Component Manufacturing: Michigan's Future in the Renewable Energy Industry

R E P P

Renewable Energy Policy Project

George Sterzinger
Jerry Stevens

Technical Report | November 2006

REPP STATE REPORTS

A national program to develop renewable energy will provide significant benefits to states and regions well beyond where projects are developed. A national program will greatly stimulate demand for manufactured components. It is clear from earlier Reports undertaken by the Renewable Energy Policy Project that many of the states and regions that have suffered the greatest loss of manufacturing jobs have a significant concentration of manufacturing potential to supply those components. This potential is little understood even by those closest to it and who stand to benefit the most from it. The REPP State Reports intend to provide an explanation of how this manufacturing potential is calculated and offer detailed analysis showing for a state, region, and county the potential for each of the 43 industrial codes that comprise the major component parts for the major renewable energy technologies. It is intended that the Reports will promote interest at the local level to actually identify the specific firms that could benefit from a national program and begin the discussion as to how best to tie reinvigorated domestic manufacturing activity into a national program to develop renewable energy.

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ENERGY AS THE FUTURE

At present, the energy sector and the national policy that determines how it evolves leaves the US exposed to three major, interconnected threats. Our national security is compromised by how we get and use energy. The inability to adequately recognize climate change as a problem only makes the inevitable task of dealing with the problem more difficult. Finally, the harmful effect of our present energy policy on the domestic economy needs an expanded and more aggressive response to reverse the damage.

Current US energy policy is often described as "drain America first" referring to our insistence on drilling more and more pristine areas of the US for oil and natural gas, but "drain America first" could also refer to the effects of our current policy on the domestic economy. The threats to the long-term economic well being of our country raised by the present policy's effects on our balance of trade deficit and outsourcing critical manufacturing capabilities cannot be ignored. Perhaps more critically, solving energy problems with policies that provide security, address climate stabilization and direct substantial economic revitalization to our domestic economy offers hope for a greatly expanded political coalition.

A major commitment to renewable electric generation will reduce our security exposure, help stabilize our climate and provide a multi-billion dollar investment and reindustrialization program. A national program of that size and scope offers a tremendous opportunity for Michigan. Seeing an energy policy as a way to create a new thrust of industrial activity requires looking at the renewable technologies in a new way. This Report breaks down renewable generation technologies into their component parts and then examines which existing Michigan industries could, if provided with appropriate support mechanisms, become suppliers of the billions of dollars of new parts that will be necessary.

The recently passed Energy Policy Act of 2005 provided some minor support for renewable energy development but stopped well short of supporting a significant national commitment. The Act completely neglected supports for the development of a robust, domestic industry to provide the component parts that make up modern renewable technology. Michigan recognizes the potential for revitalizing its industrial technology if the potential documented in this Report can be captured. This Report provides that first step, the analysis of the potential, to spur the pursuit of the policies to capture the potential.

It is well understood that a national program to develop renewable energy will benefit the regions and states that have the best renewable resource base – solar, wind, biomass and geothermal. What is less appreciated is that a national program will also create a demand for billions of dollars of components, namely the parts that make up the finished renewable plants. This demand could, if accompanied by appropriate incentives, provide important new markets for domestic manufacturers that are already manufacturing equipment similar to the components that go into new renewable generation.

In 2004, the Renewable Energy Policy Project completed an analysis of modern, large wind turbine technologies. The results of this analysis were very encouraging both for the country as a whole and for Michigan in particular. The Report showed:

> Investment in new wind will create a demand for all of the components that make up a wind generator. As a rule of thumb, every 1000 MW requires a $1 Billion investment in rotors, generators, towers and other related investments…This Report assumes 124,900 MW will be developed nationally and proceeds in three steps to trace the distribution of benefits. First we determine how the total installed cost of the new wind development will flow into demand for each of the 20 separate components of the turbines (grouped into 5 categories). Second, we spread the total demand among the regions of the country by allocating the $50 billion investment according to the number of employees at firms identified by the NAICS codes. The number of employees is used rather than number of firms to account for the different impact of large vs. small companies, and hence to more accurately distribute the investment. This produces a "map" of manufacturing activity across the United States based on firms that have the technical potential to become active manufacturers of wind turbine components. Third, we translate the regional dollar allocation by assuming that all component manufacturing has the same ratio of jobs/total investment of 3000 FTE jobs/$1 billion of investment.

The results of this initial research into the distribution of manufacturing activity are encouraging. Twenty-five states have firms currently active in manufacturing components or sub-components for wind turbines; all fifty states have firms with the technical potential to become active. Table 1 below shows the ten states which would receive the greatest portion of the investment, based on the number of employees at potentially active firms identified by the NAICS codes for wind components.

