Projected Job and Investment Impacts of Policy Requiring 25% Renewable Energy by 2025 in Michigan

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1. Introduction

Among the potential ballot proposals that will face Michigan voters in the November 2012 election is one requiring an increase in the amount of renewable energy in Michigan's electricity portfolio. The ballot proposal reads as follows:

> *"§ 55 Michigan's Clean Renewable Electric Energy Standard*
>
> *It is the policy of Michigan to promote and encourage the use of clean renewable electric energy sources. Clean renewable electric energy sources, which naturally replenish over a human rather than geological time frame, are wind, solar, biomass and hydropower.*
>
> *Beginning no later than 2025, at least 25% of each electricity provider's annual retail electricity sales in Michigan shall be derived from the generation or purchase of electricity produced from clean renewable electric energy sources. The foregoing clean renewable electric energy standard shall be implemented incrementally and in a manner that fosters a diversity of energy generation technologies. Facilities used for satisfying the standard shall be located within Michigan or within the retail customer service territory of any electric utility, municipally-owned electric utility or cooperative electric utility operating in Michigan.*
>
> *Consumers shall be charged for electricity from clean renewable electric energy sources in the same manner and on the same basis as for electricity from other sources.*
>
> *To protect consumers, compliance with the clean renewable electric energy standard shall not cause rates charged by electricity providers to increase by more than 1% in any year. Annual extensions for meeting the standard may be granted, but only to the extent demonstrated to be necessary for an electricity provider to comply with the foregoing rate limitation.*
>
> *The legislature shall enact laws to promote and encourage the employment of Michigan residents and the use of equipment manufactured in Michigan in the production and distribution of electricity derived from clean renewable electric energy sources.*
>
> *Any provision or portion of this section held invalid or unconstitutional shall be severable from the remaining portions, which shall be implemented to the maximum extent possible."*

Energy policy changes of this magnitude will have a series of impacts such as environmental impacts, land use impacts, transmission impacts, and changes in the power generation portfolio for Michigan among others. This report focuses on the investment and job impacts that would be the result of increasing Michigan's renewable energy generation to 25% of total electricity by the year 2025. While other impacts may be significant they will require future analysis. The authors of this report were contracted to assist in assessing the impacts based on their previous research in the economics of renewable energy, cluster analysis, and energy resource quantification. Previous research includes assessing the potential for onshore wind in Michigan[1], assessing the potential for offshore wind in Michigan[2], serving as consultants to the Michigan Energy Wind Resource Zone Board[3], assessing the efficacy of renewable energy policies[4] and in biomass feedstock assessment among other decision support and impact assessment research[5].

2. Definitions and Key Information

- Although "jobs" are the standard output of economic impact analyses, there are factors like duration that are generally not discussed. In essence, modeling frameworks provide job numbers for a very specific duration, so in this report all results are shown in job years.
    - Job year — Full employment for one person for 2080 hours in a 12 month span.
- All results are modeled based on the additional generation capacity that would be required under the proposed 25% renewable energy standard starting in 2016 through the year 2030. The period spanning 2026 to 2030 is modeled to capture additional capacity needed due to load growth after 2025. The development needed to meet the state's current RPS of 10% by 2015 is not included in these results.
- All operations and maintenance jobs are calculated for the life of a plant, i.e. wind operations and maintenance jobs are calculated for 20 years, landfill gas for 30 years.
- Plate Capacity — The maximum manufacturer's power output rating for an electricity generator.
- Capacity Factor — The ratio of actual output to plate capacity.
- For all technologies, we did not attempt to model clusters of deployment in any given year, rather we distributed all development in equal percentage increments year on year.

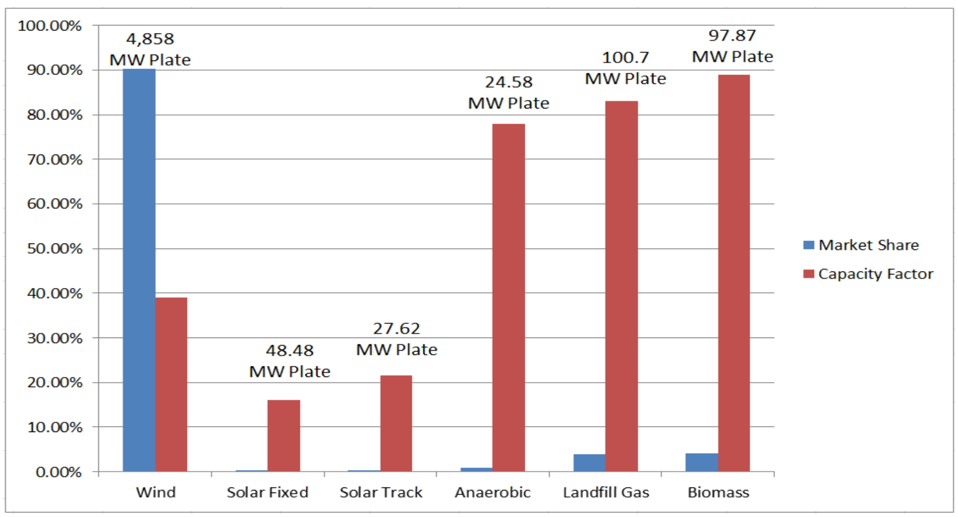

Figure 1: Market share, capacity factor and additional plate capacity needed between 2016 and 2030 to meet the 25% by 2025 policy, by generation technology.

[1] McKeown, C., A. Adelaja and B. Calnin. 2011. "On Developing a Prospecting Tool for Wind Industry and Policy Decision Support." Energy Policy 39(2):905-915.
[2] Adesoji Adelaja, Charles McKeown, Benjamin Calnin, Yohannes Hailu, Assessing offshore wind potential, Energy Policy, Volume 42, March 2012, Pages 191-200, ISSN 0301-4215, 10.1016/j.enpol.2011.11.072.
[3] Public Sector Consultants and the MSU Land Policy Institute, Final Report of the Michigan Wind Resource Zone Board, Lansing Michigan, Available at—
http://www.dleg.state.mi.us/mpsc/renewables/windboard/werzb_final_report.pdf.
[4] Adesoji Adelaja, Yohannes G. Hailu, Charles H. McKeown, Ahadu T. Tekle, Effects of Renewable Energy Policies on Wind Industry Development in the US, Journal of Natural Resources Policy Research, Vol. 2, Iss. 3, 2010
[5] For examples please see the Michigan Prosperity Initiative cluster analysis and gazelle research, available at—
http://www.landpolicy.msu.edu/MPI.

The scenario used for the impact assessment was derived from Michigan's energy resources, current development patterns and nationwide energy specific data. The electricity generation technologies that were modeled are shown in figure 1. For full documentation and description of the process please refer to Appendix 1.

To estimate the impact on employment in Michigan, we employed economic input-output modeling tools. Input-output models consist of matrices of data that describe the interconnectedness of industries, households, and government entities in a region, in this case Michigan. The output of an industry will appear as the input of other industries. Input-output models describe both the transactions between the region and the rest of the world among activities within the region. These models produce economic multipliers that measure the total effect or impact of an increase in demand on employment or income. They are used for predicting and forecasting the impacts of potential changes in an economy.[6] For this analysis, we used the Jobs and Economic Development Impact (JEDI) models for wind and solar from the National Renewable Energy Laboratory and the Impact Assessment for Planning model (IMPLAN) developed by the Minnesota IMPLAN Group. For details on the analysis please see Appendix 1.

