

CHAPTER 4

Renewable Energy Workgroup Resource Assessment

1. Introduction, Methodology and Approach, Overview

The general approach used to estimate renewable energy production potential in Michigan for the 21st Century Energy Plan (Plan) was to revisit the assumptions used in the 2005 Capacity Need Forum (CNF) report in order to identify changes that might be called for, based on newly available or more extensive data and analysis. Cost data used in the CNF was updated to account for various inflationary factors presently affecting construction costs. General inflation was estimated at about 3 percent, to reflect the cumulative change from 2005 to 2006. In addition, most renewable resource capital costs were increased by another 10 percent to account for the recent run-up on the costs of steel, copper, concrete, and labor. The cost of wind generators was increased slightly more than this, from \$1,200 per kW of installed capacity, excluding transmission interconnection costs, to \$1,425 per kilowatt (kW), to reflect the recent price escalation and strong demand for wind turbines throughout the U.S.

The Capacity Need Forum projected a potential for approximately 1,000 megawatts (MW) of new electric power capacity development in Michigan from a combination of renewable resources and cogeneration (also referred to as combined heat and power or CHP). CHP was modeled for the CNF without any direct analysis of the fuel types that might be used to power such systems (e.g., coal, natural gas, or various biofuels). Modeling for the Plan generally verified and refined the CNF assumptions. The updated analysis shows a similar total contribution available from renewable resources, but does not include coal or natural gas-fired CHP. In the Plan modeling, CHP that is likely to be powered by biofuels is analyzed separately from fossil-fuel powered CHP. Table 1 compares the total quantities of renewable resources modeled for the CNF versus the Plan.

Another difference in modeling assumptions between the CNF and the Plan involves the maximum quantities of renewable resources assumed for availability in the various scenarios. In the CNF, estimates of future renewable resources availability (1,149 MW) were not enough to meet a renewable portfolio standard of 7 percent new (total of 10 percent) Michigan electric sales in 2015 and thus were ultimately scaled up for modeling. In contrast, maximum quantities of renewable resources in the Plan were initially considered to be limited at a specific level of MW and megawatt hours (MWh) by the cost estimate associated with the 2016 level of renewable resources included in this report. In the Plan, this level was 7 percent of projected total Michigan electric sales and was based upon several conservative assumptions. In 2017 and future years, the percentage contribution of renewables was maintained at 7 percent by increasing the MW and MWh based on the Plan energy forecast rate of growth, assuming availability of renewable resources to provide the capacity and energy for each subsequent year of the planning period (i.e., through 2025). This analysis is depicted in Figure 2, for years 2007 to 2016.

Many commenters, however, have questioned the conservative nature of the assumptions used to estimate the potential renewable generation available within Michigan. These comments have focused on the wind energy potential included in the estimate of available renewable energy. Commenters have highlighted the American Wind Energy Association’s designation of Michigan as the 14th windiest state in the nation, with an estimated technical potential for approximately 25,000 MW of on-shore wind energy. These comments prompted Staff to review and further analyze the assumptions and methodologies used in this study. Based on that review, Staff recommends that an accelerated goal of up to 10 percent of the state’s electric energy needs could be met by renewable energy as part of a renewable energy portfolio standard. It appears that sufficient wind resources are available to meet this goal by the end of 2015 instead of 2016. The resource capacity projections for this accelerated portfolio analysis are summarized in Figures 1 and 2, and Figure 3 (p. 144) The energy projections for this accelerated portfolio analysis are shown in Table 3 (p. 126) and Figure 1.

Table 1: Renewable Resources Capacity Projections for CNF and Plan (MW)

Renewable Energy System Type	CNF		Plan	
	Alt-Tech ¹ 2015	Scaled-Up ¹ 2015	7% RPS Modeled 2016	10% Accelerated RPS 2015
Wind	420	443	525	2,150
LFG	131	138	131	128
Anaerobic Digestion ²	51	54	82	73
Cellulosic Biomass / CHP (Cogen) ³	547	576	385	340
Total	1,149	1,211	1,123	2,691

¹ In CNF analysis, the Alternative Generation Workgroup presented a set of resource availability projections, as reflected here in the “Alt-Tech” column. In modeling the CNF Alternative Technologies scenario, however, those resource quantities were increased by a few percent in order to model achievement of a 7% renewable portfolio standard. Those increased amounts are shown here in the “Scaled-Up” column.

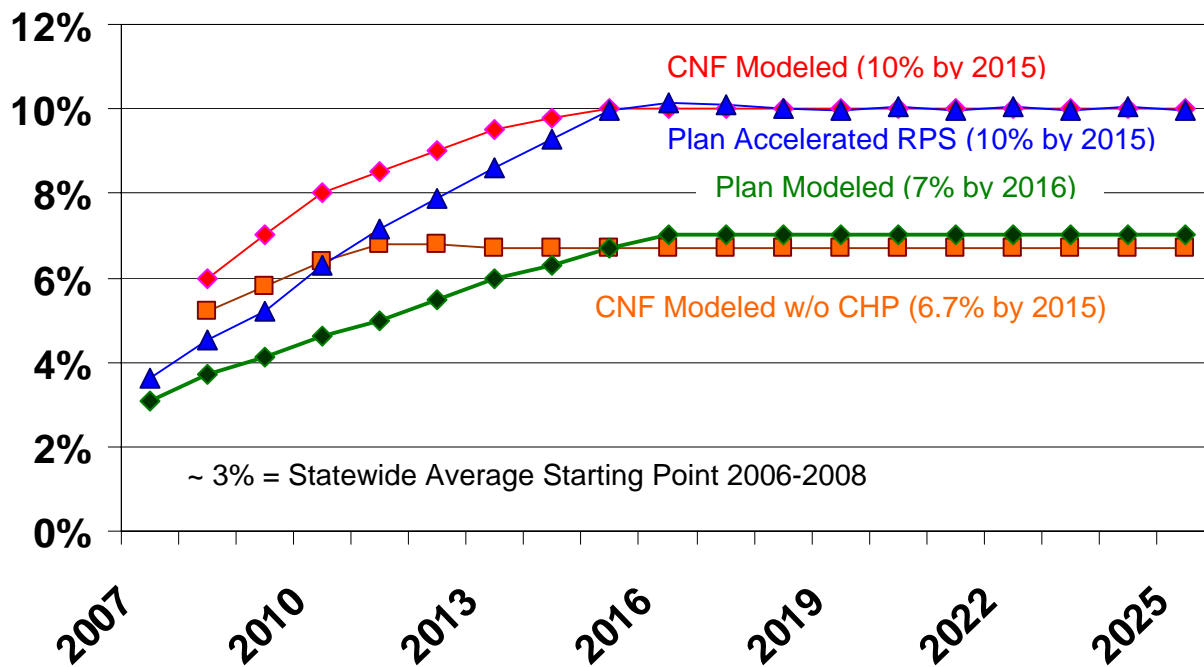
² In CNF analysis, anaerobic digestion from cattle was modeled. The Plan modeling includes anaerobic digestion from cattle, wastewater treatment plants, plus swine and poultry operations.

³ In CNF analysis, cogeneration (also known as Combined Heat and Power, or CHP) was modeled based on the estimated potential at existing large coal-burning industrial boilers in Michigan. The fuel-types considered for cogeneration in the CNF analysis included coal and natural gas. In the Plan modeling, CHP is considered along with other options in the Alternative Technologies Workgroup. The potential for biomass-fired electric power generation systems is presented here. Many such systems would likely incorporate cogeneration technology.

