Growing Michigan's Economy & Jobs: Economic Impact of Renewable Energy, 2017-2027

A Hill Group study commissioned by the Michigan Conservative Energy Forum

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Contents

Figures

Tables

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EXECUTIVE SUMMARY

Recent shifts in national energy policy have championed the growth of renewable energy as part of an "all of the above" energy development strategy. To promote increased investment in renewable energy and capitalize on the renewable resources found within the state, Michigan adopted Public Act 295 of 2008[1] and, in 2016, passed Public Act 342.[2] These acts set renewable portfolio standards (RPS) that required electric providers to generate 10 percent of electricity sales from renewable energy sources by 2015 and now require 15 percent by 2021.[3]

The falling cost of renewable energy sources combined with increasing customer demand for clean energy has driven Michigan utilities to invest in more renewable energy sources regardless of the RPS. As policymakers begin to look beyond PA 342's 2021 timeline, the Michigan Conservative Energy Forum believed it necessary to quantify the economic impact resulting from those efforts and the continued development of renewable resources in Michigan over the next ten years. This analysis focuses on the construction, operation, and maintenance activities of renewable energy capacity development, but does not include pre-construction activities or ancillary impacts including social or environmental externalities.

Input-output analysis was used to estimate the economic impact of investment in renewable energy capacity in Michigan, including construction and operation of various renewable technologies. Changes in energy demand and estimates of supply from renewable sources are used to calculate direct, indirect, and induced economic impacts including total economic output, job-years supported, and employee compensation.

Michigan can truly embrace an "all of the above" approach to energy by investing at varying levels in wind, solar, biomass, landfill gas, and other renewable energy sources. For this study, growth within each technology is estimated based on existing technology growth patterns as well as potential future shifts in technology priority over the next ten years.

Given projections of growth in energy demand and scenarios increasing the state's percent of electricity sales from renewable energy sources, analysis of the 12.5 percent by 2019 scenario indicates that the selected activities as a whole could have a potential gross impact of nearly $3.8 billion on Michigan, including more than 20,100 job-years supported and nearly $1.4 billion in employee compensation. The summary of gross impacts for the 15 percent by 2021 scenario shows a total impact of nearly $6.3 billion, more than 32,500 job-years supported and $2.2 billion in employee compensation. The summary of gross impacts for the 30 percent by 2027 scenario shows a total output of $10.3 billion, more than 68,500 job-years supported and $4.5 billion in employee compensation.

Table 1. Summary of Impacts for Each Scenario

	12.5% by 2019	15% by 2021	30% by 2027
Gross Economic Impact	$3.8 billion	$6.3 billion	$10.3 billion
Job-Years Supported	20,100+	32,500+	68,500+
Employee Compensation	$1.4 billion	$2.2 billion	$4.5 billion

[1] Michigan Legislature, 2008.
[2] Michigan Legislature, 2016.
[3] Ibid.

While environmental benefits often dominate energy policy dialogue, this study presents evidence of economic impact which should be considered in the context of likely return on investment. Study results are not intended to advocate for or against any particular policy, strategy, or investment, but rather serve as an assessment of the impacts a set of investments may have on Michigan's economy. Equipped with this analysis and others, policymakers will be better informed to make decisions regarding the state's energy future.

INTRODUCTION

Michigan’s Public Act 342 (PA 342) of 2016 requires electric providers to generate 15 percent of electricity sales from renewable energy sources by 2021.[4] This builds upon the previous, successfully-achieved RPS threshold of 10 percent by 2015 established in 2008. “A renewable portfolio standard (RPS) is a regulatory requirement to increase production of energy from renewable sources such as wind, solar, biomass and other alternatives to fossil fuel and nuclear electric generation.”[5]

As Michigan utilities prepare to reach the RPS set forth in PA 342, policymakers must continue to consider the future of the state’s energy policy. This study, *Growing Michigan’s Economy & Jobs: Economic Impact of Renewable Energy, 2017-2027*, begins to quantify the economic impact resulting from potential changes to Michigan’s energy policy that may encourage the continued development of renewable energy in the state. In 2014, the Michigan Conservative Energy Forum commissioned an initial study by the Hill Group that estimated the gross economic impact that may result from a 15 percent RPS by 2020 and a 20 percent RPS by 2025. This updated report presents and quantifies impact from three additional scenarios: 12.5 percent by 2019 (the half-way benchmark of the current law), 15 percent by 2021 (current law), and 30 percent by 2027. This latter scenario was chosen based on the current growth factor of renewables; given state utility announcements on their clean energy goals, where could technological innovation and business investment lead in a decade?