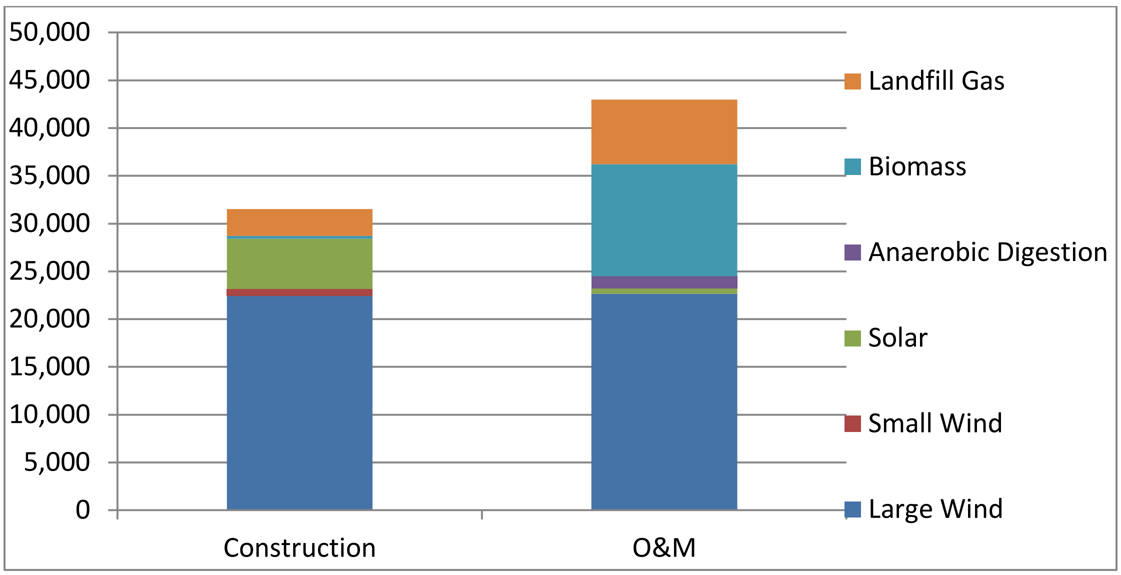

Figure 2: Job year creation by technology for construction and operations and maintenance.

3. Model Results

The total job year impacts for the 25% by 2025 policy are projected to be 74,495, which is made up of 31,513 job years from construction and 42,982 job years from operations and maintenance. This total includes employment created during construction, jobs created for ongoing operations and maintenance and jobs created through the expansion of income due to lease payments for wind energy development. The breakdown of job creation by technology and category (construction or long-term operations and maintenance) is shown in figure 2. Manufacturing jobs are not included in this total as

[6] Stimson, R.J., Stough, R.R., Roberts, B.H. (2002) Regional Economic Development: Analysis and Planning Strategy. Berlin: Springer-Verlag.

those jobs are contingent on the ability of Michigan manufacturers to capture market share in renewable energy manufacturing. This potential is examined in detail in Section 4.

3.1 Commercial Wind Impacts

Wind energy is perhaps the most deployable of all the renewable energy technologies modeled in this analysis. It is also the least expensive, and thus it has the largest market share in the scenario developed. Michigan has abundant wind resources[7], several times the capacity modeled here. The total impact of wind farm construction for the 25% by 2025 policy is 22,450 job years, 3,254 of which are from onsite jobs; 14,539 job years would potentially be created by land lease income construction materials, cabling, legal and real estate services etc. The jobs from turbine or turbine component manufacturing are discussed in Section 4. Another 4,657 job years would be induced as a result of increased demands for lodging, food etc. by the workers building wind farms. These impacts are summarized in table 1.

During Construction Period	Job Years
Project Development and Onsite Labor Impacts	3,254
Turbine and Supply Chain Impacts	14,539
Induced Impacts	4,657
Total Impacts	**22,450**

Table 1: Impacts of the construction of utility scale wind development in job years.

During Operating Years (annual)	Single Year Results (Job Year)	20 Year O&M Job Impacts
Onsite Labor Impacts	227	4,534
Local Revenue and Supply Chain Impacts	362	7,234
Induced Impacts	545	10,892
Total Impacts	**1,133**	**22,660**

Table 2: Job year impacts from the operations and maintenance of commercial wind energy in job years.

Beyond the jobs created by the construction of wind farms, there are additional jobs created for operations and maintenance of completed wind farm developments. The impacts of operations and maintenance of wind farms totals 1,133 for a single year and 22,660 total job years based on extending each year’s impacts out to the 20 year lifespan of wind generation facilities. Often these jobs are extended beyond 20 years through continued operation or through the repowering of wind farms with newer turbines; therefore, the actual impact may be higher.

3.2 Small Wind Impacts

In addition to utility scale wind energy development, there is a small slice (0.42% please see Appendix 1 for details on national trends) of the wind energy market that is met through small wind generation. Typically, this type of wind energy is scaled to the household or small enterprise level with generators ranging from 1 kw to 6,000 kw in plate

Small Wind Construction Impacts	Job Years
Direct	190.0
Indirect	234.1
Induced	269.5
Total	**693.6**

Table 3: Impacts of small wind development in job years.

[7] McKeown, C., A. Adelaja and B. Calnin. 2011. "On Developing a Prospecting Tool for Wind Industry and Policy Decision Support." Energy Policy 39(2):905-915.

capacity. The job year impacts of the deployment of small wind to meet the 25% by 2025 standard total 693.6. Operations and maintenance of the small wind sector were not modeled as they require little maintenance and the impacts would be negligible. As with large wind development, there is additional potential job creation if Michigan manufacturers capture a portion of the small wind manufacturing market. Manufacturing job potential is discussed in Section 4 of this report.

3.3 Solar Photovoltaic Impacts

The solar energy segment of the renewable energy market spans the largest generation scale, from single homes to utility scale solar projects. The inherent scalability of solar energy means it is necessary to model its impacts in several different market segments. In addition, as systems get bigger, it is cost effective to equip solar arrays with tracking systems that keep the array at an optimum angle to the sun. We broke down the solar market into a total of six market segments: residential retrofit, residential new construction, small commercial, large commercial, large commercial with tracking systems and utility scale tracking solar systems based on national averages for system size. For details on each segment, including how it was delineated, please see Appendix 1. All solar market segments have differing levels of economic impact due to different construction and operational requirements. The segments were modeled individually, and the results were summed into tables 4 (construction) and 5 (operations and maintenance).

During Construction and Installation Period	**Job Years**
Construction and Installation Labor	675
Construction and Installation Related Services	1,106
Subtotal	***1,781***
Module and Supply Chain Impacts	
Trade (Wholesale and Retail)	388
Finance, Insurance and Real Estate	
Professional Services	341
Other Services	466
Other Sectors	858
Subtotal	***2,053***
Induced Impacts	1,427
Total Impacts	**5,261**

Table 4: Impacts of the construction of all segments of solar photovoltaic in job years.

Onsite Labor Impacts	**Annual Job Years**	**20 Year O&M Job Impacts**
PV Project Labor Only	17.0	339.5
Local Revenue and Supply Chain Impacts	6.2	124.6
Induced Impacts	5.6	111.4
Total Impacts	**28.8**	**575.5**

Table 5: Impacts of ongoing operations and maintenance of solar photovoltaic in job years, 20 year system life.