No matter which potential renewable energy estimate is used for developing a portfolio standard, one of the important implications is that the further one projects into the future the more uncertainty clouds the projections. Projecting more than a decade in the future is most difficult given the rapid pace of technological improvements for some renewable energy systems and policy changes that are likely to affect all energy sources in different ways. Considering these uncertainties, Staff is confident that renewable energy sufficient to meet seven to 10 percent of the state’s needs can be developed by 2015. Staff also made policy recommendations to assure that no unforeseen events intercede, by which meeting these standards and recommendations would otherwise create an undue burden on utilities and their ratepayers. Staff also recommended reviewing the findings of the Plan every few years, to continuously subject all the assumptions to critical analysis and improve the accuracy wherever practical.

Figure 1 compares the percentage of renewable resources modeled in the CNF, both with and without the inclusion of cogeneration (CHP), with the 7 percent level modeled for the Plan and the 10 percent accelerated renewable portfolio standard (RPS).

Figure 1: Renewable Energy Percentage Projections in CNF, Plan Modeling, and Accelerated RPS



It should be noted that Governor Granholm explicitly directed the Plan to develop a proposal for an RPS, with “targets for the share of this state’s energy consumption derived from renewable energy sources.” For purposes of establishing a reasonable and achievable renewable energy portfolio standard and modeling the impact of renewable energy, Staff estimated the quantity of renewable energy shown in Table 2 and Table 3 will be available at the estimated costs shown in Table 4 between 2006 and 2016. After 2016, the Plan modeled the quantity of renewable energy to increase only at the same rate as forecast growth.

2. Resource Assessment

For the analysis completed for the Plan, the definition of renewable resources was based on 2000 PA 141, Section 10g(1)(f) (MCL 460.10g(1)(f)). That section indicates renewable energy source means “energy generated by solar, wind, geothermal, biomass, including waste-to-energy and landfill gas, or hydroelectric.”

Approximately 3 percent of the electric energy currently sold to Michigan utility customers is generated by renewable energy sources. Table 5 (p. 128) shows the renewable energy contributions used to meet Michigan utility needs in 2005, when the statewide average was about 3.0 percent.

For purposes of the Plan, biomass electricity production was modeled from five major sources: (1) combustion of cellulosic biomass, including forestry and agricultural residues; (2) anaerobic digestion for wastewater treatment plants; (3) anaerobic digestion for cattle; (4) anaerobic digestion for swine and poultry; and (5) landfill gas. Wind energy production from utility-scale wind generators was also modeled.

Table 2: Capacity Projections for 7 and 10 Percent Renewable Portfolios (MW)

Year	Modeled 7% RPS					Accelerated 10% RPS	
	Landfill Gas	Anaerobic Digestion	Cellulosic Biomass	Wind	Total	Wind	Total ¹
2006	0	0	0	0	0	0	0
2007	24	4	0	10	38	239	267
2008	47	11	41	87	185	478	577
2009	71	18	81	88	258	609	779
2010	94	24	122	119	358	956	1,196
2011	118	30	162	154	464	1,194	1,504
2012	120	43	207	272	642	1,433	1,803
2013	123	53	251	360	787	1,672	2,099
2014	126	64	296	410	896	1,911	2,397
2015	128	73	340	465	1,006	2,150	2,691
2016	131	82	385	525	1,123	2,150 ²	2,748
2017	134	83	392	535	1,144	2,150	2,759
2018	136	85	401	546	1,168	2,150	2,772
2019	139	87	410	559	1,194	2,150	2,786
2020	142	89	419	571	1,221	2,225	2,875
2021	145	91	428	583	1,246	2,225 ²	2,889
2022	147	93	437	595	1,271	2,300	2,977
2023	150	95	446	609	1,299	2,300 ²	2,991
2024	153	97	456	622	1,328	2,375	3,081
2025	155	99	465	634	1,354	2,375 ²	3,094

¹Landfill gas, anaerobic digestion, and cellulosic biomass quantities are unchanged for the accelerated RPS.

²Wind capacity remains the same some years after 2015 because biomass resource types were all projected to continue to increase from 2016 through 2025 at the same rate as forecast demand. Thus, in order to maintain the RPS as close as possible to a constant 10%, wind capacity growth was modeled at 75 MW increments every few years. See also Table 3.

Solar electricity production was not explicitly modeled for the Plan since it has experienced only limited market penetration in Michigan at this time. Although larger scale production and continuing technological improvements are likely to make solar applications more attractive in the future, Staff does not anticipate sufficient market penetration in the near-term to substantially change the modeling assumptions. Staff plans to continue to review the attractiveness of adding solar generation technology to the renewable resource mix, for modeling purposes in the future.

**Table 3: Energy Projections for 7 and 10 Percent Renewable Portfolios
(GWh/year and Percent of Total Generation Requirements)**

Year	Plan Forecast	Existing Renewable	7% by 2016 RPS Renewable Resources Modeled (GWh/year)						10% by 2015 Accelerated RPS (GWh/year)		
			Landfill Gas	Anaerobic Digestion	Cellulosic Biomass	Wind	Total New Renewable	RPS %	Wind	Total ¹ New Renewable	RPS %
2006	112,183	3,279	0	0	0	0	0	2.9%	0	0	2.9%
2007	113,021	3,279	189	28	0	25	242	3.1%	586	803	3.6%
2008	114,492	3,279	370	74	284	213	942	3.7%	1,172	1,900	4.5%
2009	115,411	3,279	560	123	568	216	1,467	4.1%	1,494	2,745	5.2%
2010	116,902	3,279	741	165	853	292	2,051	4.6%	2,344	4,103	6.3%
2011	118,442	3,279	930	207	1,135	378	2,650	5.0%	2,930	5,202	7.2%
2012	120,245	3,279	946	304	1,448	667	3,365	5.5%	3,516	6,214	7.9%
2013	121,685	3,279	970	372	1,760	883	3,985	6.0%	4,102	7,204	8.6%
2014	123,396	3,279	993	448	2,073	1,006	4,520	6.3%	4,688	8,202	9.3%
2015	125,023	3,279	1,009	509	2,386	1,141	5,045	6.7%	5,274	9,178	10.0%
2016	126,811	3,279	1,033	572	2,698	1,288	5,590	7.0%	5,274 ²	9,577	10.1%
2017	128,180	3,279	1,056	582	2,748	1,312	5,698	7.0%	5,274	9,660	10.1%
2018	129,982	3,279	1,072	595	2,807	1,340	5,813	7.0%	5,274	9,748	10.0%
2019	131,775	3,279	1,096	608	2,871	1,370	5,945	7.0%	5,274	9,849	10.0%
2020	133,721	3,279	1,120	622	2,937	1,402	6,080	7.0%	5,457	10,136	10.0%
2021	135,456	3,279	1,143	635	2,996	1,430	6,204	7.0%	5,457	10,231	10.0%
2022	137,329	3,279	1,159	648	3,059	1,460	6,326	7.0%	5,641	10,507	10.0%
2023	139,226	3,279	1,183	662	3,127	1,493	6,465	7.0%	5,641	10,613	10.0%
2024	141,266	3,279	1,206	677	3,197	1,526	6,607	7.0%	5,825	10,905	10.0%
2025	143,094	3,279	1,222	691	3,261	1,556	6,730	7.0%	5,825	10,999	10.0%

¹Landfill gas, anaerobic digestion, and cellulosic biomass quantities are unchanged for the accelerated RPS.

²Wind energy remains the same some years after 2015 because biomass resource types were all projected to continue to increase from 2016 through 2025 at the same rate as forecast demand. In order to maintain the RPS as close as possible to a constant 10%, wind capacity growth was modeled at 75 MW increments every few years.