This Report analyses the renewable energy industry assuming that the United States moves to stabilize carbon emissions. As explained more fully below, the Report assumes a "wedge" of renewable energy is developed to stabilize the emissions from the US electric sector. The Report looks at how that major new demand for renewable energy will cascade down to create new demand for the component parts that make up the major renewable energy technologies.

Here in summary form are the results of this Report for Michigan. Stabilizing emissions of carbon requires adding 18,500 MW of new renewable projects each year. The Report looks at the total demand generated by a ten-year stabilization program and tracks that demand down to the individual industries capable of manufacturing the components. The national demand is assigned to individual states and eventually to the county level. Among all of the states, Michigan is ranked fourth in terms of the amount of new investment and seventh in terms of new jobs generated from the expanded manufacturing activity to meet this demand. In all, there are more than 2,000 firms in Michigan that are currently active in the industrial sectors that could supply the component parts to meet the demand necessary to deliver an emissions stablization wedge. In addition, the demand can support the creation of more than 34,777 new Michigan jobs related to the expanded manufacturing activity.

The Report also looks at the likelihood that new demand on the scale necessary to stabilize carbon emissions would lead to bottlenecks in the component supply chain. To analyze the likelihood of this occurring, the Report looks at the incremental, annual demand for components as a percent of the available unused industrial capacity for each of the major industrial sectors. For example, climate stabilization efforts will create an annual demand for approximately $1 billion for wind turbine gearboxes. Currently, this industrial sector is running at close to full capacity. Department of Commerce data shows an available, unused capacity of roughly $15 million. In other words, any major push for renewable installations would run into an immediate

shortage of these critical components. Looking more closely at this carbon stabilization program reveals that there is a very great likelihood that severe bottlenecks will develop in many critical sectors. For wind and photovoltaic components, the annual, new demand will greatly exceed available industrial capacity for more than 50% of the industrial sectors. All of the renewable technologies face a bottleneck in one or more critical components.

This Report reveals the enormous potential that a commitment to climate stabilization is likely to produce. Michigan, by acting early, can influence national action to accelerate climate programs. By virtue of its industrial base, Michigan stands to benefit from the increased demand for renewable technology. Michigan should not rest solely on its existing manufacturing base, however. Capturing the maximum economic potential and avoiding supply-chain bottlenecks will require aggressive investment in new manufacturing capacity by the private sector. Public incentives and support mechanisms can and should be used to accelerate that action.

STABILIZING CARBON EMISSIONS

There are many ways to stabilize carbon emissions. For this Report REPP has used the "wedge" analysis developed by Pacala and Socolow. (Pacala, S. and R. Socolow, Stabilization Wedges: Solving the Climate Problem for the Next 50 Years wit Current Technologies, Science, 13 August 2004, Vol. 305) One of the breakthroughs that any complex issue like climate stabilization policy must make to gain public awareness and acceptance is to provide the public with a clear, comprehensible explanation of the problem and a solution that they can understand and believe will work. The recent article in Science provided that threshold of clarity for climate stabilization efforts. To stabilize carbon emissions, the authors proposed to split the growth of carbon emissions into seven parts or wedges and look for the set of already existing technologies that can generate the required electricity without a wedge of carbon emissions.

An international program of stabilization based on current levels of global emissions would make the United States responsible for about two wedges or two-sevenths of global carbon emissions. Since transportation and electricity generation each provide about half the emissions, electricity generation in the United States would be responsible for about one wedge.

As the Science article makes clear, there are a number of programs using existing technologies that can be used to provide a wedge of carbon reductions. For this Report, however, we look at what would be required to provide a wedge from renewable energy technologies.

The calculation of what is required to stabilize these emissions is straightforward. The base of carbon emissions now is 7 billion metric tons per year of carbon, growing at 1.5% per year. For the first year, global growth would be 105 million tons, and to stabilize or remove the growth each wedge would require removing 15 million tons of carbon. Since the most common emission from the generation of electricity is CO2, the 15 million tons of carbon per wedge would translate to 55 million tons of CO2 per year. Coal generation emits on average 2.1 pounds of CO2 per kWh produced, which translates to approximately 58 billion kWh generated with zero CO2 emissions to capture one wedge. ("Carbon Dioxide Emissions from the Generation of Electric Power in the United States" July 2000 Department of Energy Washington, DC 20585 Environmental Protection Agency Washington DC 20460).