3.4 Anaerobic Digestion Impacts

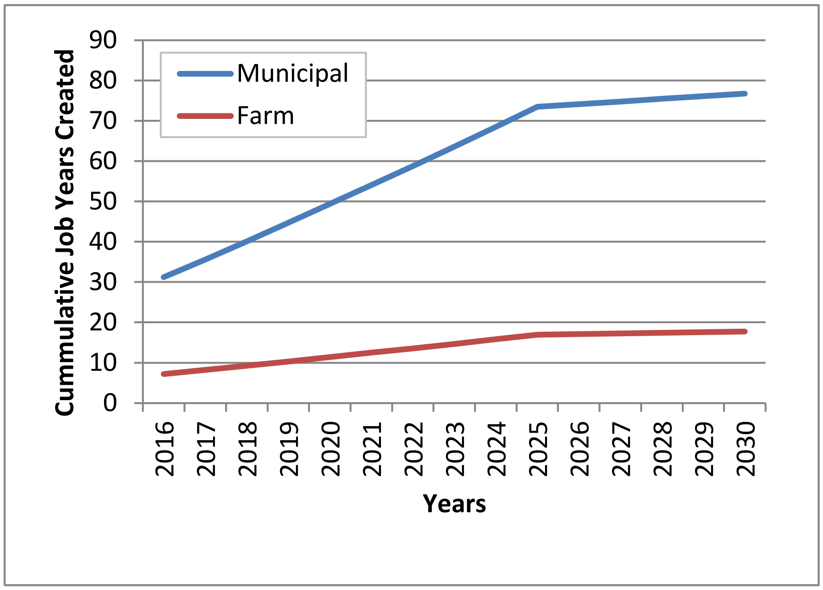

Figure 3: Cumulative impacts of anaerobic digestion in job years.

Managing animal waste is generally considered a nuisance activity associated with livestock production. Similarly, municipalities spend millions every year to manage wastewater treatment facilities. Anaerobic digestion is a common approach to breaking down biodegradable organic matter to remove pathogens. While the primary benefits of controlled anaerobic digestion are nutrient recycling, waste treatment, and odor control, a secondary benefit is the generation of methane gas. As methane gas is the primary component of natural gas, it can be used in the same applications as natural gas. A 25% renewable energy standard is expected to encourage the deployment of small and medium-sized anaerobic digestion facilities for generating electricity, where methane gas is used to turn an electricity generating turbine rather than flared or piped as a substitute for natural gas.

Cumulative Employment Impacts O&M		
Year	**Municipal**	**Farm**
2016	31	7
2017	36	8
2018	40	9
2019	45	10
2020	49	11
2021	54	12
2022	59	14
2023	64	15
2024	69	16
2025	74	17
2026	74	17
2027	75	17
2028	75	17
2029	76	18
2030	77	18
Total Job Years	**1,000**	**240**

Table 6: Cumulative impacts of Anaerobic Digestion construction and operations for the municipal waste and farm waste sectors.

Michigan affords ample resources for generating electricity through anaerobic digestion through both municipal wastewater treatment plants and livestock feeding operations. With 60% of electricity generation from anaerobic digestion coming from wastewater treatment and 40% from agricultural production, it is expected that a 25% RPS will generate 1,000 and 240 total job years over a 20 year horizon, respectively for municipal and farm operations. Job impacts are derived from operation and maintenance, as converting existing digestion operations to electricity generation is generally viewed as a low-cost conversion.

3.5 Landfill Gas Impacts

	Construction	O&M
Job Years	2,808	6,755

Table 7: Impacts of the construction and operation of landfill gas plants in job years.

Michigan's landfills afford an opportunity to generate low-cost electricity from the biodegradation of municipal solid waste. Biogas emissions from landfills have generally been considered a nuisance to their operation requiring monitoring and flaring of excess gases which can often be smelled by nearby individuals. However, gases can be refined for use as a substitute for natural gas or can be burned directly for generating electricity in gas turbines located near the landfill. The landfill capacity in Michigan for generating electricity is sufficient to fuel the 100 MW plate anticipated under a 25% RPS as per the Capacity Needs Forum Study done as part of the 21st Century energy Plan[8].

Converting landfill gas to electricity will generate some 2,808 job years through fixed investment in gas collection and turbines. Most of this is attributed to the installation of gas collection and electricity generating turbine systems. Once installed, the systems are expected to generate ongoing jobs through operations and maintenance of biogas systems that amount to 6,755 total job years.

3.6 Biomass Impacts

Electricity generation from biomass is expected to occur primarily through the co-firing of agricultural and forestry feedstock in existing coal-fired plants making up to 15% of the electricity coming from a plant. Generally, few plant modifications are necessary with low costs. The dominant source of economic impacts from co-firing biomass is in greater agricultural and forestry revenues that, in turn, increase agricultural activity.

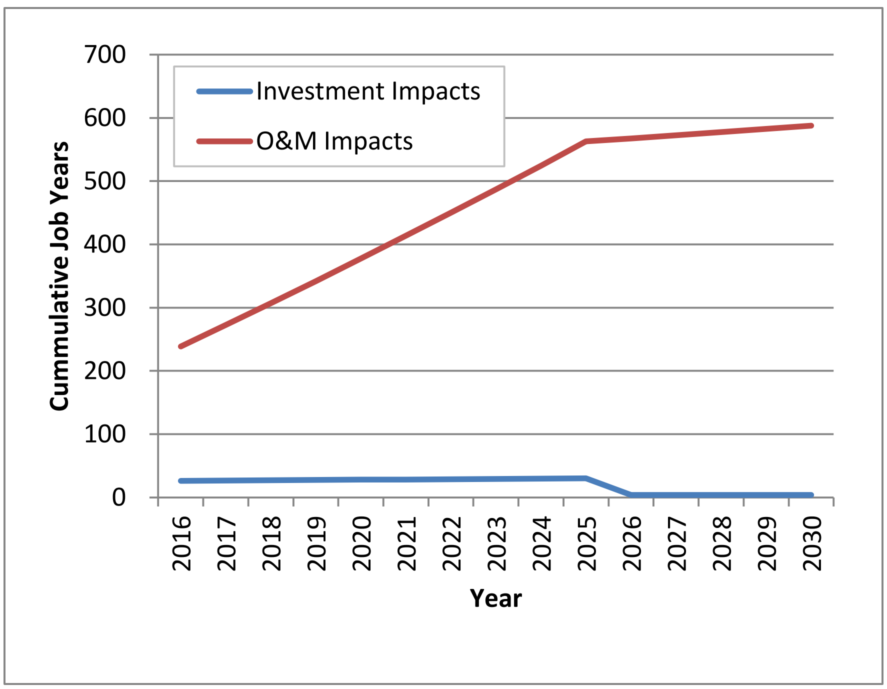

Figure 4: Cumulative investment and operations and maintenance impacts of biomass plants in job years.

[8] Michigan's 21st Century Electric Energy Plan Appendix, Volume Two, available at—
http://www.michigan.gov/documents/mpsc/energyplan_appendix2_185279_7.pdf.