Table 4: Renewable Energy Cost Estimates

	Landfill Gas at New Facilities	Landfill Gas at Existing Facilities	Anaerobic Digestion Animal Waste ¹	Cellulosic Biomass	Wind
Capital Installed Cost (\$/kW)	\$1,356	\$1,130	\$2,825	\$1,900	\$1,425
Capital Recovery Rate (%/year)	14%	14%	14%	14%	14%
Annual Operating Hours	8,760	8,760	8,760	8,760	8,760
Capacity Factor (%)	90%	90%	80%	80%	28%
Efficiency (Btu/kWh)	10,000	10,000	10,000	16,500	n/a
Fuel Costs (\$ per million Btu)	\$1.85	\$1.85	\$0	\$1.75	\$0
Resulting Costs (\$ per kWh)					
Capital Recovery	0.024	0.020	0.056	0.038	0.081
Fuel	0.019	0.019	0.000	0.029	0.000
PTC (10 years only) ²					-0.019
O&M	0.0309	0.0309	0.02575	0.002	0.01
Total³	0.074	0.070	0.082	0.069	0.072
¹ Fuel costs are shown as zero. It should be noted that the residue that remains after anaerobic digestion usually can be land applied as a fertilizer and soil amendment. Thus, there may be some residual value to more than offset any costs associated with delivering waste materials to an anaerobic digester. ² The Federal Production Tax Credit (PTC) for wind power was originally enacted as part of the Energy Policy Act of 1992 and was first scheduled to sunset on June 30, 1999. The PTC has been extended by Congress four times. The most recent extension, in the Energy Policy Act of 2005, is through December 31, 2007. (See footnote 64, on p. 142.) The PTC provides a 1.9-cent per kWh incentive for the first 10 years of operation. ³ Costs do not include interconnection costs.					

Systems that produce thermal energy rather than electricity were not explicitly modeled, though they may be already cost effective in some applications and could make contributions to meeting the state’s future energy needs. These systems might include a wide variety of biomass-fueled heating appliances, solar water heaters, and other sources but are more likely to displace natural gas than electric applications.

Michigan has benefited for many years from relatively inexpensive hydroelectric power with some hydroelectric plants in operation for 100 years. Based on a national hydroelectric resource assessment conducted by the Idaho National Laboratory, Michigan is estimated to have additional hydroelectric power development potential of 133 megawatts, on average (MWa), of feasible low power (< 1MWa) or small (>= 1 MWa and <30 MWa) units.⁴⁴ It is also possible that existing hydropower plants might be modified to increase efficiency and electric generation output. At the time of writing this report and preparing data for modeling, not enough specific information about the cost and permitting issues of new hydropower and upgrades of existing hydropower is known. As a result, additional hydropower resources were not modeled as part of

⁴⁴ See http://hydropower.inel.gov/resourceassessment/pdfs/main_report_appendix_a_final.pdf, *Feasibility Assessment of the Water Energy Resources of the Untied States for New Low Power and Small Hydro Classes of Hydroelectric Plants*. MWa means average MW production.

the Plan. While Staff did not estimate the potential energy available from these options nor factored in potential siting and construction issues, at least some additional hydroelectric power resources may be available to satisfy RPS targets by load serving entities in Michigan.

Table 5: Michigan Utility Renewable Energy Sales Source Percentages (2000-2005)

Company	Percentage of Renewable Sources, by Year					
	2000	2001	2002	2003	2004 ¹	2005
Alger Delta Co-op	n/a	n/a	n/a	n/a	n/a	11.0 ²
Alpena Power	11.2	13.0	13.3	11.4	12.5	8.1
American Electric (Indiana Michigan) Power Co. ³	n/a	0.7	0.7	1.0	1.0	0.4
Cherryland Electric Co-op	n/a	n/a	n/a	n/a	n/a	1.2
Cloverland Electric Co-op	49.7	45.5	45.3	43.0	46.3	52.4
Consumers Energy	3.8	4.8	4.6	4.5	5.0	4.5
Detroit Edison	n/a	1.4	1.4	1.2	1.1	1.1
Edison Sault	42.0	38.3	39.5	37.1	39.5	39.3
Great Lakes Energy Co-op	n/a	n/a	n/a	n/a	n/a	1.2
Midwest Energy Co-op	n/a	n/a	n/a	n/a	n/a	2.5 ²
Ontonagon County REA	n/a	n/a	n/a	n/a	n/a	11.0 ²
Presque Isle Electric & Gas Co-op	n/a	n/a	n/a	n/a	n/a	1.2
Thumb Electric Co-op	n/a	n/a	n/a	n/a	n/a	1.0 ²
Tri-County Electric Co-op	n/a	n/a	n/a	n/a	n/a	1.2
Upper Peninsula Power Co. ⁴	12.0	12.0	17.0	12.0	11.0	9.7
We Energies	n/a	2.0	2.4	2.2	2.2	1.8
Wisconsin Public Service Corp.	2.1	2.2	2.6	2.8	2.9	2.8
Wolverine Electric Power Co-op ⁵	n/a	1.1	0.7	0.9	1.2	1.2
Xcel Energy ⁶	13.6	15.3	14.3	13.6	16.1	15.5 ²
Statewide Average⁷	n/a	n/a	n/a	n/a	n/a	3.0

¹In its May 18, 2004 Order in Cases Nos. U-12915 & U-13843, the Commission stated, “[T]he utilities’ annual disclosure requirements should accurately reflect that green power customers are paying additional costs for renewable and environmentally-friendly energy and...utilities should not represent in future reports that they are providing these services to all rate classes.” (Order, pp. 3-4). Data beginning with the 2004 reporting year, represents percentages of renewable sources for customers who are not participating in special voluntary green rate programs.

²Data for year ended March 31, 2006.

³Includes hydroelectric and 0.1 percent or less from other renewable fuels. 2003 data did not include hydroelectric.

⁴Upper Peninsula Power Company’s renewable energy was impacted in 2003. In May of that year a fuse plug at the Silver Lake reservoir owned by UPPCO was breached. This breach resulted in subsequent flooding downstream on the Dead River, which is located in Michigan’s Upper Peninsula near Marquette, and impacted hydroelectric generation. UPPCO has announced its decision to restore Silver Lake as a reservoir for power generation pending approval of a license amendment and an economically feasible design by the FERC. The FERC has required that a board of consultants evaluate and oversee the design approval process. UPPCO is developing a timeline for the project, provided the FERC approves an economically feasible design. Once work is done, Silver Lake is expected to take approximately two years to refill, assuming average precipitation.

⁵Wolverine Power Supply Cooperative is the sole supplier of electric generation service to four of Michigan’s cooperative (member-owned) electric distribution companies: Cherryland Electric Cooperative, Great Lakes Energy, Tri-County Electric Cooperative, and Presque Isle Electric and Gas Co-op. Wolverine data for 2003 includes 0.51 percent and 2004 includes 0.66 percent of hydroelectricity. Previous years did not include hydroelectricity.

⁶Includes generation and purchases in Wisconsin. Data for Xcel prior to 2005 reflects fiscal years, ending in October.

⁷Calculated by MPSC Staff.

2.1 Biomass Energy Modeling Introduction

The general methodology used to model biomass resources for the Plan is to first estimate the potential biomass resources that could be made available in Michigan on a sustainable basis, then investigate likely technological applications for converting such resources into useful energy, including electric power, and then review the economics associated with those applications.

For purposes of this study, ethanol from corn and biodiesel from soy were not included among renewable resources for electricity production. Both biofuels are of increasing importance to Michigan as transportation fuels, but are not likely to be widely used in electric power production because they are generally higher in cost compared to solid biofuels and have greater value as vehicle fuel. Biodiesel, however, might be used in diesel generators, for emergency, standby service. Further, with the exception of an analysis of existing wood-fired boilers in the State of Michigan performed in conjunction with the analysis of CHP, there was no explicit analysis for the Plan of biomass used for thermal energy (such as wood, corn, or other materials used for space and water heating fuels).

