis Elliott, Lawrence Flowers, and Donna Heimiller, whose assistance is greatly appreciated.

[6] These three regions are: (1) Southeast Michigan and the Thumb area, most of which is served by the International Transmission Company (ITC) and generally coinciding with the Detroit Edison Company service territory; (2) the rest of Michigan's Lower Peninsula, most of which is served by the Michigan Electric Transmission Company (METC) and generally coinciding with the Consumers Energy Company service territory; and (3) Michigan's Upper Peninsula, most of which is served by the American Transmission Company (ATC). <Reference to CNF document that explains regions. Be sure to refer to these areas the same way as other CNF documents, for consistency sake.>

[7] The assumptions about exclusions are reviewed in detail on page <crossreference>.

[8] Include conversion factor between km^2 and square miles (mi^2) to help readers understand: One square kilometer equals X square miles, or one square mile equals XX square kilometers. Thus, the estimate of wind generating potential used is approximately Y MW/mi^2.

through 7, and made estimates of Michigan wind energy development potential for 2006 through 2020. Those estimates, presented in Table 8, were guided by a series of assumptions, which are explained in the following paragraphs.

Economics of Wind Energy Production

A few assumptions are based on ideas about the economics of wind energy production. These include: (1) minimum size developments to achieve economies of scale in production; (2) minimum wind speed requirements; and (3) the eventual emergence of viable wind energy storage technologies.

A first assumption is that developers need to install several wind generators in a single project (typically called a wind farm), in order to spread certain fixed costs across multiple units and to achieve economies of scale in operations and maintenance. For wind farms in Michigan, the result is a need to develop facilities equal to at least 25-35 MW in any given project. Greater economies will accrue to even larger developments, but 25-35 MW appears to be a reasonable lower boundary. This assumption translates into the minimums depicted in the early years being analyzed by the CNF. For example, the low (30 MW) and mid (60 MW) estimates for Upper Peninsula development, 2006-2010, would basically represent the minimum sizes of one or two wind farms.

A second assumption involves estimates of the lowest average wind speeds that can support wind farm developments. Given today's utility-scale wind generator technology, viable developments in Michigan are expected to require contiguous or near-contiguous areas large enough to support a minimum of roughly 20 or more generators, where wind speeds will be classified as Class 4 or better, or near Class 4.[9] It is expected that continued progress in wind turbine design and engineering will gradually improve performance. Future wind generators are being developed with the intent of extracting more useful energy from lower speed winds. Thus, by 2011, it is likely that areas with Class 3 winds will also be economically feasible for development.

In reviewing the data that forms the basis for the MREP wind estimates, however, it should be noted that utility scale wind generators may already employ tower heights in excess of 50 meters. It is generally understood that for onshore installations, wind power increases as the hub height and rotor diameter increase. Therefore, prospectors are likely to identify areas with better wind resources at somewhat higher elevations. Many of the areas identified as class 2 or 3 on the 50 meter wind resource map may yield class 3 or 4 winds as tower heights increase. To some extent, this factor can be observed by comparing the 50 and 100 meter maps that have been developed for Michigan (see Figures 1 and 2 on page X).[10]

A third basic assumption is that augmenting wind or other variable output electric generating technologies by the use of energy storage technologies is not presently economical for utility

[9] Near Class 4 may also be referred to as high Class 3. Where Class 3 winds average X mph and Class 4 Y, the threshold for economic viability of utility scale wind generators in Michigan is estimated at about Z mph. +++

[10] The reader should bear in mind that the 100 meter map was developed based on typical formulas used to project wind speed at higher elevations. It has not yet been validated through actual data collection and reporting.

scale wind generators. Many technologies are being explored to enable economical storage of electricity, and it is expected that at least some of those technologies may become viable during the 15-year time horizon being investigated by the Capacity Need Forum. Storage technologies have yet not been incorporated into the MREP technology assessments for utility scale wind systems, however. This subject should be revisited in the not-too-distant future, though. As storage technologies improve, the economics of wind generation and its value to the utility system could change markedly.

Finally, the economics of utility scale wind developments have been estimated by MREP, based on preliminary information. It is expected that more and better information on these resource costs in Michigan will become available in the coming months, as Consumers Energy and Detroit Edison embark on their new and expanded renewable energy programs. In the meantime, however, MREP has developed estimated supply curves based on generally accepted rules of thumb and preliminary wind power data. Those preliminary supply curves are presented in Figures 3, 4, and 5, on page X.