Michigan has ample biomass resources to meet its projected share of electricity generation under the proposed 25% by 2025 standard. Since the marginal capital investment of adding or retrofitting biomass to new and existing coal-firing electricity plants is minimal, the resultant employment impact is expected to be small at about 211 job years over a 20 year horizon.

Additional operations and maintenance employment impacts of generation are expected to negligible as those plants will likely not be adding new workers after conversion. However, the impact to the agricultural and forestry sector is anticipated to be more significant. Accounting for direct and indirect impacts due to feed stock procurement, transportation, logistics, storage etc., it is expected that biomass generation under a 25% RPS will result in nearly 12,000 job years. Together, the investment and operations impact is expected to reach 12,052 job years.

Year	Investment Impacts	O&M Impact
2016	26	239
2017	27	272
2018	27	307
2019	28	342
2020	28	378
2021	28	414
2022	29	450
2023	29	487
2024	30	525
2025	30	563
2026	4	568
2027	4	573
2028	4	578
2029	4	583
2030	4	588
Total O&M job years (20 year project lifespan)		11,751
Total Job Years		**12,052**

Table 8: Cumulative impacts of biomass generation in job years.

4. Manufacturing Job Creation Potential

Michigan has been ranked second in the nation for manufacturing potential coupled with renewable energy resources[9]. There are numerous companies in Michigan either entering or established in the renewable energy manufacturing supply chain; however, projecting job growth due solely to manufacturing as a result of policy changes is not possible as the jobs in Michigan will be the result of the ability of Michigan's manufacturers to capture market share. For this analysis, we separate the manufacturing jobs created in total by the leading renewable energy technologies and then present scenarios of job creation based on differing levels of market capture.

4.1 Utility Scale Wind Manufacturing

Michigan firms have traditionally not been involved in the manufacture of wind turbines or their engineering. Recently, this has started to change as more firms enter the wind turbine supply chain. As a result of the turbines needed to fulfill this policy, the manufacturing and site engineering job creation potential ranges from 3,935 job years at 10% market capture to 39,350 jobs at 100% market capture. These scenarios focus on the potential market within Michigan, as a result of the 25% by 2025 policy proposal and do not include

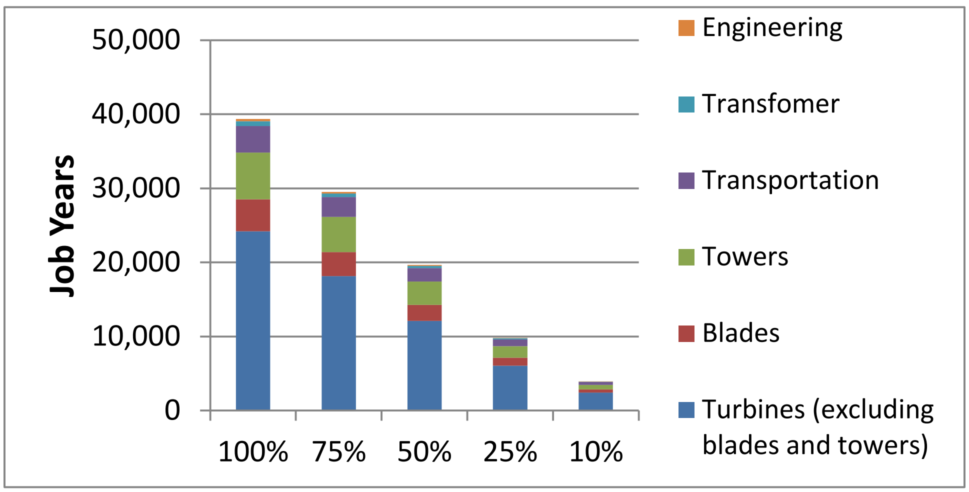

Figure 5: Potential utility scale wind energy manufacturing impacts by sub assembly in job years.

	100%	75%	50%	25%	10%
Turbines (excluding blades and towers)	24,193	18,145	12,096	6,048	2,419
Blades	4,324	3,243	2,162	1,081	432
Towers	6,315	4,737	3,158	1,579	632
Transportation	3,595	2,696	1,797	899	359
Transformer	632	474	316	158	63
Engineering	291	219	146	73	29
Total	39,350	29,512	19,675	9,837	3,935

Table 9: Potential utility scale wind energy manufacturing impacts in job years.

[9] Sterzinger, G., & Svrcek, M. (2004). Wind Turbine Development: Location of Manufacturing Activity (p. 66). Retrieved from http://www.repp.org/articles/static/1/binaries/WindLocator.pdf.

the potential for exporting products to other states or internationally. While both of these extreme scenarios are unlikely, the intervening scenarios shown in figure 5 and table 9 show potential job creation scenarios inside the extremes and across six wind industry subsectors.

4.2 Small Wind Manufacturing

Michigan has several companies that manufacture small wind turbines, so the potential expansion of the industry due to an increase in renewable energy in Michigan is not an unreasonable assumption. However, as with utility scale wind manufacturing, the ultimate magnitude of those impacts will be dependent on market penetration.

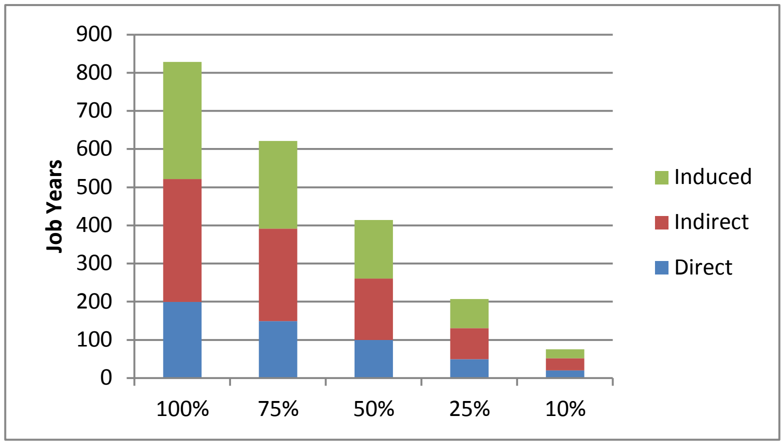

Figure 6: Potential job creation in small wind manufacturing in job years.

The potential job creation from small wind manufacturing ranges from 75.2 at 10% market capture to 858.5 at 100% market penetration. As small wind exists in a single NAICS (North American Industrial Classification System) code, it is possible to calculate indirect and induced impacts, these results are shown in figure 6 and table 10.

Market Capture	**100%**	**75%**	**50%**	**25%**	**10%**
Direct	199.2	149.4	99.6	49.8	19.9
Indirect	322.6	242.0	161.3	80.7	32.3
Induced	306.7	230.0	153.4	76.7	30.7
Total	**828.5**	**621.4**	**414.3**	**207.1**	**82.9**

Table 10: Potential impacts of small wind manufacturing in job years.

4.3 Solar Photovoltaic Manufacturing

There are several companies active throughout the solar photovoltaic supply chain. These companies manufacture products ranging from solar panels, mounting systems, inverters, and raw materials such as polysilicon wafers. As with the other technologies, the potential for solar photovoltaic manufacturing job creation was assessed based on scenarios of market penetration. The results are shown in figure 7 and table 11.