In many ways, the assessment process for biomass resources is less certain compared to wind, hydroelectric, or solar resources. The basic reason is that biomass fuel handling, fuel processing, and energy conversion systems are not yet standardized to the same degree that they are for other generating options, so each application involves unique engineering design and that translates into a wider dispersion of cost estimates for biomass energy, even among systems that employ the same basic processes and component parts.⁴⁵ In addition, there is already a great deal of interest in a wide variety of bioproducts, including uses for food, fiber, chemical feedstocks, and fuels. Therefore, there may be significant competition for the use of Michigan biomass resources in the future, and only a portion of the sustainable yield might be available for energy production with only a fraction of that used to generate electricity. Thus, several conservatisms are included in the analysis of bioenergy potential for the Plan.

2.2 Cellulosic Biomass

Michigan already obtains about 1 percent of its electricity supply from power plants designed to burn primarily wood residues. Table 6 (p. 131) presents a list of Michigan's currently existing utility-scale wood-burning power plants, including their production data for 2005. In addition to the wood residues presently utilized for the production of electric power, recent data on wood and waste consumption in Michigan shows a total of nearly 60 trillion British Thermal Units (Btus) per year or approximately 3.85 million tons available.

⁴⁵ A recently published report on a feasibility study for a biomass anaerobic digester system for west Michigan illustrates this point. In response to a request for preliminary proposals, which identifies a single type and quantity of waste to be converted into energy, the four firms propose four different kinds of methane digesters, and their preliminary costs range from approximately \$3.7 to \$12.5 million. These proposals do not include electric generating equipment, the estimates are only for the methane production systems. See *West Michigan Regional Anaerobic Digester Feasibility Study*, at <http://www.michigan.gov/biomass>.

Three major sources of additional cellulosic biomass resources were considered for modeling in the Plan.⁴⁶ They include: (1) surplus growth from commercial forest land; (2) biomass produced on abandoned cropland; (3) agricultural residues and plantings on conservation reserve program lands.⁴⁷ The following is a review of the major assumptions regarding each of these resource types.

2.2.1 Surplus Growth from Commercial Forest Land⁴⁸

At present, only about one third of the annual sustainable forest growth in Michigan is being harvested each year to supply Michigan's forest products industries. The remaining two thirds either continues to accumulate in the forest or is lost to mortality. In theory, most of this surplus growth, estimated at 16.8 million dry tons per year, could be harvested for energy.

Practically speaking, however, there are many competing commercial uses for wood and wood residues, and it will be no small achievement to expand Michigan's commercial forest industry to take advantage of the significant quantities of wood residues modeled here. In fact, most of the biomass used today in Michigan's existing wood-burning power plants and biomass-fired boilers is wood residues from commercial forest harvesting and the primary forest products industries. Commercial forestry residues, including diseased wood, tree tops, branches, and stumps are typically chipped for delivery to wood-burning power plants. Primary forest products industry residues include bark, etc., from lumber production and a variety of wastes from pulp and paper making operations. Thus, to date there has always been a direct relationship between economic activity in Michigan's forest products industry and the residues that have traditionally been made available to wood-burning power plants.

Although harvesting this volume of wood residues would be a challenge for Michigan's existing forest products industry, Staff believes that the industry has sufficient supply elasticity to expand harvest volume over time. This may occur from an expansion of the industry or through new forest management programs. That expansion will take some time to accomplish, based on a review of recent changes in these industries in Michigan. If Michigan's forest products industries were to rebound from recent plant closures and expand, however, then the analysis

⁴⁶ Data on these resources was provided by Dr. Raymond O. Miller, Manager of the Upper Peninsula Tree Improvement Center, Michigan State University. In addition, a task force working in conjunction with the Michigan Biomass Energy Program and Michigan Renewable Energy Program provided input for the analyses described here. Task-force participants included: Dulcey L. Simpkins, Ph.D. and Trista Gregorski, Michigan Biomass Energy Program; Greg Mulder, Coffman Electrical Equipment; Jessica Simons, Southeast Michigan Resource Conservation & Development Council; Anthony Weatherspoon, Michigan DNR, FMFM Division; Prof. Karen Potter-Witter, MSU Dept. of Forestry; Julie Baldwin and Tom Stanton, Michigan PSC Staff.

⁴⁷ Conservation reserve program (CRP) provides annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland. See <http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>.

⁴⁸ In order to be designated by the U.S. Forest Service as commercial forest land, parcels must meet minimal productivity standards, in terms of the annual sustainable yield of timber, and must be available for forest management activities. Parcels that are restricted from harvesting or are otherwise sensitive sites are not included in the basic inventory of commercial forest land.

completed for the Plan suggests there would be plenty of biomass resources, on a sustainable basis, to fuel roughly a doubling of Michigan’s existing wood-fueled power plants using only the residues from the expanded wood harvesting and primary forest products production.

Table 6: Michigan Utility Scale Wood-Burning Power Plants (2005 Production in MWh)

Wood - Burning Power Plants	Plant Capacity (MW)	2005 Generation (MWh)
Cadillac Renewable Energy	34.0	219,150
Genesee Power Station	35.0	233,503
Grayling Generation Station ¹	36.2	254,721
Hillman Power Company ¹	18.0	134,572
Viking-Lincoln ¹	18.0	144,360
Viking-McBain ¹	18.0	138,971
Total	159.2	1,125,277

¹Licensed scrap-tire end user. (Feedstock may include scrap-tires.) Source: Consumers Energy Annual Report, 2005
See http://www.michigan.gov/documents/wood_energy_in_michigan--final1_169999_7.pdf, p. 16 for map of plant locations.

In the near-term, however, increased demand for waste wood material could cause the fuel price for existing wood-burning generating facilities to increase.

Another potential expansion, however, is through advanced forest management practices. That approach does appear promising, but would require substantial investments. In this approach, cullings from more aggressive forest management practices become the primary fuel for the near-doubling of Michigan’s existing wood-fueled power plants. Again, the analysis completed for the Plan suggests there would be plenty of biomass resources, on a sustainable basis, to meet the needs modeled here.

Ultimately, these two different paths are not necessarily mutually exclusive. As long as either or both happen to a sufficient extent, there would be plenty of biomass resources, on a sustainable basis, to meet the needs modeled here. In addition, however, it must be understood that there are many competing and complementary uses, not only for forest products but also for forests themselves. Forests provide many vitally important natural services, including helping to prevent soil erosion, ensuring biodiversity, and creating habitat for wildlife. Forest lands are critically important to Michigan’s travel and tourism industries. Policy makers must be vigilant to assure that poor forest management is not an unintended effect of energy policies intended to promote greater use of biomass energy resources. To the contrary, among all possible uses, the use of biomass for energy is generally considered preferable only to landfilling. Ideally, higher value purposes for biomass as a raw material for paper or lumber products, or as a chemical feedstock, will be maximized and only residues not suitable for such higher purposes will be converted to energy. Furthermore, it is imperative that some biomass residues should remain on

the forest floor, in order to ensure continued productivity of forest soils and biodiversity.⁴⁹ Still, it is generally understood that conscientiously applied forest management practices can simultaneously improve forest productivity while helping to meet this entire variety of purposes.

2.2.2 Biomass Produced on Abandoned Cropland

Approximately 3.2 million acres of cropland has been abandoned in Michigan since 1950. It is assumed that 1.9 million acres is presently standing idle, which might make it available for growing energy crops such as willow, poplar, or switchgrass. Willow and poplar have a three year harvest cycle. Switchgrass requires three years to mature to the first harvest, and then it can be harvested annually. Based on those assumptions, presently abandoned cropland could potentially contribute an estimated 5.7 million dry tons to the annual energy needs of the state.

2.2.3 Agricultural Residues and Plantings on Conservation Reserve Program Lands

Active cropland is producing a range of commodities, some of which can be diverted into energy feedstocks. These crops are not included here since it is assumed that farming will continue regardless of the end product. The potential for additional production lies in the use of non-traditional sources like crop residues and perennial crops (like switchgrass) growing on Conservation Reserve and Wetland Reserve lands. Together these sources of biomass might yield about 5.0 million dry tons of biomass. Table 7 summarizes the data regarding cellulosic biomass resource estimates.