The assumption that each CO2-free kWh removed a kWh of coal fired generation rather than natural gas fired generation is very likely imprecise. It is used here as a way to begin the discussion of how this type of program might work. It is not meant as a definitive resolution of these complex issues regarding electric generation dispatch. To achieve these reductions would

Investment and Job Creation Potential
Top 10 States Ranked by Average Investment

The results indicate that a significant national investment has clear potential to benefit regions of the U.S. other than only those states that have a significant renewable resource. Furthermore, investigating the demographics of the top 20 states benefiting from manufacturing indicates that investment will particularly target the most populous regions of the country, and will especially benefit regions that are most in need of new manufacturing jobs. Notably, the 20 states benefiting the most from investment in components are almost identically the 20 states that have lost the most manufacturing jobs in the country over the past 3 years. These states account for more than 76% of the manufacturing jobs lost. Investment will particularly benefit these states, sending new jobs where they are needed most. Furthermore, these states are also the most populous, indicating that investment in wind will benefit a large range of people in the country."

	Number of MW	Number of Firms	Millions $ Investment	New FTE Jobs
Wind	124,900	16,480	$62,338	398,470
Solar	23,150	10,272	$69,624	298,194
Geothermal	15,190	3,926	$15,330	72,324
Biomass	21,760	12,020	$13,248	81,615
Total:	185,000	42,698	$160,541	850,603

Investment and Job Creation Potential Top 10 States Ranked by Investment

State	Number of Jobs	Average Investment ($ Billions)	2001 Population	Rank in U.S.	Manufacturing Jobs Lost, Jan. 2001 - May 2004*	Rank in U.S.
California	95,616	$20.90	34,501,130	1	318,000	1
Texas	60,100	$13.22	11,373,541	7	165,500	3
Illinois	56,579	$9.93	21,325,018	2	169,600	2
Ohio	51,269	$8.84	9,990,817	8	129,300	8
New York	47,930	$8.40	12,482,301	5	131,500	6
Pennsylvania	42,668	$7.92	6,114,745	14	63,500	13
Indiana	39,221	$6.26	12,287,150	6	155,200	5
Michigan	**34,777**	**$5.53**	**5,401,906**	**18**	**68,300**	**10**
North Carolina	28,544	$5.33	19,011,378	3	130,500	7
Missouri	22,796	$5.26	8,186,268	11	156,600	4
10 State Total	524,558	$91.59	140,674,254		1,488,000	
% U.S. Total	65%	57%	50%		55%	

I. National Rankings

The methodology we developed for the Wind Report has since been extended to cover photovoltaics, bio-mass steam generators, and geothermal technologies. For the combined renewable technologies, we assumed that 124,900 MW of wind would be developed, 15,190 MW of photovoltaic, 23,150 MW of biomass, and 21,760 MW of geothermal.

Summary of National Development, Resulting Investment and Jobs

U.S.	Total New MW	Number of Firms	Millions $ Investment	New FTE Jobs
Wind	124,900MW	16,480	$62,338	398,470
Solar	23,150MW	10,272	$69,624	298,194
Geothermal	15,190MW	3,926	$15,330	72,324
Biomass	21,760MW	12,020	$13,248	81,615
Total:	185,000MW	42,698	$160,540	850,603

Nearly 43,000 firms throughout the United States operate in industries related to the manufacturing of components that go into renewable energy systems. If the 185,000 MW of renewable energy assumed in this model were to be developed, these companies have the potential to fill the demand for new components that would be generated. This national development would represent nearly $160 billion dollars of manufacturing investment, and would result in more than 850,000 new jobs. Michigan is particularly well positioned to benefit from such a national development. As shown in the tables below, Michigan stands to receive nearly 34,777 new jobs and $5.53 billion dollars of investment in manufacturing components to supply this national development of renewables. Michigan is ranked ninth among states in terms of job gain, and seventh for potential investment. (Note: The wind figures shown here are different from those in REPP's initial wind manufacturing report because we are using a more refined model that defines cost information at the component level.)

Location	# of Firms	Jobs Wind	Jobs Solar	Jobs Geothermal	Jobs Biomass	Jobs Total
California	5,409	32,046	48,896	8,465	6,209	95,616
Texas	3,358	25,044	23,221	4,660	7,175	60,100
Illinois	2,289	30,010	19,298	3,396	3,875	56,579
Ohio	2,465	29,820	11,833	5,079	4,537	51,269
New York	1,925	18,523	14,617	8,150	6,640	47,930
Pennsylvania	2,188	19,588	15,767	3,402	3,911	42,668
Indiana	1,321	25,180	7,485	3,191	3,365	39,221
Michigan	2,050	24,350	6,644	1,502	2,281	34,777
North Carolina	1,096	10,964	11,062	2,810	3,708	28,544
Missouri	785	10,260	7,532	2,907	2,097	22,796

II. Michigan and Michigan Counties Information

As shown in the wind report on manufacturing activity, Michigan is particularly well positioned to benefit from wind energy development. When the picture is expanded to include other

renewable energy technologies, the potential benefit to Michigan manufacturing industries is even greater. As in the case of wind technology, Michigan has a manufacturing base in most of the industries relevant to the production of other renewable energy components.