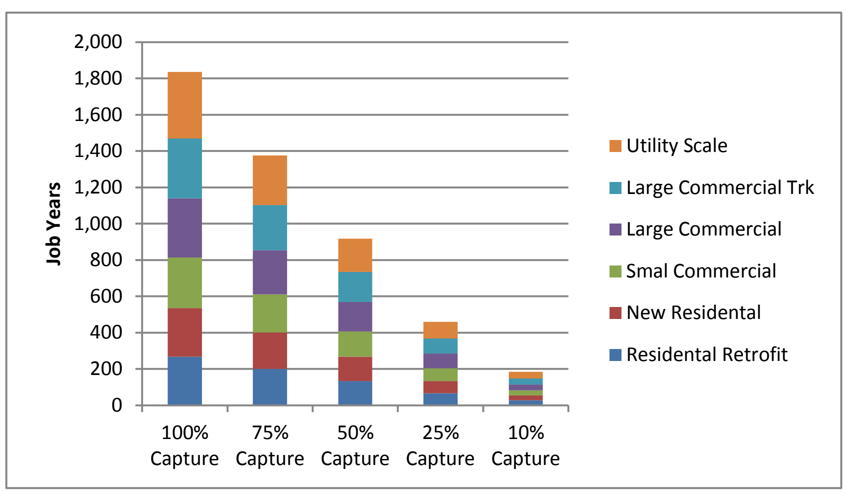

Figure 7: Potential manufacturing job creation in solar photovoltaics in job years.

Type	100% Capture	75% Capture	50% Capture	25% Capture	10% Capture
Residential Retrofit	267.7	200.7	133.8	66.9	26.8
New Residential	267.7	200.7	133.8	66.9	26.8
Small Commercial	278.9	209.2	139.4	69.7	27.9
Large Commercial	324.5	243.4	162.3	81.1	32.5
Large Commercial (T)	330.2	247.7	165.1	82.6	33.0
Utility Scale (T)	366.4	274.8	183.2	91.6	36.6
Total	**1,835.3**	**1,376.5**	**917.6**	**458.8**	**183.5**

Table 11: Potential manufacturing job creation in solar photovoltaics in job years (T) indicates tracking system.

5. Investment Totals

As with any electricity generation project in Michigan, the investment funding comes from the utilities, private developers, and private capital and is ultimately paid for over time by the ratepayers. Capital investment and project costs are the basis for projecting the job year creation in the model framework. Table 12 below provides a summary of the capital and operations and maintenance investments that served as the basis for the projections of job impacts. All numbers are presented in 2010 base dollars.

	Investment (2016 - 2030)	MW Plate
Wind	$9,565,455,053	4,858
Solar	$514,821,278	76.1
Anaerobic	$6,050,229	24.58
Landfill Gas	$204,640,526	100.7
Biomass	$21,993,826	97.87
Total	**$10,312,960,912**	**5,157.25**

Table 12: Investment and operations and maintenance dollars to meet the 25% by 2025 standard.

6. Summary

The $10.3 billion investment in renewable energy in Michigan that would be required by the proposed 25% by 2025 policy could create 74,495 job years in Michigan, which is divided into 31,513 construction jobs years and 42,982 operations and maintenance job years. This total includes employment created during construction, jobs created for ongoing operations and maintenance, and jobs created through the expansion of income due to lease payments for wind energy development. Additionally, there is potential to capture manufacturing job creation; however, the magnitude of that gain is dependent on the success of Michigan manufacturers' ability to capture market share in the renewable energy market.

Appendix 1) Analysis and Technical Inputs

The ballot proposal reads as follows:

"§ 55 Michigan's Clean Renewable Electric Energy Standard

It is the policy of Michigan to promote and encourage the use of clean renewable electric energy sources. Clean renewable electric energy sources, which naturally replenish over a human rather than geological time frame, are wind, solar, biomass and hydropower.

Beginning no later than 2025, at least 25% of each electricity provider's annual retail electricity sales in Michigan shall be derived from the generation or purchase of electricity produced from clean renewable electric energy sources. The foregoing clean renewable electric energy standard shall be implemented incrementally and in a manner that fosters a diversity of energy generation technologies. Facilities used for satisfying the standard shall be located within Michigan or within the retail customer service territory of any electric utility, municipally-owned electric utility or cooperative electric utility operating in Michigan.

Consumers shall be charged for electricity from clean renewable electric energy sources in the same manner and on the same basis as for electricity from other sources.

To protect consumers, compliance with the clean renewable electric energy standard shall not cause rates charged by electricity providers to increase by more than 1% in any year. Annual extensions for meeting the standard may be granted, but only to the extent demonstrated to be necessary for an electricity provider to comply with the foregoing rate limitation.

The legislature shall enact laws to promote and encourage the employment of Michigan residents and the use of equipment manufactured in Michigan in the production and distribution of electricity derived from clean renewable electric energy sources.

Any provision or portion of this section held invalid or unconstitutional shall be severable from the remaining portions, which shall be implemented to the maximum extent possible."

The proposal specifically restricts the technologies to those that regenerate within a human rather than geological timeframe, therefore, technologies that have in other renewable energy legislation such as cogeneration were not assessed for their impacts. Those that were modeled are defined as:

- Landfill Gas – A gas produced by the biological breakdown of organic matter in the absence of oxygen.
- Biomass – Biomass is organic material from living or recently living organisms that contains stored energy from the sun.
- Solar Photovoltaic – Solar power is the conversion of sunlight into electricity. Sunlight can be converted directly into electricity using photovoltaics, also known as solar cells. It can also be converted indirectly into electricity through solar thermal/electric power plants.
- Wind Energy – Wind power is the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power which is then converted into electricity.

Any assessment of the impact of energy policy change on the economy must start with projections of the electricity demand during the period in question. To create energy demand projections, we started with load projections for the two largest utilities in Michigan (Consumers Energy and DTE Energy) that were derived from current filings with the Michigan Public Service Commission. While these two providers constitute the majority of the electricity market in Michigan, additional information was required to create complete statewide projections. The Energy Information Administration's National Energy Modeling System (NEMS)[10] was used to project load growth, using the reference case scenario, for Michigan until the year 2030. This provided year on year percentage electricity load growth. We then aggregated Michigan electricity providers' respective current loads and applied the year on year percentage growth numbers. To aggregate the load across investor owned utilities, municipal utilities and electric cooperatives, we referenced data from the various sources[11] on electricity generation in Michigan. The resulting projections for electricity load in Michigan are shown in table 13.

Year	MWH Needed
2016	99,989,147.49
2017	100,917,933.52
2018	101,904,283.37
2019	102,916,770.88
2020	103,950,172.71
2021	104,823,422.69
2022	105,690,337.47
2023	106,579,117.68
2024	107,501,126.96
2025	108,406,003.39
2026	109,342,567.80
2027	110,289,155.72
2028	111,245,863.45
2029	112,186,597.61
2030	113,154,484.73

Table 13: Electricity needs projections for Michigan through 2030.

The next step was to develop a projection of the market share of each generation technology, MWHs of generation needed and capacity factors. Finally, we used this information to calculate the plate capacity needed from each renewable energy technology. This projection was based on an expansion of current renewable energy market shares in Michigan with a few important caveats:

1. Hydro power development was not assumed to expand in Michigan due the low level of undeveloped resource left in the state as well as the political and permitting climate that makes development unlikely.