Table 7: Michigan Additional Cellulosic Biomass Resource Estimates

Resource Type	Resource Potential (dry tons/year)	Exclusions	Resource Available (dry tons/year) ¹
Surplus Growth from Commercial Forest Land	16,800,000	86%	2,352,000
Biomass Produced on Abandoned Cropland	5,700,000	86%	798,000
Agricultural Residues and Plantings on Conservation Reserve Program Lands	5,000,000	86%	700,000
Total			3,850,000

Notes: Resources are "additional" to those already in use at present. Data on these resources was provided by Dr. Raymond O. Miller, Manager of the Upper Peninsula Tree Improvement Center, Michigan State University.
¹Refer to text for conversion from dry-tons/year to MW and MWh.

In practice, each MW of wood-fired electric power uses approximately 10,000 tons of wood residues per year. This assumes the power plant operates at approximately 80 percent capacity,

⁴⁹ Ash residues from wood combustion can often be reapplied to forest or agricultural lands as a soil amendment with positive results for productivity, as long as the ash does not contain high quantities of metals or potential pollutants.

generating about 7,000 MWh per year, per MW of capacity.⁵⁰ As evident from the above, Michigan is estimated to have an additional 27.5 million dry tons of biomass available that could, in theory, fuel 2,750 MW of generation each year. For modeling purposes, however, only 14 percent of this cellulosic biomass potential (about 3.85 million dry tons per year) was assumed to be available for electricity generation by 2016, and a capacity factor of 80 percent was used for analyzing cellulosic biomass energy potential.⁵¹ The large exclusion percentage is a conservative assumption intended to reflect competing land uses, high transportation costs for agricultural and forestry residues (which effectively limit the distance from resource lands to biomass generating facilities), and stiff global competition in the paper and forest products industries.

Existing biomass fueled facilities in Michigan, as depicted in Table 6, are predominantly wood-fired boilers. Future applications could include biomass conversion via direct combustion, gasification, or anaerobic digestion, and biomass could be used in stand alone electricity generators, in CHP applications, or via co-firing in coal-burning power plants. The resource analysis completed for the Plan does not assume any particular conversion approach or application technology, but costs associated with cellulosic biomass facilities are based on representative costs for direct combustion facilities like those listed in Table 6. It should be noted, however, that this modeling does not address biomass gasification. Preliminary research suggests a potential for roughly doubled conversion efficiency using gasification, which implies a much greater potential for cellulosic sources if gasification proves practical and economical.

2.3 Anaerobic Digestion

Anaerobic digestion converts organic wastes into methane, which can then be used to fuel an electric generator. The CNF report estimated that 51 MW of generating capacity was available in Michigan, assuming that farms with 500 or more head of cattle would provide the most likely sites for this option. For the Plan, Staff added swine and poultry operations and wastewater treatment facilities. These farms have the potential to contribute an additional 15 MW of generating capacity. It should be noted that the estimate of farm-based electricity production is based on the number of Michigan farms that are thought to be large enough to support economical anaerobic digesters. Additional generation, from facilities that aggregate wastes from many smaller operations, is not included. Staff is not yet convinced that this is an economically viable option, given the additional costs associated with transportation.⁵² Another opportunity being explored for future anaerobic digester projects is blending animal wastes with food processing wastes. Mixing the two waste streams increases biogas production and thus electricity output. Locating digesters for easy access to multiple waste streams could also provide additional generation that might be used to meet RPS targets.

⁵⁰ See <http://efile.mpsc.cis.state.mi.us/efile/docs/14031/0161.pdf>, p. 134.

⁵¹ In comparison, the average capacity factor in 2005 for Michigan's major existing biomass fueled facilities, as shown in Table 6, was 81%.

⁵² See *West Michigan Regional Anaerobic Digester Feasibility Study*, at <http://www.michigan.gov/biomass>.

Additional electric generation potential of approximately 30 MW was calculated based on an analysis of wastewater treatment plants with sufficient flow rates. While some wastewater treatment plants already have anaerobic digesters on site, the installation of electric generation equipment would still be necessary. For the Plan, it was assumed that 15 MW of the potential 30 MW would be reached by 2016.

The anaerobic digestion capacity factor was adjusted from 90 percent used in the CNF modeling to 80 percent for the Plan modeling. At the time the CNF report was written, very limited operational data was available for anaerobic digestion. However, data is beginning to become available as new projects are developed. Installations in Vermont's Cow Power™ program have experienced capacity factors averaging about 77 percent.⁵³ For Plan modeling purposes, Staff believe updating the capacity factor from 90 percent to 80 percent provides a closer estimate of what might be an achievable anaerobic digestion capacity factor. A new Michigan dairy farm anaerobic digester system began operating in November 2006 and a second project is expected to begin generating electricity in April 2007. More data will be known about anaerobic digestion capacity factor values as experience is gained from these projects.

2.4 Landfill Gas

Landfill gas likewise relies on the conversion of organic material to methane, which is used as a fuel for electric generation. Staff adopted the quantities and costs of landfill gas generation estimated to be available from the CNF.

2.5 Biomass Resources and Combined Heat and Power Analysis

Combined heat and power systems typically use energy sequentially to generate steam and then electricity, or electricity and then steam. The steam is used to provide industrial process heat or for building space or water heating. In some systems, called tri-generation, an absorption chilling circuit is added so that chilled water can be provided as a third potential energy use.⁵⁴ CHP systems can be a preferred method of energy conversion because they make greater use of the energy inherent in the fuel.

CHP is not new technology, by any means. Michigan has a long history of CHP facilities that provide process steam for industrial facilities, district heating systems in urban areas and for some of Michigan's largest college and university campuses.⁵⁵ Biomass-fueled CHP is also a tried and true technology in some Michigan installations. For example, Dow Chemical used a

⁵³ Dunn, David J. (2006, May), *Financial Incentives for New Renewable Generation on Vermont Dairy Farms*. Presented at Renewable Portfolio Standards East Conference, Cambridge MA, for Central Vermont Public Service Corporation.

⁵⁴ CHP stands for combined heat and power. CHP plants incorporate both power and heat from a single heat source.

⁵⁵ District heating systems grew in the time period through the first half of the 20th Century. Later, as natural gas became more readily available and the price of natural gas remained low during roughly the 1970s through the 1990s, many district heating customers replaced their use of the steam from central power plants with cheaper natural gas. Though the natural gas price trend has reversed and prices have been volatile in the early years of the 21st Century, district heating systems have not yet recovered the sales lost.

22 MW facility for many years, fueled by wood waste, and Central Michigan University operates a 1 MW system that has successfully provided electricity and steam for its campus, on and off since 1985.

There are some industrial boilers that are presently fueled with wood residues. Those wood fueled boilers were not included in the CHP analysis undertaken by the Alternative Technologies Workgroup. Instead, they are considered to be available in the Renewable Energy report to be converted to biomass-fired cogeneration systems, utilizing a small portion of the available cellulosic biomass resources. With the intent to avoid double-counting these facilities in both CHP and biomass assessments, their potential contribution is embedded in the biomass electricity production estimates, above. In essence, the biomass resources identified in the Plan are thought to be available for utilization in a variety of facilities, and it is expected that perhaps sites with existing wood-fired boilers would be among the first to consider adding electric generation to become biomass-fueled CHP facilities. If those facilities were to add electric generation, it is estimated that their total biomass fuel use would increase by approximately one-third; approximately 45,000 dry tons per year or roughly 1 percent of the total available cellulosic biomass resource.