Table 4: Potential Benefit to Michigan from National Development

Michigan	Number of Firms	Investment (Millions)	New FTE Jobs
Wind	967	$ 3,452.5	24,350
Solar	360	$ 1,255.6	6,644
Geothermal	129	$ 271.5	1,502
Biomass	594	$ 348.8	2,281
Total:	2,050	$ 5,328.4	34,777

This report and the previous wind manufacturing report identify that Michigan stands to benefit greatly from national renewable energy development throughout the manufacturing supply chain. The next step is to identify specific actions to take in order to move towards making this potential benefit a reality. In order to do so, it is useful to have more specific information about the location and nature of the manufacturing potential in Michigan.

Importantly, the census information for manufacturing industries contains data refined down to the county level. This county level information makes it possible to take a closer look at the locations within a state that have the potential to manufacture components related to renewable energy. The methodology for arriving at investment and jobs numbers at the county level is the same as for the state level. Each county receives a portion of the total investment from the national program, according to the percentage of firms in each of the relevant NAICS industries operating in that county, and jobs are distributed in the same manner.

Table 5: Top 20 Michigan Counties Ranked by Impact

County	Wind Investment (millions)	Jobs	Solar Investment (millions)	Jobs	Geothermal Investment (millions)	Jobs	Biomass Investment (millions)	Jobs	Totals Investment (millions)	Jobs
Wayne	$300.80	1,976	$193.50	1,055	$28.90	174	$33.80	226	$557.00	3,431
Kent	$336.70	2,478	$104.50	648	$22.00	117	$50.80	332	$514.00	3,575
Oakland	$278.90	1,927	$128.10	738	$38.00	168	$35.10	230	$480.10	3,063
Macomb	$357.70	2,603	$75.30	437	$9.40	43	$22.70	144	$465.10	3,227
Grand	$283.20	1,917	$148.60	1,032	$1.10	5	$6.20	45	$439.10	2,999
Monroe	$17.00	104	$365.10	1,518	$6.40	22	$7.90	49	$396.40	1,693
Saginaw	$164.20	1,135	$12.50	43	$1.40	7	$2.00	12	$180.10	1,197
Muskegon	$132.70	915	$35.30	231	$5.00	28	$3.50	21	$176.50	1,195
Berrien	$52.70	382	$6.20	45	$66.40	411	$13.50	85	$138.80	923
Ottawa	$93.80	701	$6.50	52	$4.90	35	$25.50	178	$130.70	966
Washtenaw	$75.20	541	$17.50	53	$4.00	21	$25.40	178	$122.10	793
St. Joseph	$103.10	769	$0.80	5	$0.00	0	$2.60	16	$106.50	790
Kalamazoo	$39.40	303	$12.40	37	$40.60	216	$13.80	77	$106.20	633
Calhoun	$80.80	588	$3.00	19	$9.50	50	$2.70	15	$96.00	672
Charlevoix	$88.40	626	$0.00	0	$0.00	0	$2.70	20	$91.10	646
Clinton	$82.00	536	$0.00	0	$1.10	5	$0.50	3	$83.60	544
Shiawassee	$58.10	396	$0.20	1	$2.70	9	$19.80	143	$80.80	549
St. Clair	$62.20	466	$7.90	25	$4.90	19	$2.90	13	$77.90	523
Allegan	$42.50	267	$28.30	144	$1.70	12	$2.00	12	$74.50	435
Livingston	$62.70	425	$3.30	15	$1.30	7	$3.80	24	$71.10	471
Ingham	$41.90	260	$4.30	12	$15.80	114	$2.10	15	$64.10	401

The table above lists the 20 counties in Michigan that would receive the greatest investment in manufacturing from the national development of wind, solar PV, geothermal, and dedicated biomass. To further clarify, the '"Investment" dollar figure is arrived at by starting with an assumed number of MW of new capacity for the entire U.S. – we use 124,900 MW new wind for this report. This 124,900 MW results in a certain manufacturing cost for each component that goes into a wind turbine, which we calculate based on specific cost information ($/MW) that we have researched for each part. Each component also has an NAICS industry associated with it – for example, the wind turbine gearbox falls under the code 333612 "Speed Changer, Industrial". The total dollars that go into making gearboxes for the 124,900 MW of wind are then apportioned to each county based on the relative number of firms operating in 333612 in that county (to be more precise, the number of employees working at those firms is used to account for different size companies). This process is repeated for each component and then summed to arrive at the total for each technology.