Renewable energy scenarios have been previously analyzed by other researchers to understand impacts related to potential policy changes. Each study has provided stakeholders with new perspectives on the opportunities and challenges Michigan faces in making decisions regarding energy policy. This study quantifies specific renewable energy scenarios in the context of gross job-years and economic output impacts within Michigan and provides an additional data point to enhance decision making.

Michigan is well poised to meet the current RPS by investing at varying levels in renewable energy technologies. In fact, it is likely that Michigan’s major utilities would increase their production of renewable energy regardless of the new requirements recently put into law due to growing demand and falling costs. This study adopts current investment trends in wind, solar, biomass, and landfill gas renewable technologies to forecast increased capacity within each scenario. This subset of technologies was selected based upon current activity and preliminary thoughts on future investment choices of public and private sector stakeholders.

This study is meant to inform state-level conversations already occurring within Michigan by providing objective evidence that renewable energy capacity development can create a direct, indirect, and induced economic effect on the state. It is not intended to exclusively promote nor deter any particular policy, strategy, or investment in renewable energy capacity.

[4] Michigan Legislature, 2016.
[5] National Renewable Energy Laboratory, 2014.

This study uses input-output analysis to assess the economic impact of renewable energy construction and generation activities on Michigan's economy. The Jobs and Economic Development Impact (JEDI) model developed by the National Renewable Energy Laboratory (NREL) and MIG Inc.'s IMPLAN models were used to estimate the regional impact of construction, operation, and maintenance activities associated with renewable energy sources.

Construction activities include contractors and subcontractors directly engaged in construction tasks (i.e. carpenters, electricians, welders, laborers, equipment operators) and related administrative staff (i.e. purchasing, accounting, personnel). Operations and maintenance activities include the contractors and subcontractors directly engaged in operation and maintenance tasks (i.e. electricians, mechanics, and equipment operators) and related administrative staff (i.e. purchasing, accounting, personnel). Direct, indirect, and induced economic impacts from construction, operation, and maintenance activities are combined to estimate total economic impact.

Input-output economic impact modeling calculates the direct, indirect, and induced economic impact on a regional economy based on a shift in economic activity such as increased construction of renewable energy capacity as a result of a shift in final demand. The model developed for this study calculates impact based on:

- Forecasted changes in demand for renewable energy capacity by 2019, 2021, and 2027
- Estimates of costs for the construction of renewable energy capacity
- Estimates of costs for the operation and maintenance of renewable energy capacity
- Estimates of sector-to-sector trade based on IMPLAN software and data

This information is essential to the development of an input-output economic impact model and for the analysis of direct, indirect, and induced impacts. Modeled scenarios are an illustration of potential increases in Michigan's renewable energy development. This study only considers the construction, operation, and maintenance of capacity built to meet increased demand for renewable energy. It does not consider pre-construction activities or ancillary impacts like social or environmental externalities.

CURRENT STATE OF RENEWABLE ENERGY IN MICHIGAN

Michigan has a long history of supporting renewable energy and pursuing energy efficiency, including early investment in biomass power plants, hydroelectric dams, solar energy systems, and wind turbines.[6] [7] While these efforts are noteworthy, Michigan has historically generated a majority of its energy from nonrenewable energy sources. Michigan's limited nonrenewable energy resources, in the form of coal, natural gas, nuclear, and petroleum, require the state to import a majority its energy from other states and countries.[8]

To promote increased investment in renewable energy and capitalize on the renewable resources found within the state, Michigan adopted PA 295 of 2008 and PA 342 of 2016. According to Michigan compiled law, these acts are intended to:

> *"…promote the development and use of clean and renewable energy resources and the reduction of energy waste through programs that will cost-effectively do all of the following:*
>
> > *(a) Diversify the resources used to reliably meet the energy needs of consumers in this state.*
> >
> > *(b) Provide greater energy security through the use of indigenous energy resources available within the state.*
> >
> > *(c) Encourage private investment in renewable energy and energy waste reduction.*
> >
> > *(d) Coordinate with federal regulations to provide improved air quality and other benefits to energy consumers and citizens of this state.*
> >
> > *(e) Remove unnecessary burdens on the appropriate use of solid waste as a clean energy source.*[9]

PA 295 required electric providers to deliver 10 percent of their electricity sales from renewable energy sources by 2015. PA 342 requires at least 15 percent by 2021 and sets a goal of 35 percent by 2025 through a combination of energy waste reduction and renewable energy production. To achieve this requirement, providers are required to either purchase renewable energy, purchase renewable energy capacity, build renewable energy capacity, or purchase renewable energy credits (RECs).[10]

Since 2008, Michigan has invested in its renewable energy infrastructure and generation capacity creating nearly 2,500 megawatts (MW) of total renewable energy capacity, and it is expected to grow. Since 2008, this is approximately 3.3 billion dollars of investment to bring new renewables online.[11] This investment in renewable energy has increased Michigan's

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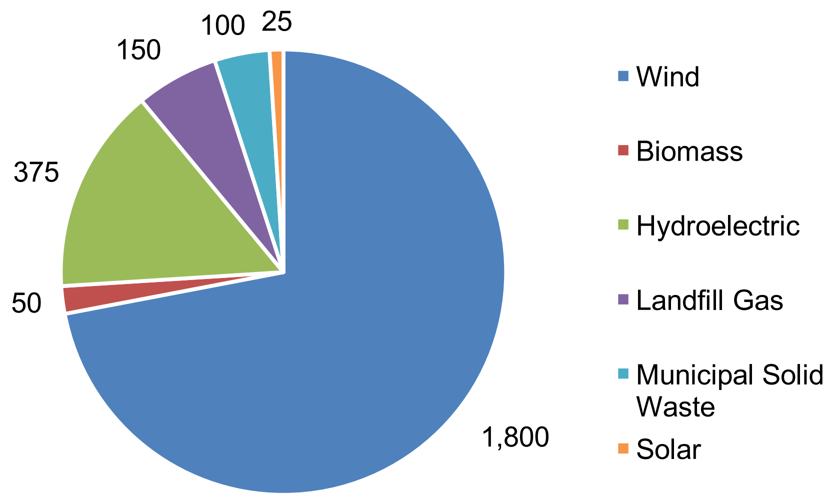
[6] American Council for Energy-Efficient Economy, 2013.
[7] Michigan Energy Options, 2009.
[8] Michigan Department of Licensing and Regulatory Affairs, 2011.
[9] Michigan Legislature, 2016.
[10] Ibid.
[11] Michigan Department of Licensing and Regulatory Affairs, 2017.

energy independence and provided capacity to meet the state's increasing energy demands and the generation requirements of PA 295 and PA 342. Figure 1 provides Michigan's current renewable energy technology portfolio by MW of nameplate capacity.[12]

Figure 1. Total Renewable Energy MW Capacity by Source, 2017



[12] Michigan Department of Licensing and Regulatory Affairs, 2017.

FUTURE RENEWABLE ENERGY SCENARIOS IN MICHIGAN

As Michigan approaches 2021 and the 15 percent RPS, policymakers must consider the future of the state's energy policy. To this end, the economic impacts of various renewable energy scenarios resulting from changes to Michigan's energy policy or market demand have been estimated prior to this study.[13] [14] [15] The purpose of this study is to be a resource for policymakers by adding depth and breadth to the discussion through quantifying the economic impact resulting from three potential scenarios which modify Michigan's reliance on renewable energy.

The three scenarios used for analysis envision 12.5 percent of Michigan's electricity being generated from renewable resources by 2019 and 15 percent by 2021, thresholds required by law, and an increase to 30 percent by 2027 based on current growth trends and utility goals. Specifically, this report focuses on the employment and economic output impacts an increase in Michigan's renewable development would have on the state. To meet the 10 percent requirement by 2015, Michigan utilities relied, in part, on purchases of Renewable Energy Credits (RECs); however, this study models that utilities will meet future thresholds through renewable energy generation without RECs.