The analysis of biofuel availability for Michigan shows a substantial potential. Almost any of those materials can be utilized in CHP facilities, depending on the energy conversion technologies applied. Anaerobic digesters, landfill gas facilities, and wastewater treatment plants can all utilize methane fuel in a CHP boiler system or gas turbine generator (either simple-cycle or combined cycle). Solid biomass can be converted to liquid or gas fuels prior to combustion using biochemical or thermal processes, or the solid fuels can be utilized directly in solid-fuel combustion boilers. In fact, solid biomass can be blended in coal-fired boilers, in a process called co-firing. Co-firing involves the simultaneous combustion of different fuels in the same boiler.⁵⁶ CHP systems can be developed using any of these basic types of energy conversion technologies.

2.6 Biomass Resources Summary and Conclusion

In many ways, utilization of the biomass potential identified for modeling in the Plan ultimately depends a lot on public policies, which are discussed later in this report. If policies are established which remove barriers and support utilization of biofuels for electricity production, then the state could expect to successfully meet the potential for biomass energy modeled in the Plan. With or without such policy changes, however, making available the quantity of new biomass electric power generation modeled for the Plan will represent substantial technical challenges. This Plan cellulosic biomass resource assessment reflects a near doubling of Michigan's existing biomass fueled electricity generation, at a time when Michigan forest products industries have been contracting rather than expanding. With favorable policies, however, Staff is confident that the quantities of biomass resources identified here, and perhaps even substantially more, could economically be obtained and converted to electricity.

⁵⁶ Simpkins, Dulcey, (2006, June), *Clean Energy from Wood Residues in Michigan*, p. 35. Available online at http://www.michigan.gov/documents/wood_energy_in_michigan--final1_169999_7.pdf.

2.7 Wind Energy Modeling for the Plan

Wind energy potential for the Plan was analyzed based on a few basic incremental changes applied to data used for the Capacity Need Forum report. Similar to the analysis of biomass energy resources, a very large gap currently exists between the technical potential and achievable near-term potential for wind generated electricity in Michigan, based on the best available wind energy mapping completed for the state.

The CNF estimate of potential wind generation began with wind mapping completed for Michigan in 2004.⁵⁷ The wind assessment was co-sponsored by the Michigan Energy Office and the U.S. Department of Energy's National Renewable Energy Laboratory and provided wind speed and wind power density maps for Michigan which were verified at 50 meters above the ground. These maps served as the basis for estimating the technical potential for wind generation in Michigan.

The CNF estimate of wind generation was calculated for those regions within Michigan with an on-shore wind class of 4 or higher (also designated 4+) at a 50 meter height. Class 3 regions make up a large part of the Lower Peninsula at 50 meter heights but were deemed to have insufficient wind speed and duration to be economically harnessed. Therefore, the CNF participants excluded the class 3 regions from their analysis of available wind energy in Michigan. Additional downward adjustments to wind potential in the state were made by CNF participants to account for the difficulty of building facilities in designated wilderness areas, state and national forests, urban areas, wetlands, and other areas. After the exclusions, 831 MW of electric generating capacity was estimated to be available from on-shore sites with class 4+ wind regimes. This amount was further reduced by 50 percent as another conservative adjustment to account for potential local siting impediments.

Wind maps were also produced for 70 meter and 100 meter heights, where wind speed and duration are typically greater than at lower elevations. Modern utility scale wind generators are typically installed with hub-heights of 70 to 80 meters, however, and the data currently available for 70 and 100 meters must be considered preliminary and not yet verified. In 2005 and 2006, several wind developers requested utility interconnections in Michigan, and information based on those requests led Michigan Public Service Commission Staff and other interested parties to question the accuracy of information provided in the 2004 Michigan wind maps. The crux of the questions revolved around the fact that previous National Renewable Energy Laboratory (NREL) estimates of wind potential in the Thumb area of Michigan were far lower than requests already published in the Midwest Independent System Operator (MISO) queue by early 2006 (see Table 8, p. 140).

As NREL researchers explain, the potential wind energy presented in the 2004 maps for Michigan must be considered to be a general estimate. The existing wind maps for Michigan are

⁵⁷ See http://www.michigan.gov/cis/0,1607,7-154-25676_25774-101765--,00.html.

intended to provide a general picture of wind availability, but those maps must be supplemented by on-site wind data measurement and analysis prior to siting wind generators.⁵⁸

At sites that have been measured in the Midwest, substantial wind shear has been identified at heights above 50 meters. That implies that wind speed and power could be substantially greater at typical hub-heights (70 to 80 meters) for currently installed utility-scale wind generators, compared to what has been predicted at 50 meters. For example, in northwest Indiana near Lake Michigan, tall-tower measurements have indicated more wind shear and a greater wind resource at 90 meters than would be estimated by conventional assumptions and wind energy rules of thumb based on upward extrapolation of the 50 meter data at the same location.⁵⁹ This example points out how the map estimates (largely based on data from weather stations, collected at 10 meters) and even measurements taken at 50 meters can be misleading when it comes to estimating the resource available for potential wind development for large wind turbines with hub-heights of 70 meters and higher.

As shown in Table 8, Michigan wind energy projects totaling 1,191 MW have contacted MISO at some point in the past couple of years, requesting grid interconnection. During the time period covered by research for the Plan, however, there were significant developments regarding the MISO queue in the Thumb area of Michigan. In total, 911 MW of wind generation in Michigan's Thumb had requested interconnection studies from MISO. Costs associated with interconnections at both the distribution and transmission levels have resulted in many of the proposed projects withdrawing from the MISO queue. Presently, out of the initial 911 MW, only about 400 MW remain in the queue and interconnection facilities studies for these projects are ongoing.⁶⁰ The amount of future wind development in Michigan may be constrained by the limitations of the existing transmission/distribution infrastructure and the costs necessary for upgrading it to accept large quantities of wind generation.

The CNF based its estimates for Michigan's wind energy potential on wind maps provided by NREL. These maps generally depict wind regimes in the state, but must be supplemented by local wind studies. Based on proposed projects in the MISO queue (Table 8) and discussions with wind energy participants in Michigan, Staff initially increased the amount of wind estimated

⁵⁸ These cautions about appropriate uses for the Michigan wind maps were included in a draft report, *Michigan Wind Energy Potential, 2006-2020*, which was provided to participants in the Capacity Need Forum project. See http://www.dleg.state.mi.us/mpsc/electric/capacity/cnf/othersgen/mi_wind_energy_potentialjun14_2005.pdf. In particular, see footnote 7 on p. 2, and the discussion about exclusions, on p. 6-7.

⁵⁹ The measured wind resource at 50 meters for this Indiana location reflected low class 3 wind power and an average 6.7 meters per second wind speed. At 90 meters, however, it measured 7.7 meters per second, which would be equivalent to almost class 5 at 50 meters. The gross capacity factor at 90 meters was 42.6 percent for the GE 1.5 MW 77-meter hub height machine (personal communication from Dennis Elliott, National Renewable Energy Laboratory, August 4, 2006).

⁶⁰ Because some of the wind generators previously included in a MISO group study for interconnections requested in Michigan's Thumb area recently withdrew from the queue, a new facilities study must now be completed to reflect the lower number of MW under consideration for interconnection in this area. The new facilities study is expected to be completed by October 2006. When completed, it will be posted on the MISO website, under *MISO Generator Interconnection Queue*, at <http://www.midwestiso.org/page/Generator+Interconnection>.

to be available for the Plan to 525 MW. In reviewing wind energy resource information for Michigan, there is a technical potential for much more than the 525 MW of installed capacity modeled for this report. The initial modeling for the Plan begins with an estimate of wind energy potential for the coming several years, based on the projects already participating in the MISO queue that appear on track to be developed. There is ample reason to believe that additional wind energy resource development will prove easier as time goes by and more experience is gained with the early installations in Michigan. This has certainly been the pattern in many other states in the U.S.⁶¹

Table 9 (p. 140) shows the comparison of the wind power projections for the Plan and the Capacity Need Forum. Several Plan participants, notably the Energy Office, have indicated that the conservative adjustments made to the NREL study result in Michigan's wind energy potential being significantly underestimated. Specifically, they note that a wind class encompasses a range of wind speeds. For example, class 3 runs from an average speed of 6.4 meters per second to 7.0 meters per second. Even average speed differences of 0.5 meters per second can make a large difference in the ability of a site to produce electricity economically. According to some of the commenters, better class 3 sites may be suitable and capable of producing electricity economically, especially when one considers that the wind speeds are measured from a 50 meter height. Commenters note that some of the class 3 wind regions measured at 50 meters are likely to be class 4+ at 70 meters or 100 meters; the heights at which commercial wind turbines are more likely to be built. Commenters also indicate that the proposed schedule for achieving renewable generation is unnecessarily protracted. Some commenters pointed out that no substantial impediments were identified by Renewable Energy Workgroup participants to a somewhat accelerated implementation of portfolio standards.