The number of new "Jobs" is also based on census information. By combining the number of employees working in a given industry, the total value of components produced by that industry, as well as the cost per megawatt for those components, we are able to calculate a ratio of Jobs/MW for each NAICS industry for each of the four technologies. This number of jobs is then divided geographically in the same as the investment. To take a closer look at a particular county of interest, we can break out the investment and job allocation by specific NAICS codes, in order to examine the particular kinds of manufacturing that are relevant to a given county. As an example of this, below we look in further detail at the Michigan county with the most renewable

energy manufacturing potential: Wayne. While a variety of data is available, three items are of particular relevance. The number firms operating in the county in each NAICS industry gives an idea of the manufacturing base located in the county for a particular industry, while the investment and new job creation, using the method described above, provide an idea of the potential for the county to benefit in particular industries from the national development of renewable energy. The following tables break down the results for Wayne County.

Wayne County, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	27	$123.7	710
326199	All Other Plastics Product Manufacturing	43	$67.1	534
333612	Speed Changer, Industrial	2	$35.0	237
335999	Electronic Equipment and Components, NEC	3	$25.6	166
333613	Power Transmission Equip.	6	$25.5	167
331511	Iron Foundries	4	$11.0	77
334519	Measuring and Controlling Devices	6	$9.8	65
335312	Motors and Generators	3	$1.4	9
333412	Industrial and Commercial fans and blowers	1	$1.3	9
334418	Printed circuits and electronics assemblies	1	$0.4	2
Total:		96	$300.8	1,976

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	3	$64.2	416
335931	Current-Carrying Wiring Device Manufacturing	1	$50.7	387
325211	Plastics Material and Resin Manufacturing	3	$37.3	51
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	4	$24.0	95
334515	Instrument Manufacturing for Measuring and Testing	4	$7.8	36
332322	Sheet Metal Work Manufacturing	30	$6.9	56
335313	Switchgear and Switchboard Apparatus Manufacturing	3	$2.6	14
Total:		48	$193.5	1,055

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	1	$15.8	114
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	4	$8.6	31
332410	Power Boiler and Heat Exchanger Manufacturing	2	$2.6	19
333923	Overhead Traveling Crane, Hoist, and Monorail System	3	$0.6	3
333415	Air-Conditioning and Warm Air Heating Equipment and	3	$0.6	3
333911	Pump and Pumping Equipment Manufacturing	1	$0.4	2
333912	Air and Gas Compressor Manufacturing	1	$0.2	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	1
Total:		16	$28.9	174

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	2	$13.1	97
332410	Power Boiler and Heat Exchanger Manufacturing	2	$9.0	64
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	4	$4.2	15
333922	Conveyor and Conveying Equipment Manufacturing	11	$2.7	17
333412	Industrial and Commercial fans and blowers	1	$2.0	15
335999	Electronic Equipment and Components, NEC	3	$1.0	6
333999	All Other Miscellaneous General Purpose Machinery	17	$0.9	6

333415	Air-Conditioning and Warm Air Heating Equipment and	3	$0.2	1
335313	Switchgear and Switchboard Apparatus Manufacturing	3	$0.2	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	1
334513	Instruments and Related Products Manufacturing for	5	$0.1	1
333911	Pump and Pumping Equipment Manufacturing	1	$0.1	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	3	$0.1	1
333997	Scale and Balance (except Laboratory) Manufacturing	1	$0.1	1
333120	Construction Machinery Manufacturing	3	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	6	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
335311	Power, Distribution, and Specialty Transformer Manufacturing	1	$0.0	0
Total:		68	$33.8	226
Grand Total for Wayne County, MI:		**228**	**$557.0**	**3,431**

III. Component Breakdown and NAICS Methodology

Assessing the dispersion of manufacturing of the components of renewable energy systems proceeds in 3 steps. First we identify the component parts that make up each system, then we identify a relevant NAICS code for each component, and finally we use the census data to identify potential manufacturing activity.

A. Component Breakdown

In so identifying the component parts that make up each system, we must decide what constitutes a major component – for this study we consider a part that would likely be sold by a manufacturer as a single unit, and not the parts that went into that unit further up the supply chain. For example, we consider the gearbox in a wind turbine as a component, but not the bolts that went into making the gearbox. For each of four technologies – wind, solar PV, geothermal, and biomass generation – we identified the most prevalent modern technology, and then identified the major components that go into each.

For wind technology, this Report looks at utility scale modern wind turbines, which are three bladed, upwind, horizontal axis machines, typically larger than 1 MW capacity. In this type of wind turbine, wind flows over three large composite blades mounted on a rotor, causing them to rotate. The rotational energy is transferred through a gearbox to a generator, where it is converted into electricity. Almost all wind turbines currently being installed for power generation for electric utilities are of this kind. We identified 19 separate components for the utility scale wind turbine, many of which are shown below in Figure 1. For a complete list of the components and a description and photograph of each, please refer to Appendix A.