Scenario 1: 12.5 percent by 2019

Scenario 1 estimates the impacts of electric providers equipping themselves to generate at least 12.5 percent of their annual retail sales of electricity from renewable energy sources by 2019, an intermediate step as they prepare to meet the 2021 RPS requirements. For this study, eligible renewable energy sources include wind, solar, biomass, hydroelectric, and landfill gas.

Overall energy demand across the country is expected to grow five percent over the next 20 years.[16] Retail sales of electricity in Michigan could increase from approximately 102.9 million megawatt hours (MWh) in 2017[17] to nearly 103.3 million MWh in 2019 (see Appendix B). Michigan will need additional renewable energy capacity to meet growth in demand and achieve a 12.5 percent renewable threshold. Table 2 shows the minimum MWh to be generated by renewables in 2019 in order to achieve 12.5 percent.

Table 2. Total Energy Demand, Renewable, and Non-Renewable, 2019

Projected Retail Sales in MI	12.5 Percent Renewable	87.5 Percent Non-Renewable
103.3 million MWh	12.9 million MWh	90.4 million MWh

Renewables in Michigan currently produce approximately 8.9 million MWh, an estimate based on likely capacity factors and known, existing technology mix. An additional 3.9 million MWh of

[13] Kulesia, S. et.al., 2007.
[14] Tuerck, D. et.al., 2012.
[15] Calnin, B. et.al., 2012.
[16] United States Department of Energy, Annual Energy Outlook, 2017.
[17] United States Department of Energy, State Electricity Profiles, 2017.

renewable energy will need to be produced in order to meet the goal of 12.9 million MWh, or 12.5 percent of projected retail sales in 2019.

Michigan can meet the increase in renewable energy demand by investing at varying levels in wind, solar, biomass, landfill gas, and hydroelectric technologies. Projected growth within each technology is based on the current portfolio mix in Michigan, which is not likely to change significantly by 2019. Table 3 shows projected growth for each technology. New biomass, landfill gas, and hydroelectric facilities are not expected to become operational through 2019.

Table 3. Current and Projected MW Capacity and MWh Generated by Renewable Technology to Achieve 12.5 percent by 2019

Technology	Current Nameplate Capacity (MW)	Current MWh Generated	Projected New Nameplate Capacity (MW), 2019	Projected New MWh Generated, 2019
Wind	1,800	5,991,840	887	2,953,388
Biomass	50	367,920	--	--
Landfill Gas	375	1,090,620	--	--
Hydroelectric Water	150	1,478,250	--	--
Solar	100	62,415	535	984,463
Total	2,500	8,991,045	1,422	3,937,850

In order to meet the renewable energy demands of 12.5 percent by 2019, Michigan would need to build additional capacity totaling 1,422 MW. Wind is anticipated to grow by 887 MW and solar installations would grow by 535 MW. There are a number of technology configurations, including varying sizes of equipment and facilities that could achieve this additional nameplate capacity and generation. This study models implementation of 444 new 2 MW utility wind turbines and 36 new 15 MW utility-scale solar systems.

Scenario 2: 15 percent by 2021

Scenario 2 estimates the impacts of electric providers equipping themselves to generate at least 15 percent of their annual retail sales of electricity from renewable energy sources by 2021, in line with PA 342 requirements. For this study, eligible renewable energy sources include wind, solar, biomass, hydroelectric, and landfill gas.

Retail sales of electricity in Michigan could increase from approximately 102.9 million megawatt hours (MWh) in 2017 to nearly 103.7 million MWh in 2021 (see Appendix B). Michigan will need additional renewable energy capacity to meet growth in demand and achieve a 15 percent RPS threshold. Table 4 shows the minimum MWh to be generated by renewables in 2021 in order to achieve 15 percent.