NREL has estimated that approximately 15,700 MW of potential wind generation is available from on-shore class 3 wind regions within Michigan based on 50 meter measurements. Many of these sites are more favorable than others and are likely to have class 4+ wind characteristics at 70 to 100 meter hub heights. Based upon the observations, information, and recommendations received from participants, Staff reassessed Michigan's achievable wind energy potential based upon slightly less conservative assumptions of wind availability. Considering the role played by wind shear at higher elevations and the NREL wind maps for 70 and 100 meters, Michigan has substantially more wind generating capability than the conservative assumptions initially adopted for the Plan. If one assumes that a quarter of the class 3 wind regions can be economically harnessed at 70–100 meters, that would still produce nearly 4,000 MW of wind capacity. If one were again to assume that only half this amount could be harnessed because of siting difficulties (in addition to the exclusions already made in arriving at the 15,700 MW amount), that would leave nearly 2,000 MW of potential capacity available from class 3 regions. This 2,000 MW amount together with the 415 MW from the class 4+ regions used in the CNF serves as an upper estimate of the wind potential of 2,415 MW that can be harnessed in Michigan by the end of 2015 to meet a renewable energy portfolio target. Furthermore, information provided to the Staff indicates that ample high-quality sites are available, in areas thought to be sufficiently accessible to wind developers, to move the target compliance date to 2015.

⁶¹ Please see the discussion in the Policy document, Appendix Volume I, for additional insights about how policy changes are expected to open the market for wind energy development in Michigan.

When this amount of wind energy is added to other sources of renewable energy, the result is a little more than 10 percent of Michigan's forecast energy sales by the end of 2015. The broader assessment of 10 percent combined with the initial more conservative estimate of 7 percent produces a range of reasonable portfolio targets running from seven to 10 percent. A renewable portfolio target within this range should be achievable on reasonable terms by the end of 2015.

It should be noted that achieving the upper end of this range may require significant additional transmission investment. Staff anticipates working with MISO and Michigan's transmission owners to assure that sufficient transmission will be available when needed. Staff will also work with Michigan distribution utilities to assure the Michigan system will be able to accommodate the major use of wind power anticipated by this proposal.

**Table 8: Michigan Renewable Resource Facilities in MISO Interconnection Queue,
Including Withdrawn Projects (September 2006)**

MISO Queue Number	County	In Service Date	Max Summer Output (MW)	Fuel Type	Point of Inter-connection
37494-01	Shiawassee	01-Jan-03	4	Biomass	
38377-01	Sanilac/ Huron	01-Nov-06	36	Wind	DTE 41kV system near Talbot to Delaware/Neff/Sandusky ckts
38394-02	Huron	30-Oct-07	37.5	Wind	
38425-02	Huron	30-Oct-06	158	Wind	
38425-03	Sanilac	30-Oct-07	158	Wind	ITC 120kV circuit from Sandusky to Lee
38457-02	Oceana	01-Oct-06	100	Wind	White Lake Substation
38478-01	Sanilac	30-Oct-07	40	Wind	ITC 120kV Sandusky Station
38484-04	Huron	30-Oct-07	50	Wind	DTE 41kV system north of Bingham Station
38485-01	Huron	30-Oct-07	100	Wind	DTE 41kV Pigeon Station
38509-01	Huron	15-Oct-06	60	Wind	120kV Bad Axe-Arrowhead line DTE
38660-01	Huron	01-Aug-07	60	Wind	Existing 120kV line near Rapson Rd and Minden Rd
38663-01	Missaukee	01-Aug-07	60	Wind	69kV line near La Chance and Steif Roads
38715-02	Ontonagon	10-Jun-08	14	Biomass	White Pine Sub
38835-02	Huron	30-Oct-07	37.5	Wind	
38835-03	Huron	30-Oct-07	37.5	Wind	
38835-04	Huron	30-Oct-07	37.5	Wind	
38888-01	Allegan	01-Jul-08	102	Wind	Argenta to Tallmadge 345kV line
38937-01	Huron	15-Nov-07	49.5	Wind	ITC Wyatt-Sandusky 120kV
38937-02	Sanilac	15-Nov-07	49.5	Wind	ITC Wyatt-Sandusky 120kV
Total MW (Includes MW from withdrawn projects.)			1,191		
Total MW (Does not include MW from withdrawn projects.)			920.5		
Note: Strikeouts represent projects withdrawn from the MISO queue. Above information is online at http://www.midwestiso.org/page/Generator+Interconnection .					

Table 9: Wind Power Capacity Projections by Region for CNF and Plan

Region	MW Nameplate Capacity			Capacity Factor		GWh/Year		
	Plan 7% RPS Modeled (2016)	Plan 10% Accelerated RPS (2015)	CNF (2015) ¹	Plan ²	CNF	Plan 7% RPS Modeled (2016)	Plan 10% Accelerated RPS (2015)	CNF (2015) ¹
Southeast Michigan	250	1,150	53	28%	25%	613	2,821	116
Balance of Lower Peninsula	200	650	285	28%	25%	491	1,594	624
Upper Peninsula	75	350	105	28%	25%	184	859	230
Total	525	2,150	443			1,288	5,274	970

¹ During the CNF modeling process, wind contributions were scaled up to the numbers shown to meet the required additions of the modeled portfolio standard (3 percent in 2008, 5 percent in 2010, and 7 percent in 2015).
² The wind capacity factor used was 20%, for both the 7% RPS modeled for the Plan and the 10% accelerated RPS.

The chief factors driving the cost of wind generation include the installed cost for the wind generator, interconnection costs and the expected capacity factor. Costs calculated on a kWh basis are highly dependent on the unit’s capacity factor (on how often it operates, and at what percentage of its design capacity). For the CNF, Staff estimated the average capacity factor of wind generators at 25 percent. However, it seems reasonable to assume that wind developers are already targeting projects to sites with good wind resource characteristics, including high average wind speeds and capacity factors, and low interconnection costs. Prospective developers have indicated Michigan has considerable land area with estimated capacity factors of 30 percent or greater. Based on these assumptions and observations, Staff believe the 28 percent capacity factor used in modeling wind energy for the Plan is reasonably conservative.⁶² A number of participants indicate there is a very large potential for wind energy generation off-shore, in the Great Lakes. Staff did not estimate, nor incorporate into the estimates, any off-shore wind generation.⁶³ This decision is based in large part on the assumption that anything more than experimental or pilot scale off-shore wind energy development is not likely in the next decade. Should off-shore wind development in the Great Lakes prove practical, however, current estimates show it could produce substantial additional energy for the Michigan system.

⁶² Additional details explaining further the assumptions used in wind energy modeling for the Plan will be made available in a separate publication, to be posted on the Renewable Energy Workgroup website, <http://www.dleg.state.mi.us/mpsc/electric/capacity/energyplan/renewables/renewables.htm>.