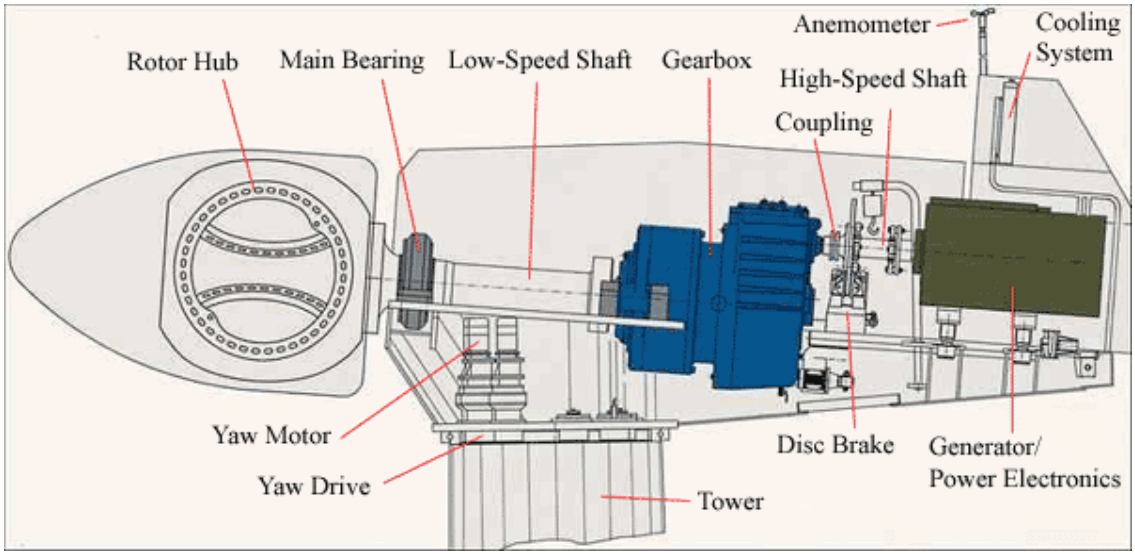


Figure 1 – Wind Turbine Component Diagram

For solar photovoltaics, we considered crystalline silicon modules, as these are by far the most common type of PV module currently deployed. Although not specifically considered in this report, amorphous silicon and other "thin-film" modules are also produced in small amounts in a handful of countries. However, with the exception of the glass top plate and the framing structure, the components for both systems are practically the same and so much of what is written in this report will also apply to thin-film modules. All PV systems convert the energy from photons striking the cells into electrical current. This direct current electricity is then either stored in a battery for later use, or converted into AC power by an inverter, which can then be connected to household appliances and to the electric grid. We identified 13 separate components for solar PV systems.

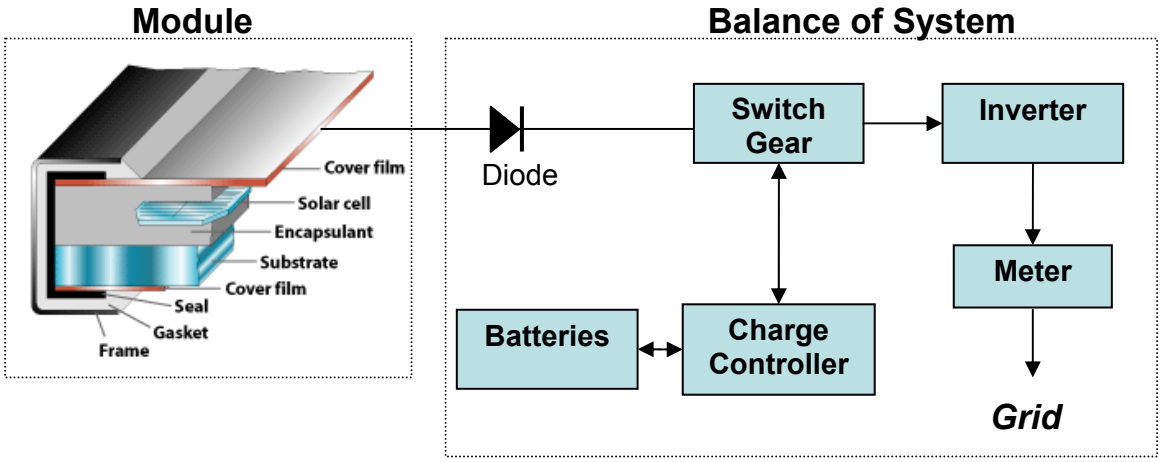


Figure 2 – Solar PV Component Diagram

For geothermal power generation, we considered two technologies that represent almost all of the current operating and planned plants – flash steam and binary cycle. Flash steam plants operate by expanding the hot geothermal fluid to make steam, which is then passed through a steam turbine-generator set to make electricity. The steam is then condensed, and in most cases the

excess fluid is reinjected underground to preserve the resource. In a binary plant, a fluid with a low boiling point is circulated in a closed loop, receiving heat from the geothermal fluid through a heat exchanger, vaporizing, being expanded through a turbine-generator, and then recondensed. Most of the components that make up these plants are similar, such as various pumps, heat exchangers and piping, but a handful of parts are distinct for each technology. Listed below are the components that both technologies have in common, and then those that are specialized for each type of plant. The figures below illustrate the major components of a flash steam plant and a binary cycle plant.