Table 4. Total Energy Demand, Renewable, and Non-Renewable, 2021

Projected Retail Sales in MI	15 Percent Renewable	85 Percent Non-Renewable
103.7 million MWh	15.6 million MWh	88.2 million MWh

Renewables in Michigan currently produce approximately 8.9 million MWh, an estimate based on likely capacity factors and known, existing technology mix. An additional 6.6 million MWh of renewable energy will need to be produced in order to meet the goal of 15.6 million MWh, or 15 percent of projected retail sales in 2021.

Michigan can meet the increase in renewable energy demand by investing at varying levels in wind, solar, biomass, landfill gas, and hydroelectric technologies. Projected growth within each technology is based on the current portfolio mix in Michigan, which is not likely to change significantly by 2021, although growth of solar may increase more rapidly than wind and other technologies due to physical or political ceilings. Table 5 shows projected growth for each technology. New biomass, landfill gas, and hydroelectric facilities are not expected to become operational through 2021.

Table 5. Current and Projected MW Capacity and MWh Generated by Renewable Technology to Achieve 15 percent by 2021

Technology	Current Nameplate Capacity (MW)	Current MWh Generated	Projected New Nameplate Capacity (MW), 2021	Projected New MWh Generated, 2021
Wind	1,800	5,991,840	1,483	4,936,374
Biomass	50	367,920	--	--
Landfill Gas	375	1,090,620	--	--
Hydroelectric Water	150	1,478,250	--	--
Solar	100	62,415	894	1,645,458
Total	2,500	8,991,045	2,377	6,581,832

In order to meet the renewable energy demands of 15 percent by 2021, Michigan would need to build additional capacity totaling 2,377 MW. Wind is anticipated to grow by 1,483 MW and solar installations would grow by 894 MW. There are a number of technology configurations, including varying sizes of equipment and facilities that could achieve this additional nameplate capacity and generation. This study models implementation of 741 new 2 MW utility wind turbines and 60 new 15 MW utility-scale solar systems.

Scenario 3: 30 percent by 2027

Scenario 3 estimates the impacts of electric providers equipping themselves to generate at least 30 percent of their annual retail sales of electricity from renewable energy sources by 2027, significant growth that would place Michigan among only 11 other US states and territories with renewable energy targets at 30 percent or above.[18] Though other technologies may emerge over the next ten years, renewable energy sources within the scope of this study continue to include wind, solar, biomass, hydroelectric, and landfill gas.

[18] Durkay, 2017.

Retail sales of electricity in Michigan could increase from approximately 102.9 million megawatt hours (MWh) in 2017 to nearly 104.9 million MWh in 2027 (see Appendix B). Michigan will need additional renewable energy capacity to meet growth in demand and achieve a 30 percent renewable threshold. Table 6 shows the minimum MWh to be generated by renewables in 2027 in order to achieve 30 percent.

Table 6. Total Energy Demand, Renewable, and Non-Renewable, 2027

Projected Retail Sales in MI	30 Percent Renewable	70 Percent Non-Renewable
104.9 million MWh	31.5 million MWh	73.5 million MWh

Renewables in Michigan currently produce approximately 8.9 million MWh, an estimate based on likely capacity factors and known, existing technology mix. An additional 23.6 million MWh of renewable energy will need to be produced in order to meet the goal of 31.5 million MWh, or 30 percent of projected retail sales in 2027.

Michigan can meet the increase in renewable energy demand by investing at varying levels in wind, solar, biomass, landfill gas, and hydroelectric technologies. Growth within each technology, except hydroelectric, is projected in order to achieve the 30 percent threshold. Opinions vary on the ceilings for wind power in Michigan,[19] and this study projects that significant growth in solar along with marginal growth in biomass and landfill gas will be required to meet standards. Table 7 shows projected growth for each technology.