[10] Available at—http://www.eia.gov/oiaf/aeo/overview/.
[11] For Municipal Utility sales: U.S. Energy Information Administration, Form EIA-861, and "Annual Electric Power Industry Report. For Electric Cooperative sales and the remaining investor owned utilities; MPSC Statistical data for total sales, electric utilities in Michigan, available at—http://www.dleg.state.mi.us/mpsc/electric/download/electricdata.pdf.

2. Landfill gas development was capped at 155MW of plate capacity as per the 21st Century Energy Plan Capacity Needs Forum resource availability study[12].

Market Share	Technology	Capacity Factor	MW of Plate Capacity Needed 2016 – 2030
90.30%	Wind	0.39	4,858
0.37%	Solar Fixed	0.16	48.48
0.28%	Solar Track	0.216	27.62
0.91%	Anaerobic	0.78	24.58
3.98%	Landfill Gas	0.83	100.7
N/A	Hydro	N/A	N/A
4.15%	Biomass	0.89	97.87

Table 14: Market Share, Capacity factors, and plate capacity needed as derived from national and Michigan data.

The current market share of renewable energy technologies was calculated using data from the MPSC on the mix of technologies being deployed to meet the current renewable energy standard[13]. These current trends were extrapolated out to 2030. Capacity factors for the technologies were sourced from the National Renewable Energy Association[14] for wind and landfill gas. Anaerobic and Biomass capacity factors are from the MPSC[4] , and solar energy was from the NREL PVWatts modeling system[15]. Different sources were required as not all technology capacity factors were available in a single reliable citation. The results are shown in Table 14. For solar and wind technology, which both have different market segments, the market shares were further broken down using national averages.

For wind technology, the national average of 0.42%[16] was applied to carve out a market share for small onsite use wind energy systems. Utility scale wind turbines continue to increase in capacity and are expected to continue to get larger. We used turbine size projections created by Wind Utility Consulting and Wind Management as the baseline for turbine size in any given year.[17]

The market breakdown of solar systems into the categories of residential retrofit, residential new build, small commercial, large commercial and utility scale is derived from the NREL Open PV Project[18] with the sizes in each category defined by the NREL Jobs and Economic Development Impact (JEDI) solar model. We compiled all of the systems data available in the Open PV Project database and sorted them into

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[12] Michigan's 21st Century Electric Energy Plan Appendix, Volume Two, available at—http://www.michigan.gov/documents/mpsc/energyplan_appendix2_185279_7.pdf.

[13] Report on the implementation of the p.a. 295 renewable energy standard and the cost-effectiveness of the energy standards, available at--http://www.michigan.gov/documents/mpsc/implementation_PA295_renewable_energy2-15-2012_376924_7.pdf.

[14] The National Renewable Energy Laboratory's Supporting Data for Energy Technology Costs, available at—http://www.nrel.gov/analysis/docs/re_costs_20100618.xls.

[15] The PVWatts system is available at—http://www.nrel.gov/rredc/pvwatts/.

[16] From American Wind Energy Association, U.S. Wind Industry Statistics and the AWEA Small Wind Market Report for 2011.

[17] Projections of Wind Generation in the Upper Midwest, available at—http://www.iowaeconomicdevelopment.com/business/downloads/windgenerationreport.pdf

[18] Available at—http://openpv.nrel.gov.

categories based on size and application. Solar system sizes used for modeling were sized based on the national average of the installed solar systems that fall into each category, with the exception of large scale utility systems, which were capped at 1 MW as it was deemed unlikely that larger systems would be developed in Michigan during the timeframe used for analysis. Solar systems that track the suns movement are inherently more efficient; however, they are more costly as well and are limited in the market to the largest systems. Residential retrofit, residential new build, small commercial and 50% of large commercial are defined as fixed axis systems while utility scale and 50% of large commercial systems are defined as tracking systems based on current national industry trends. Single axis tracking systems have been shown to increase in efficiency of energy capture by 25% in the upper Midwest and dual tracking systems provide a 45% increase[19]. The JEDI solar model does not have inputs for dual tracking systems so a weighted average capacity factor increase of 5.6% was used for modeling purposes calculated as 35% of the base capacity factor of 16%. This information is summarized in table 15.

System Type	Solar Market Share	Average System Plate Capacity (KW)	Capacity Factor
Residential Retrofit	12.90%	4.65	16.0%
Residential New Build	12.90%	4.65	16.0%
Small Commercial (10 to 100 kw)	14.20%	21.4	16.0%
Large Commercial Fixed (100 kw to 1 MW)	16.53%	310.4	16.0%
Large Commercial Tracking (100 kw to 1 MW)	16.53%	310.4	21.6%
Utility Scale Tracking (over 1 MW)	26.95%	1,000.0	21.6%

Table 15: Solar Industry Breakdown

Anaerobic digestion is assumed to come from municipal wastewater (60%) and from livestock waste production (40%), where municipal solid waste energy content is estimated to be 6000 Btu's per pound of biomass upon pre-treatment.[20] Electricity conversion from btu is assumed to be 0.29 watts per btu. Only livestock operations are assumed to combine heat and power generation, saving approximately 9.1 gallons of heating propane per head, where typical biomass generation is 28.4 cubic feet/a per head.[21]

We assumed that there is no impact of fixed capital investment for municipal wastewater power plants, as all new anaerobic digestion investment would take place regardless of state electricity policy to meet environmental standards. The downside of this assumption is that we are not taking into account investment in steam generators. However, direct effects of fixed investment for livestock operations were tracked; expected investment is $624 per head and is expected to largely take place at dairy facilities. Only 30% of the investment costs through federal subsidy programs in manure management are assumed to create a direct effect, as the farm share was assumed to supplant other farm level investment in manure management.

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[19] Smart Tracking: and economic analysis of PV tracking systems, Matt Kesler, North American Clean Energy, 6, 3, May 2012.)

[20] USDA Technical Note No. 1. *An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities.* (October, 2007)

[21] One cubic foot weighs approximately 10 pounds.

Direct economic impacts of operations and maintenance of the electricity generation component of municipal wastewater treatment facilities and livestock operations are estimated. For both municipal wastewater and livestock operations, labor costs are set to $36.48 per MWh, and revenue from electricity sales is $0.06 per kWh. In addition to electricity sales revenues, municipal operations receive a $90 per ton tipping fee and livestock operations co-generate heat saving 9.1 gallons of heating propane per head, which was valued at $2.15 per gallon.

Generation from biomass assumes plant efficiency in converting biomass to energy of 0.28[22] with a plant capacity factor of 0.89. Biomass production is derived from a multitude of agricultural and forest related activities, where a ton of biomass contains 9.25 MMBtu of heat content.[23] Adjusting for plant efficiency, this amounts to 665.3 kWh per ton of biomass. Economic impacts are derived from fixed investment and operations and management of generation facilities as well as farm and forestry operations.

Fixed investment for electricity generation facilities include fixtures and equipment for converting biomass into electricity for co-firing with coal at a 15% rate. These investments may include facilities and equipment for storage, drying and moving biomass as well as boilers and generators that sum to $200 per kW plate capacity.[24] Additional operational and maintenance costs of co-firing biomass with coal were set at $1.60 per biomass-generated MWh. While the analysis did not consider fixed investment in trucking and transport, operational costs of trucking is estimated to be $0.27 per ton mile for short hauls averaging 50 miles.[25] Farm and forestry income per ton of biomass was set at $21.00 per ton.