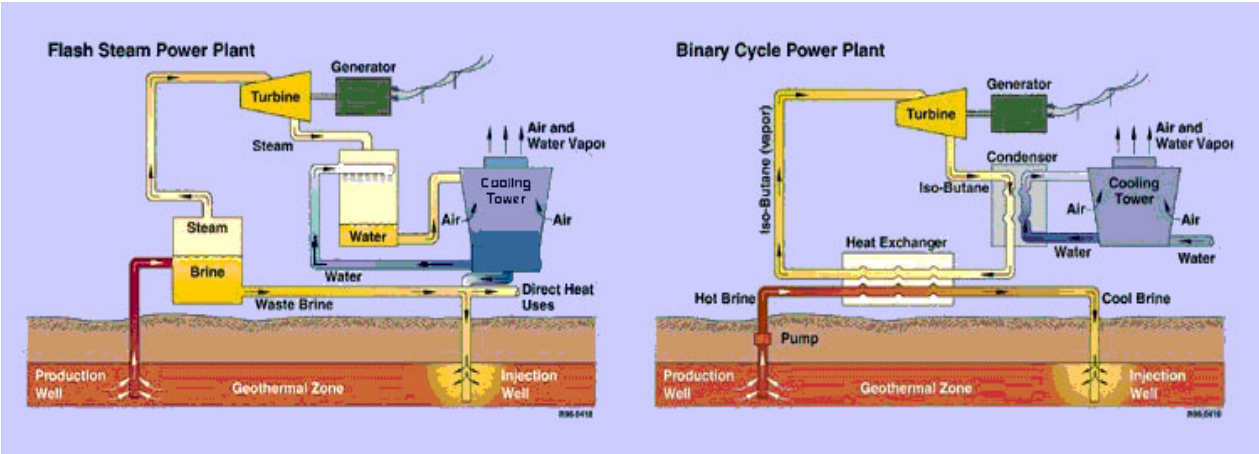


Figure 3 – Geothermal Component Diagram

For biomass power generation, we looked at dedicated biomass plants (as opposed to co-firing with coal) that burn biomass in a boiler to generate steam. The steam is then passed through a steam turbine-generator, just like the kind used in coal or other fossil-fuel plants, to generate electricity. While other methods of power-generation from biomass exist, such as gasification or anaerobic digestion, direct steam plants are the most common, and are the only technology widely ready for commercialization. We identified 33 separate components for a biomass-fired steam plant.

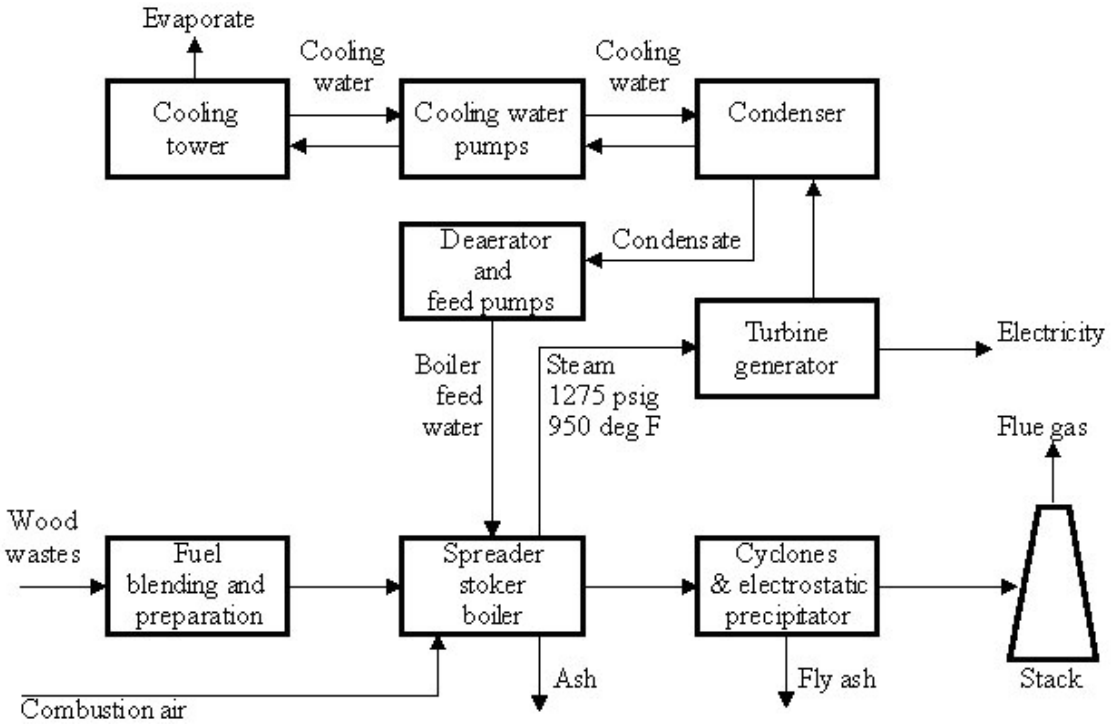
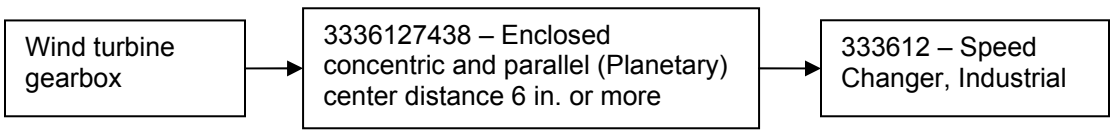