Table 7. Current and Projected MW Capacity and MWh Generated by Renewable Technology to Achieve 30 percent by 2027

Technology	Current Nameplate Capacity (MW)	Current MWh Generated	Projected New Nameplate Capacity (MW), 2027	Projected New MWh Generated, 2027
Wind	1,800	5,991,840	4,733	15,755,049
Biomass	50	367,920	76	562,680
Landfill Gas	375	1,090,620	77	562,680
Hydroelectric Water	150	1,478,250	--	--
Solar	100	62,415	3,059	5,626,803
Total	2,500	8,991,045	7,946	22,507,212

In order to meet the renewable energy demands of 30 percent by 2027, Michigan would need to build additional capacity totaling 7,946 MW. Wind is anticipated to grow by 4,733 MW, biomass by 76 MW, landfill gas by 77 MW, and solar installations would grow by 3,059 MW. There are a number of technology configurations, including varying sizes of equipment and facilities that could achieve this additional nameplate capacity and generation. This study models implementation of 2,367 new 2 MW utility wind turbines, 204 new 15 MW utility-scale solar systems, construction of 3 new 30 MW biomass gasification facilities, and 17 new 4.6 MW landfill gas facilities. In addition to construction of capacity, the operation and maintenance

[19] Wallace, 2017.

associated with the increased renewable energy capacity would impact Michigan's economy. The impacts from the operation and maintenance would support employment and economic output for the lifetime of the built capacity, estimated as a 20-year lifespan for each technology.

ECONOMIC IMPACT FINDINGS

Overview of Model

The economic impact of the construction, operation, and maintenance activities related to Michigan's renewable energy capacity were estimated using JEDI and IMPLAN to quantify direct, indirect, and induced economic effects.

NREL developed the JEDI models to estimate the regional impact of construction, operation, and maintenance associated with renewable and nonrenewable energy sources. Model defaults are based upon interviews with industry experts and project developers. Economic multipliers contained within the model are derived from IMPLAN software.[20]

IMPLAN is a software and data package that enables development of input-output economic impact models for a particular geography or study area. Michigan state-level data for the year 2016 (the most recent data available) are used to build the model for this study. The models are developed to quantify the direct, indirect, and induced economic impacts based on spending changes in defined industries.

> **Direct** economic impact includes changes in production that result from final demand changes. In this case, direct impact may include increases in spending that result from additional purchases related to the construction, operation, and maintenance of wind turbines, solar panels, biomass conversion devices, or landfill gas devices within the scope of this study.
>
> **Indirect** economic impact includes changes in production of inputs resulting from changes in demand for a final product. In this case, indirect impact may include new purchases of steel and plastics by firms producing in-demand wind turbines or other renewable energy devices within this study scope.
>
> **Induced** economic impact includes the changes in household spending patterns as a result of altered household income from direct and indirect impacts. In this case, induced impact may include increased spending by individuals employed by steel, plastic, and wind turbine manufacturing companies or other supply chain component or final product manufacturers within the study scope.
>
> **Total** economic impact is the sum of direct, indirect, and induced economic impacts for the renewable energy construction, operation, and maintenance activities included in the scope of this study.

[20] National Renewable Energy Laboratory, 2017.

Results

Capacity projection and energy demand estimates were analyzed by the JEDI and IMPLAN models for their direct, indirect, and induced impacts. Results were computed for the three demand scenarios on projected job-years supported, labor income, and total output.

Employment (Job-years Supported) is the total number of jobs supported by the estimated construction, operations, and maintenance activities. The jobs supported refer to one job-year (2,080 hours). The actual headcount of jobs will vary depending on the intensity and duration of jobs.[21]

Labor Income is the sum total of all forms of employment income, including employee compensation (wages and benefits) and proprietor income.[22]

Output represents the total value of industry production. In IMPLAN, these are annual production estimates for the year of the data set and are in producer prices. For service providers, production is equal to sales.[23]

Summary of Impacts

Scenario summaries show the potential impact of increased renewable energy capacity development on Michigan economy. Analysis of the 12.5 percent by 2019 scenario indicates that selected activities as a whole have the potential to create a total impact of nearly $3.8 billion on Michigan's economy, including more than 20,100 job-years supported and nearly $1.4 billion in employee compensation. Table 8 provides direct, indirect, and induced impacts for the first scenario

Table 8. Summary of Impacts for Scenario 1 – 12.5 Percent by 2019 Impacts (in 2017 dollars)

Impacts	Job-Years	Earnings (in Millions$)	Output (in Millions$)
Construction			
Direct	2,788.8	$276.1	$338.7
Indirect	8,725.7	$601.8	$2,228.3
Induced	5,240.4	$264.4	$766.8
Operation and Maintenance (over lifetime of technology)			
Direct	1,370.2	$126.4	$126.4
Indirect	1,224.4	$80.3	$251.1
Induced	800.9	$42.8	$85.7
Total	20,150.5	$1,391.9	$3,797.1

[21] MIG, Inc., 2017
[22] Ibid.
[23] Ibid.