Exclusions for Onshore Wind Energy Production

As NREL staff work on estimating the wind energy potential, they use data from various Geographic Information System (GIS) databases, and exclude various lands from consideration for wind energy development. Generally speaking, the exclusions are based on environmental concerns and criteria used to identify competing land uses. NREL's analysis therefore excluded from consideration:

1. All lands managed by the National Park Service and Fish and Wildlife Service, including a 3 km surrounding buffer area;
2. All federal lands designated as parks, wilderness, wilderness study areas, national monuments, national battlefields, recreation areas, national conservation areas, wildlife refuges, wildlife areas or wild and scenic rivers, including a 3 km surrounding buffer area;
3. All state and private lands that are equivalent to those first two classification types, where GIS data is available to indicate those land use types, including a 3 km surrounding buffer area;[11]
4. One-half of all remaining U.S. Department of Agriculture Forest Service lands, including National Grasslands, that are not already classified in one of the first two types;
5. One-half of all remaining Department of Defense lands that are not already classified in one of the first two types;
6. One-half of all state forest land, where GIS data is available;[11]
7. One-half of all forest lands that are not ridge-crests;
8. All airfields, including a 3 km surrounding buffer area;[12]

[11] NREL indicates it did not have access to Michigan GIS data to identify these land uses at the time the preliminary Michigan wind assessments were completed.
[12] The source for airfield identification is a GIS database of airfields and airports from ESRI (2003). +++ Spell out ESRI +++

9. All urban land, all wetlands, and all inland water areas, including a 3 km surrounding buffer area;[13]
10. All areas where the slope of the land exceeds 20 percent; and
11. Exclude small resource areas, where there is not a density of at least 5 km^2 of Class 3 or better resources within the surrounding 100 km^2 area.

As an additional conservatism for the purposes of the estimates provided to the CNF, MREP assumed that no more than 2/3 of the land areas identified by NREL will be available for development, due to additional exclusions not yet identified by NREL (e.g., viewshed issues, other competing land uses, local community judgment, etc.).

Exclusions for Offshore Wind Energy Production

NREL based its estimates of Michigan's offshore wind energy potential on two major exclusions:

1. All offshore areas less than 5 nautical miles (about 10 km) and more than 10.8 nautical miles (about 20 km) from shore; and
2. 2/3 of all offshore areas between 5 and 10.8 nautical miles.

Additional overriding assumptions were made by MREP, related to the trajectory and speed of possible offshore wind energy resource development in Michigan. NREL has identified a very significant resource potential for Michigan offshore development, but many uncertainties remain about the viability of developing that resource.[14] The MREP assumptions include:

3. No significant offshore wind resources will be developed in Michigan waters between now and 2015;
4. Under a low wind energy production scenario, no significant offshore development will occur by 2020;
5. Preparatory work on offshore development will continue, so that by 2010 the first efforts to better evaluate the offshore resources will be undertaken and by 2015 some experimental offshore generators can be operating;
6. Thus, by 2016, it should be clear whether or not offshore resources are likely to be developed prior to 2020; and,
7. In the mid and high wind energy production scenarios for 2016-2020, the obstacles to offshore wind resource development are overcome, so that resources equal to a small percentage of the total estimated technical potential can be developed; equivalent to not more than 2 percent in the mid and 5 percent in the high production scenario.

Wind Energy Limited to 15% of Regional Capacity

Wind energy should be constrained in CNF modeling, to not exceed 15 percent of the total capacity in any region. With continuing advances in energy storage options and techniques

[13] NREL is presently identifying these land-use types using U.S. Geological Survey GIS maps of Land Use and Land Cover (1993).
[14] See Offshore Wind Energy Development Briefing Paper <full citation and link>.

employed by utility system operators to integrate larger percentages of variable output electric generators, it is conceivable that wind energy penetration could grow to exceed 15 percent. Thus, this assumption should be revisited in the future.[15] For the time being, however, 15 percent of Michigan's statewide electric capacity needs represents approximately 1,000 times more wind energy than is presently operating in our state. MREP participants note many important uncertainties remain about how much wind energy capacity can and will be developed in Michigan, and at what cost. Therefore, MREP participants do not believe it is unreasonable at this time to constrain CNF modeling of the next 15 years, based on the assumption that 15 percent represents an upper limit to the penetration of wind energy in Michigan's three electric planning regions. +++

Small Wind Energy Conversion Systems (SWECS) Modeled as Demand Reductions

Like solar technologies. Under the Renewables scenario, higher penetration of SWECS is modeled. <Insert table regarding SWECS installations, 2006-2020, based on low & high assumptions, McKenzie Bay success, etc.>

Some Promising Michigan Wind Sites Are Ready Now for Commercial Development

Near term readiness for 200-400 MW in 2006-2010. <Can we discuss in any more details the few sites we already know about where developers have been working for a couple of years already, and have township and county approvals?>

Basic Assumptions for Low, Mid, and High Wind Energy Penetration

Low – Markets keep blocking. Policies don't change. Hard to finance.

Mid – Major obstacles removed. Developers proceed to bring on wind power, apace with expectation to grow at rate of between 1-2% per year of total capacity in each resource area.

High – Major obstacles are removed, and policies actively encourage Michigan renewable energy development. For example, RPS; emissions requirements; economic development interest, etc. To the extent that all other constraints and exclusions are incorporated in model, wind grows to equal as much as 15 percent of service area capacity by 2020.