Many of Michigan's landfill sites already have much of the infrastructure necessary to convert landfill gases to electricity as part of their gas collection and flare systems, however, we anticipate that statewide investment in biogas collection to be about $365 per MW of plate capacity. In addition, facilities will need to invest about $1,668 per MW of plate capacity for turbines and related electricity generating equipment and facilities. In total, the state is expected to see $204 million investment in capital formation for converting landfill gases to electricity. Once operational, ongoing activities will generate about $211.28 in operational and maintenance costs per MW of plate capacity.[26] Using IMPLAN 3.0 populated with Michigan 2009 data, direct effects were specified as non-residential construction for investment expenditures and as sales of waste management and remediation services for operations and maintenance expenditures.

For all technologies, we did not attempt to model clusters of deployment in any given year, rather we distributed all development in equal percentage increments year on year.

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[22] Timmons, D., D. Damery, G. Allen, and L. Petraglia. 2007. *Energy from forest biomass: Potential economic impacts in Massachusetts*.
[23] *Ibid*
[24] English, B.C., K.L. Jensen, J. Menard, M. Walsh, D.D.L.T. Ugarte, C. Brandt, J. Van Dyke, and S. Hadley (2004) Economic Impacts Resulting from Co-firing Biomass Feedstocks in Southeastern United States Coal-Fired Plants, American Agricultural Economics Association (New Name 2008: Agricultural and Applied Economics Association).
[25] U.S. Department of Transportation. (2009) *National Transportation Statistics.*
[26] U.S. Methane Emissions 1990-2020: Inventories, Projections, and Opportunities for Reductions (1999)

Appendix 2) Literature Review: Overview of Renewable Energy and its Economic Impacts

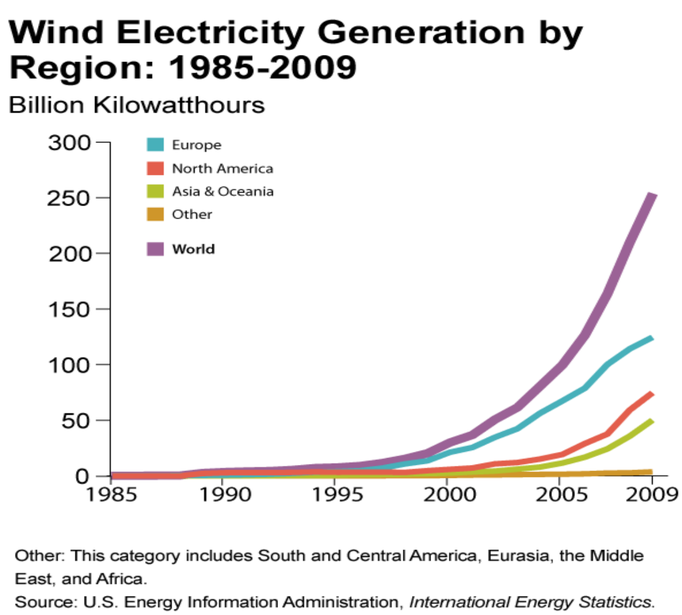
This Appendix presents an overview of the global, national and state-wide analysis of the renewable energy industry including its economic impacts.

Background

Renewable energy is obtained from energy sources that can be replenished by nature such as the wind, sun, water, geothermal, plants and animal residues. Growing concerns related to air emissions from power plants has led to a search for alternative, clean and sustainable energy sources. In addition to these environmental benefits, renewable energy development and investments have been shown to have economic impacts and potentially beneficial impacts on energy security and national security.

Global Trends

Globally the increasing acceptance of renewable energy is evident in the market penetration of renewable energy in developed and developing countries. In predominant agrarian communities in developing countries, for example, modern biomass energy has been utilized as an inexpensive source of energy. Wind energy, small hydroelectric, solar photovoltaic and solar thermal technologies are well suited for developing countries (Ottinger and Williams, 2002). Globally, it is projected that from 2006 to 2030 electricity production from nuclear sources will decrease from 15% to 10% while electricity generated from renewable energy sources such as solar and wind will increase more than exponentially from 0.8% to 5.3% (Ottinger and Williams, 2002).



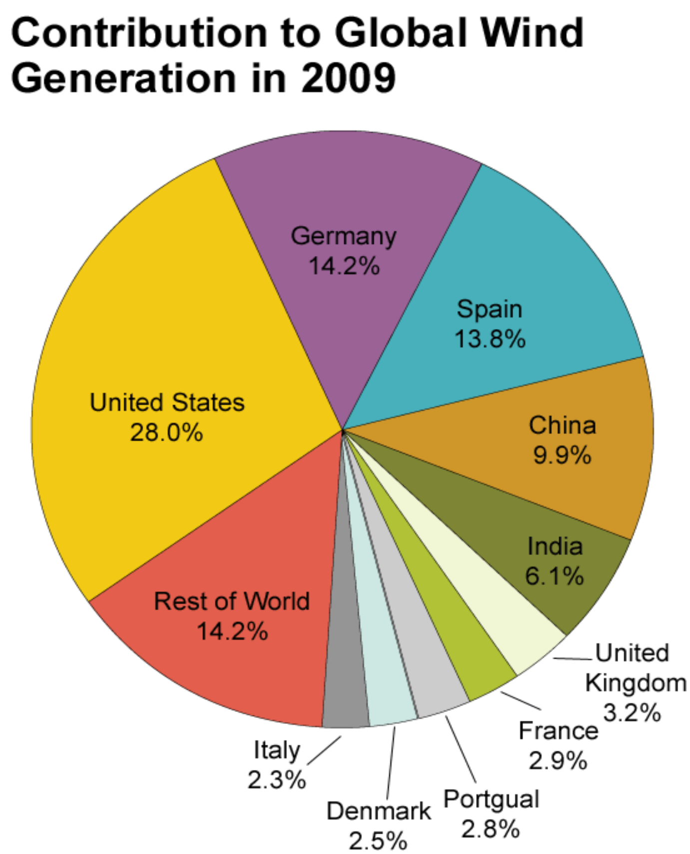
Wind energy for example has grown rapidly. According to the EIA (2011), global wind power generation has exceeded 250 billion kWh in 2009 which is equivalent to the annual electricity consumption of over 22 million US households, as shown in the figure below.

It is projected that by 2015 the total electricity generation from wind and hydro will rise from 18 % in 2006 to 23 % in 2030 globally and that renewable energy is expected to become the second largest source of electricity generation after coal, overtaking natural gas (Hardcastle et. al., 2009).

Global renewable energy output, energy efficiency and global investment in green energy technologies, including venture capital investments, are all expected to grow. It is projected that renewable energy supply investments will top $5.5 trillion between 2007 and 2030 with electricity generation from new renewables accounting for 48% of this investment (Hardcastle et. al., 2009). This stems from the increasing interests and favorable government policies and support programs around the world that foster the development of renewable energy and technologies. These support programs include the feed-in tariff in Germany which provides financial incentives that encourages the use of electricity from renewable sources by requiring utility companies, through legislation, to buy renewable electricity from renewable electricity generators at a price higher than its wholesale price; the wind capacity targets set by the Chinese government; and the production tax credit and state-wide Renewable Portfolio Standards (RPS) in the United States.