The summary of impacts for the 15 percent by 2021 scenario shows a total impact of nearly $6.3 billion, including more than 32,500 job-years supported and $2.2 billion in employee compensation. Table 9 provides direct, indirect, and induced impacts for Scenario 2.

Table 9. Summary of Impacts for Scenario 2 – 15 Percent by 2021 Impacts (in 2017 dollars)

Impacts	Job-Years	Earnings (in Millions$)	Output (in Millions$)
Construction			
Direct	4,300.4	$422.8	$518.5
Indirect	14,248.6	$985.6	$3,677.4
Induced	8,428.2	$425.5	$1,235.1
Operation and Maintenance (over lifetime of technology)			
Direct	2,233.6	$203.5	$203.5
Indirect	2,029.5	$133.2	$417.0
Induced	1,314.8	$70.3	$204.8
Total	32,555.1	$2,241.0	$6,256.4

The summary of impacts for the 30 percent by 2027 scenario shows a total output of $10.3 billion, including more than 68,500 job-years supported and $4.5 billion in employee compensation. Table 10 provides direct, indirect, and induced impacts for Scenario 3.

Table 10. Summary of Impacts for Scenario 3 – 30 Percent by 2027 Impacts (in 2017 dollars)

Impacts	Job-Years	Earnings (in Millions$)	Output (in Millions$)
Construction			
Direct	12,553.2	$1,165.9	$1,520.5
Indirect	18,633.2	$1,069.4	$3,193.3
Induced	13,687.9	$695.0	$2,008.0
Operation and Maintenance (over lifetime of technology)			
Direct	9,647.3	$790.1	$973.6
Indirect	8,261.2	$526.5	$1,717.3
Induced	5,797.9	$297.4	$878.2
Total	68,580.8	$4,544.4	$10,290.9

CONCLUSION

The conversation on renewable energy development is most often in the context of environmental stewardship. While this conversation is important and worthwhile, it often fails to acknowledge the economic impacts that can arise from investments in renewable energy. As this and other studies have shown, there are benefits derived from the construction and generation activities associated with renewable energy.

In Michigan, there are opportunities to leverage the current momentum related to the implementation of PA 295 and PA 342. Further development of the state’s renewable energy can reduce the state’s dependence on imported energy and increase economic vitality by supporting jobs for Michigan’s workforce and creating value added output for its strong industrial supply chain.

Input-output economic impact analysis of the 12.5 percent by 2019 scenario indicates that the selected activities as a whole could have a potential gross impact of nearly $3.8 billion on Michigan, including more than 20,100 job-years supported and nearly $1.4 billion in employee compensation. The summary of gross impacts for the 15 percent by 2021 scenario shows a total impact of nearly $6.3 billion, more than 32,500 job-years supported and $2.2 billion in employee compensation. The summary of gross impacts for the 30 percent by 2027 scenario shows a total output of $10.3 billion, more than 68,500 job-years supported and $4.5 billion in employee compensation. These results are gross impacts of the economic activity resulting from the modeled scenarios.

These results are not intended to advocate for or against any particular policy, strategy, or investment, but rather serve as an assessment of the impacts that a set of investments may have on Michigan’s economy. Michigan can meet increased demand for renewable energy by investing at varying levels in a spectrum of clean energy technologies.