⁶³ Background information about Michigan’s offshore wind energy resources in the Great Lakes is available in a report completed for the Capacity Need Forum. See *Potential for MI Offshore Wind Energy* at <http://www.dleg.state.mi.us/mpsc/electric/capacity/cnf/othergen/other.htm>. As that report concludes, however, any development of offshore wind energy resources in Michigan waters of the Great Lakes is not likely to proceed until research is completed on many significant technical and policy issues. Thus, offshore wind is not likely to make any substantial contribution within the roughly 10-year time frame explored in modeling for the Plan. However, a 710 MW offshore wind farm is presently being considered for installation in Canadian waters in Lake Ontario. See <http://www.renewableenergyaccess.com/rea/news/story?id=45079>.

Some other participants question whether the cost assumed for wind generators is high enough to reflect current and future market prices. Instead of \$1,425 per kW installed cost, some participants report current prices in the range up to \$1,700. Staff recognizes that current prices may be significantly higher than the \$1,425 incorporated into the model, but Staff notes the long-term general trend for wind energy costs has been declining relative to fossil fuel prices. Staff believes there are other important countervailing factors, too, that support the lower cost used in this modeling; even if the prices used do turn out to be inaccurate in the present and near future. First, prices for fossil fuel units are just as likely as wind machines to be affected by high commodity prices (for steel, concrete, copper, etc.), in which case the costs of both types of facilities will generally rise together and the relative cost comparisons will remain fairly stable. Second, wind conversion efficiencies are expected to continue to improve, and thus result in some combination of higher production and lower cost, but those improvements are not captured in this modeling. And, third, the current wind generator prices are partly a response to what are generally high short-term demands chasing limited manufacturing capability. The demand is caused in part by growth in many states' RPS targets combined with the on-again, off-again threat that federal production tax incentives will expire.⁶⁴ Thus, on the whole, Staff expects the current market prices for wind systems to moderate as additional manufacturing capability comes online and production increases to meet growing demand.

3. Renewable Energy Modeling Summary and Conclusions

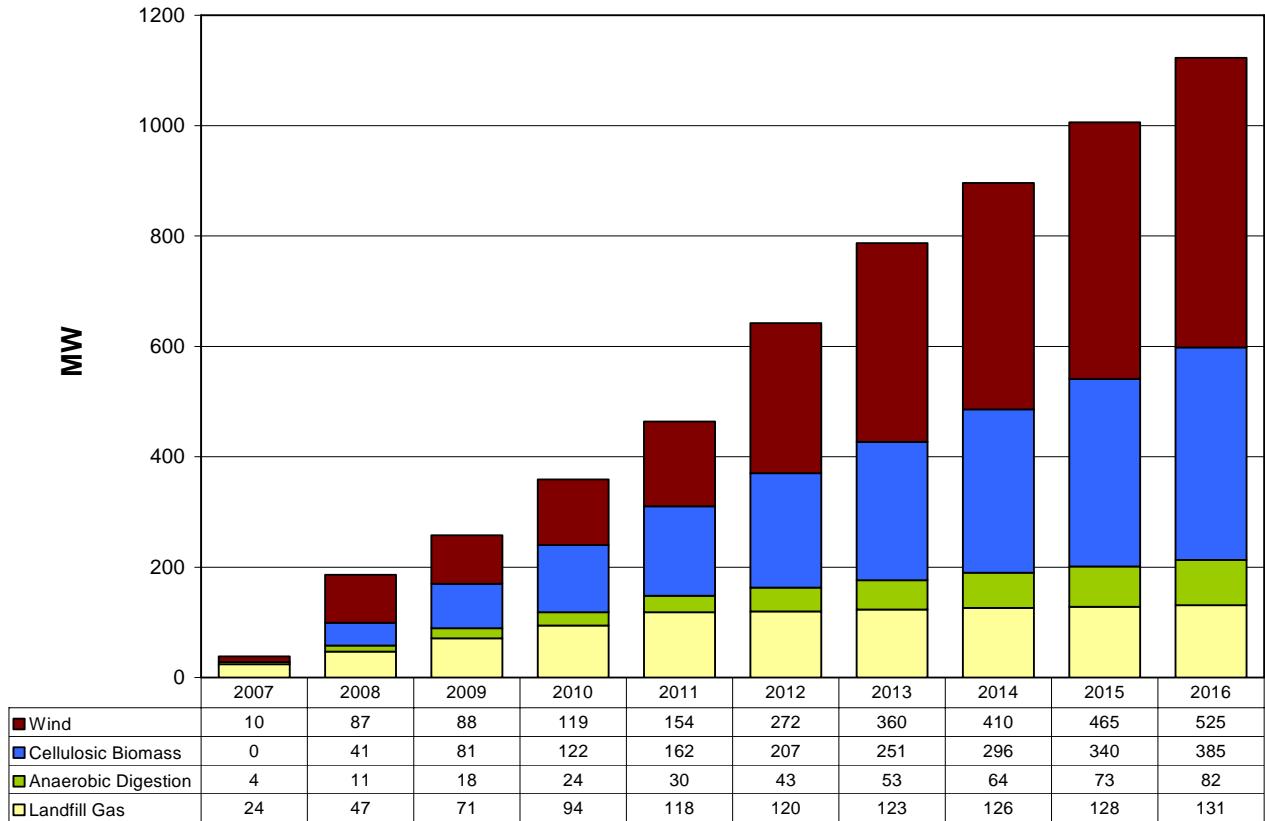
The Plan's renewable resource assessment shows a potential for Michigan's electric supply portfolio to incorporate the renewable range running from about 7 percent to 10 percent renewable energy by the end of 2015. The conservative portfolio option, used for expansion plan modeling for the Plan, begins with the current level of approximately 3 percent renewable energy in the current supply portfolio and adds renewable energy totaling 4 percent of retail sales, to reach a statewide target of 7 percent. Based on the energy forecast for the Plan, this amounts to 1,123 MW or 5,590 gigawatt hours (GWh) of additional renewable energy by 2016 for the conservative case. Alternatively, the accelerated schedule depicted in Figure 3 begins with the current 3 percent level and increases to 10 percent by the end of 2015. Again, based on the energy forecast for the Plan, this amounts to 2,691 MW or 9,178 GWh. The resource assessment conducted for the Plan demonstrates that Michigan does have ample renewable resources available for statewide electricity production to achieve, in this timeframe and with little if any incremental cost, at least these levels of renewable energy production.

Figure 2 shows the renewable energy supply portfolio modeled. The accelerated renewable energy supply portfolio is shown in Figure 3. The specific divisions shown among the various sources of renewable energy depicted in both Figures should be understood to be illustrative only. As was discussed earlier in this report, the specific resources to be developed might include at least some contributions from solar and hydroelectric resources that have not been explicitly included in Plan modeling, and the resource potential investigated for both wind and

⁶⁴ The U.S. Congress passed on December 11, 2006, an extension of the wind energy production tax credit through 2008. See http://www.awea.org/newsroom/releases/Congress_extends_PTC_121106.html.

biomass is ample for either or both of those resources to exceed the quantities of production modeled here. Thus, the eventual contributions from each resource type might differ from the quantities depicted in Figures 2 and 3, but Staff is confident that these overall levels of additional renewable resources for Michigan’s electric power production portfolio are achievable.

Figure 2: New Renewable Resources in the 7 Percent Portfolio (MW)



Still, reaching Michigan’s renewable potential will require a substantial increase from the existing renewable resource base in Michigan, and reaching these levels within the expected timeframe will necessitate overcoming regulatory, technical, financial, and policy challenges. Nevertheless, as the modeling of various scenarios for the Plan demonstrates, the challenges associated with the addition of traditional energy resources or with reliance on neighboring markets for Michigan’s future electric power supply are also perhaps equally or even more challenging. Therefore, Staff consider these preliminary targets, in the range from 7 to 10 percent renewable resources, to be reasonable for near-term policy consideration.

Figure 3: New Renewable Resources in the 10 Percent Accelerated Portfolio (MW)