U.S. Renewable Energy

In the US, renewable energy generation, consumption and investment have experienced significant growth in the past decade. In 2011, approximately 13% of US electricity consumption was generated from wind (23%), solar (less than 1%), geothermal (3%), hydroelectric (63%), biomass wood (7%), and biomass waste (4%). The growth rate of electricity generation from wind and other non-hydro renewable energy sources is expected to increase at a rate of 4.3% per annum in 2030 Sovacool and Watts (2009). In 2009, 28% of global wind power generation was supplied by the US alone, followed by Germany, Spain, China, India, the United Kingdom and the rest of the world, as shown in the figure below (EIA, 2010).



Source: U.S. Energy Information Administration, *International Energy Statistics*.

For example, according to Sovacool and Watts (2009), if existing technologies are utilized, the U.S. has the potential of producing 3,730,721 MW of renewable energy, indicating that the U.S. can “provide 3.7 times the total amount of installed electricity capacity operating in 2008.” In fact, in a study by the US Department of Energy, about 93.2%

of all domestic energy are mostly renewable—wind, geothermal, solar, and biomass—which is equivalent to 657,000 billion barrels of oil (Sovacool and Watts (2009).

Recently, under the Obama administration, the US has shown political will that tends to support renewable energy development. Thirty States and the District of Columbia have enforceable renewable portfolio standards (RPS) which require electric utilities to adopt renewable energy resources. For example, California's RPS requires that use 33% of their electric utilities sales be derived from eligible renewable energy resources by 2020, with interim targets of 20% by end of 2013 and 25% by the end of 2016. In addition to the RPS legislation, there have also been production tax credits that serve as incentives for renewable energy production. It is expected that if this trend of favorable political climate in renewable energy development continues, the combination of the expected growth in the renewable energy industry and renewable energy potentials will ensure that the US will be a leader in the world's renewable energy market.

Michigan Renewable Energy

Michigan is endowed with an abundance of wind, solar, hydro, biomass (especially wood and wood waste) and geothermal resources that can potentially surpass its energy needs and contribute to economic development. There is also substantial endowment of onshore wind resources such that 5 megawatts per sq. km of turbines can be installed (Heimiller, 2005).

Similarly, Michigan also has a rich source of renewable energy from biomass resources, with wood and wood waste being Michigan's largest source of renewable energy and producing about 1.7 million megawatts hours of power in 2008.[27]

Other sustainable energy sources such as solar and biogas energy sources are also abundant but mostly untapped. According to the US Department of Energy, Michigan has an average sunlight of 4 to 4.5 kilowatt-hour per square meter per day and is economically capable of producing 2,350 megawatts (Chaudhari et. al. 2004). On biogas potential, Michigan ranks among the top 10 states for biogas production through its commercialized dairy operations (EPA, 2010) that produce more than 26 million tons of methane emissions per year. Michigan brownfield sites have also been shown to have high potential renewable energy. Adelaja et. al., (2010) showed that the Michigan brownfield sites have the potential of generating 4,320 megawatts from wind and 1,535 from solar.

The renewable energy resources in Michigan, particularly wind, solar, biogas and biomass energy and a favorable political climate have led to a growing interest and investment in renewable energy industry in the state. Presently, renewable energy technology manufactures are planning to transform a factory in Wixom to become the nation's largest renewable energy park, which is expected to produce solar panels and large-scale batteries that can store power for the electric power grid. Since 2007, more than 35 firms have either emerged or reengineered their factories to manufacture wind turbines and other parts to supply the wind industry, in the process hiring laid off auto workers and creating new jobs

[27] Natural Resources Defense Council (NRDC) (2012), http://www.nrdc.org/energy/renewables/michigan.asp#footnote13

(AWEA, 2010). For example, Kubiak (2011) reports that Astraeus Wind, a factory that manufactures wind turbine components, employs about 30 highly-skilled technicians in Eaton Rapids, Michigan.

Though renewable energy has shown some great international, national and statewide prospects and promise, many questions still abound, one of which is, “How many jobs can renewable energy create?” Or put differently, “What is the potential economic impact of renewable energy?”

Economic Impact of Renewable Energy

There is well documented evidence of job creation from renewable energy in the U.S. Wei et. al. (2010) concludes that the renewable energy, energy efficiency and low carbon sources create more jobs per unit of energy than coal and natural gas. They projected that a 30% RPS target, in addition to measures that facilitate energy efficiency, can create more than 4 million full-time equivalent job years by 2030. Slattery et. al. (2011) used the Jobs and Economic Development Impacts (JEDI) model to estimate the state and local economic impact of a 1,398 megawatts of wind power development in Texas. The study showed that about 41,000 full time equivalent (4 year) construction related jobs were created including a lifetime economic activity of $1.3 million in operations and maintenance per megawatt of installed capacity over the 20 year life cycle of the wind farms. Sterzinger and Syrcek (2004) showed that the development of 50,000-70,000 megawatts of wind energy has the potential of creating about 215,000-331,000 full time equivalent jobs.

Brown et. a. (2011), using ordinary least squares showed that wind turbine development has a total marginal economic impact of $21,604 per megawatt. Also, in a study that used the JEDI model to estimate the economic impact of 1000 megawatts of wind energy in Colorado, Reategui and Tegen (2008) found that about 300 permanent jobs in rural Colorado were supported, equivalent to $14.7 million annual payroll. The study also found that $226.4 million in economic activities related to construction were generated as well as $34.9 million local economic activities per annum.

Other renewable energy sources have also been shown to create jobs and improve the economic activities of the communities and states where they are located. These include biomass (please see Thornley et. al., 2008; Sterzinger and Stevens, 2006; Easterly and Margo, 1996; Gan and Smith, 2007; Grassi, 1999), biogass (EPA, 2010) and solar (McNeil Technologies, 2004; PISC, 2001; Navigant Consulting, 2008; DOE, 2008; GEPIA, 2006).

Michigan has the capacity to create 24,350 wind manufacturing job years, which is the sixth highest state total in the country and can create more than 25, 000 new jobs by 2025 according to the American Wind Energy Association (AWEA, 2011). NRDC (2012) observed that the wind industry supported 2,000 to 3,000 jobs in Michigan in 2009. Sterzinger and Stevens (2006) in a study conducted by Renewable Energy Policy Project in 2006 showed steam and electric power produced from biomass can produce 10.5 jobs per megawatt of added capacity in Michigan.

Modeling Tools

In estimating economic impacts of renewable energy, a number of modeling tools are available, the most commonly used are: the Jobs and Economic Development Impact (JEDI), Impact Analysis for Planning (IMPLAN) and the Regional Economic Models, Inc. (REMI) models. In this report, we employ the JEDI and IMPLAN models. Though the results from the JEDI model only reflect gross and not net impacts**,** they are based on approximations of industrial input-output relationships, and among others, do not include intangible effects. The JEDI model is widely used because it teases out the estimates of construction and other projects economic impacts at the local (usually state) levels. Jobs, earnings and output can be distributed across project development and onsite labor impacts, local revenue and supply chain impacts and induced impacts.

The IMPLAN model estimates the economic impact of a dollar invested into a sector and the resulting wave of multiplier effects. These multipliers are used to generate the economic impacts of the project in three different categories namely: direct, indirect and induced. As a result of the economic multipliers of the JEDI model derived from the IMPLAN model, a combination of the JEDI and the IMPLAN model gives a more detailed estimate of the economic impact of renewable energy projects, as used in this report.

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