[15] For example, evidence from Denmark and at least one state in Germany and another in Spain suggests that utility systems can be successfully operated with upwards of 20 percent penetration of wind energy capacity. See <references>.

Table 4: Wind Resource Classification of Onshore Michigan Land Areas, After Exclusions (Reporting Areas in Square Kilometers)

Region	Class 3	Class 4	Class 5	Class 6	Total Class 3+	Total Class 4+
Southeast Michigan	1492.1	2.5	0.0	0.0	1,494.6	2.5
Rest of Lower Peninsula	1267.3	91.1	13.6	2.6	1,374.7	107.3
Upper Peninsula	387.4	50.2	5.9	0.0	443.6	56.2
Total[1]	3146.8	143.9	19.6	2.7	3,312.9	166.1

Source: Donna Heimiller, National Renewable Energy Laboratory, March 2005.

Notes: [1]Totals may not add correctly due to rounding. Total Class 3+ and Total Class 4+ represent the sum of areas classified as having wind resources higher than, respectively Class 3 or Class 4.

Table 5: Wind Resource Classification of Offshore Michigan Land Areas, After Exclusions (Reporting Areas in Square Kilometers)

Region	Class 3	Class 4	Class 5	Class 6	Total[2] Class 3+	Total[2] Class 4+
Southeast Michigan	7	242	2,251	933	3,434	3,427
Rest of Lower Peninsula	1	33	2,359	6,863[3]	9,257	9,255
Upper Peninsula	345	1,993	6,395	5,502	14,236	13,891
Total[1]	353	2,268	11,005	13,298	26,924	26,571

Source: Donna Heimiller, National Renewable Energy Laboratory, March 2005.

Notes: [1]Totals may not add correctly due to rounding.
[2]Total Class 3+ and Total Class 4+ represent the sum of areas classified as having wind resources higher than, respectively Class 3 or Class 4.
[3] Included with Class 6 data for the Rest of Lower Peninsula are 4 km^2 of area classified as Class 7.

Table 6: Wind Resource Estimates for Onshore Michigan Land Areas, After Exclusions (Reporting Nameplate Capacity Values in MW)

Region	Class 3	Class 4	Class 5	Class 6	Total[2] Class 3+	Excluded[3] Class 3+	Total[2] Class 4+	Excluded[3] Class 4+
Southeast Michigan	7,460	13	0	0	7,473	9%	13	2%
Rest of Lower Peninsula	6,337	456	68	13	6,873	37%	537	62%
Upper Peninsula	1,937	251	30	0	2,218	59%	281	56%
Total[1]	15,734	719	98	13	16,565	32%	831	60%

Source: Donna Heimiller, National Renewable Energy Laboratory, March 2005.

Notes: [1] Totals may not add correctly due to rounding.
[2] Total Class 3+ and Total Class 4+ represent the sum of areas classified as having wind resources higher than, respectively Class 3 or Class 4.
[3] Excluded data represents the percentage of land area removed from consideration due to the various reasons explained in <cross reference to exclusions table>.

Table 7: Wind Resource Estimates for Offshore Michigan Land Areas, After Exclusions (Reporting Nameplate Capacity Values in MW)

Region	Class 3	Class 4	Class 5	Class 6	Total[2] Class 3+	Total[2] Class 4+
Southeast Michigan	12	404	3,751	1,556	5,723	5,711
Rest of Lower Peninsula	2	55	3,932	11,439[3]	15,428	15,426
Upper Peninsula	575	3,322	10,658	9,171	23,726	23,151
Total[1]	589	3,781	18,341	22,166	44,877	44,288

Source: Donna Heimiller, National Renewable Energy Laboratory, March 2005.

Notes: [1] Totals may not add correctly due to rounding.
[2] Total Class 3+ and Total Class 4+ represent the sum of areas classified as having wind resources higher than, respectively Class 3 or Class 4.
[3] Class 6 data for Rest of Lower Peninsula includes 7 MW of Class 7.

Table 8: MREP Estimates of Michigan Developable Wind Energy Potential, 2006-2020 (Cumulative MW of utility scale development)

	2006-2010			2011-2015			2016-2020		
Region	Low	Mid	High	Low	Mid	High	Low	Mid[1]	High[1]
Southeast Michigan	60	120	300	120	300	700			
Rest of Lower Peninsula	100	200	400	200	725	1,250	750	1,125	1,800
Upper Peninsula	30	60	140	60	120	280	270	450	1,050
Total									

Notes: [1] For 2016-2020, Mid-potential includes X% and High-potential Y% of estimated offshore wind potential identified by NREL. See <cross reference to offshore potential table(s)>.

Summary, Conclusions, and Recommendations for Further Research – MREP Estimates of Resource Potential, 2006-2020

References

List here all published references and sources used.

MREP Offshore Briefing Paper, 2005. <link>.