As policy makers, industry leaders, and other stakeholders begin to understand the economic impact of increased investment in Michigan’s renewable energy resources and plan for the future of Michigan’s economy, the following are potential considerations:

1. A state-level strategy for renewable energy capacity development and state policy changes should be developed in the context of likely return on investment for Michigan’s economy.
2. Investments in energy efficiency at a state level, combined with the development of additional renewable energy sources, may exponentially decrease Michigan’s dependence on imported energy and increase local and regional economic investment.
3. As Michigan transitions away from nonrenewable sources and toward renewable sources of energy, there may be a temporary displacement of workers. A long-term energy transition plan may help to mitigate this impact.
4. Impacts on Michigan’s economy may increase if Michigan businesses are able to meet the increased activity from the construction, operation, and maintenance of renewable energy sources to a degree higher than modeled. Efforts to encourage use of local supply chains may help attract new investment from out-of-state firms and increase efficiencies in capacity development.

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APPENDIX A: RESEARCH LIMITATIONS

The following are additional considerations to be consulted while reviewing the results of this study.

- Data used for this report is cited from current, reliable sources. When conflicts in data arose, the most conservative estimates were utilized to avoid overestimation.

- Averaging and using linear projections in the modeling of renewable energy capacity development may skew specific yearly forecasts; however, the average values are critical to assessing economic impact in an efficient manner.

- The study relies heavily on secondary data since primary data was unavailable to researchers. Assumptions made by researchers in the development of source data are reflected in the results of this study.

- Import and export figures for the State of Michigan are calculated by the JEDI and IMPLAN model. JEDI and IMPLAN's default values and percentages were used to quantify the Michigan trade flows. Modification of the IMPLAN industry margins, ratios, and percentages may allow for the creation of a more exact model should primary data become available. Impacts on Michigan's economy may increase if firms within the state are able to meet the increased activity from the construction, operation, and maintenance of renewable energy sources to a degree higher than modeled.

- This study assumes that hydroelectric water power capacity will not grow in Michigan based on current regulations and the environmental impacts associated with dam development.

- In calculations, researchers set aside the Renewable Energy Credits (RECs) and estimated the economic impact on the state as if the demand for renewable energy will be fully met by capacity built within Michigan.

- Growth in each technology is projected based upon past investments within Michigan. The study does not account for new technologies or improvements in technologies that may emerge through 2027.

APPENDIX B: RETAIL SALES PROJECTIONS

Retail sales are used in this study as a proxy for electricity demand and utilization in Michigan. Historical retail sales of electricity, shown in Table 11, were used to project future demand.

Table 11. Retail Sales of Electricity in Michigan, 2008 to 2015

Year	Total Retail Sales (MWh)	Total Net Generation (MWh)
2015	102,479,921	113,008,050
2014	103,314,098	106,816,991
2013	103,038,746	105,417,801
2012	104,818,191	108,166,078
2011	105,053,558	109,169,507
2010	103,649,219	111,551,371
2009	98,121,014	101,202,605
2008	105,781,271	114,989,806

According to the U.S. Energy Information Administration, demand for electricity across the country is expected to grow by five percent between 2015 and 2040. Using this overall projection, potential demand for electricity in Michigan was calculated through 2027, as shown in Table 12.

Table 12. Projected Retail Sales of Electricity in Michigan, 2016 to 2027

Year	Projected Retail Sales (MWh)
2016	102,684,881
2017	102,889,841
2018	103,094,801
2019	103,299,761
2020	103,504,721
2021	103,709,681
2022	103,914,641
2023	104,119,601
2024	104,324,561
2025	104,529,521
2026	104,734,481
2027	104,939,441

APPENDIX C: CAPACITY FACTOR

The capacity factor of renewable energy sources is the ratio of actual output to nameplate capacity. Scenarios were developed by calculating the installed capacity necessary to meet renewable energy demand given technology specific capacity factors.

Equation 1. Capacity Equation

$$Technology\ Capacity = \frac{(Demand) * (Technology\ Marketshare)}{(Time) * (Technology\ Capacity\ Factor)}$$

Advances in technology resulting in improvements to capacity factor would modify the renewable energy capacity that Michigan would need to build to meet generation standards associated with each scenario.

Table 13. Renewable Energy Technology Capacity Factor[24]

Technology	Capacity Factor
Biomass	84%
Landfill Gas	83%
Wind	38%
Solar, Photovoltaic - Track	21%

[24] Transparent Cost Database, *Capacity Factor,* 2017

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