Figure 4 – Direct-fired Biomass Steam Plant Component Diagram

B. Identifying the NAICS Codes

Manufacturing activity has historically been tracked by Standard Industrial Classification (SIC) codes. The four-digit SIC code was developed in the 1930s to classify businesses by the type of activity in which they are primarily engaged and to promote the comparability of business data to describe various aspects of the U.S. economy. In 1997 the SIC was replaced by the North American Industry Classification System (NAICS). In the Economic Census conducted by the U.S. Census Bureau, every firm operating in North America reports one or more NAICS codes, indicating what types of products or services they provide. Companies reporting the same NAICS code are involved in similar activities, for example every company that reports "333911" manufactures some type of pump.

Using this system, REPP was able to tabulate the companies involved in activities similar to the manufacturing of renewable energy components. The NAICS codes have several levels of detail, up to ten digits, with each digit indicating a higher level of detail. For example, a first digit of 3 indicates Manufacturing, 333 is "Machinery Manufacturing," 333911 is "Pump and Pumping Equipment Manufacturing," and 333911148M is "All other centrifugal pumps, over 6 in. discharge." For this report, we matched each component with a 10-digit code, the highest level of detail in the NAICS, in order to ensure that we had accurately identified the correct code. We then went back up the hierarchy to the 6-digit code for interfacing with the census data.



Advantages to Using the 6-digit Codes

The 6-digit NAICS codes replaced the 4-digit SIC codes, which were the highest level of detail available in the SIC. Hence the 6-digit NAICS are the standard level reported by all companies in North America, with the 10-digit codes providing additional detail. The U.S. Census Bureau itself provides data primarily at the 6-digit level, reporting 10 only at the request of a special study. Furthermore, for a given NAICS code and a given geographical area, such as a county, if there are less than 2 companies operating or if one company is dominant, disclosure rules require the Census to not report information for that particular code and for that area, to avoid disclosing private company information. The small number of companies reporting in a given 10-digit code makes it unlikely that information would be available for all codes and states. Therefore, for this study we had to rely on the 6-digit codes. Additionally, the specificity of a 10-digit code could have excluded companies with good potential for entering the geothermal market, which the 6-digit industry code includes.

Caveat to Using the 6-digit Codes

When interpreting the results of a 6-digit code search, it is important to be aware of the potential broadness of companies included. For example, under the 6-digit NAICS, charge controllers and inverters fall under "Electronic Equipment and Components, Not Easily Classified." Along with rectifying equipment, such as inverters, this also includes laser power supplies and ultrasound equipment. However, this is mostly a problem for one or two particular codes, the majority of NAICS codes used in this study have much less variation of product type. Furthermore, even a company that makes laser power supplies has a significant advantage over a company starting from scratch, as they have basic knowledge and capabilities for making sophisticated electrical equipment.

C. Identifying the Economic Impact of Renewables Manufacturing

To provide an estimate of market development, we must start with a figure for the amount of development to occur in each of the technologies considered in this report. This assumed development figure drives the demand for manufacturing of the components, which in turn creates the potential for economic development in locations that could supply these components. The intention of this report is not to take guesses at the number of MW of renewable energy likely to be installed in the next 20 years; rather we base our calculations on reasonable assumptions in order to provide an estimate of the economic potential. The table below lists the drivers we used for each of the four technologies, and their source.

Table 6: Sources for Assumed National Development

	Number of MW	Number of Firms	Investment (Millions)	New FTE Jobs
Wind	124,900	16,480	$62,338	398,470
Solar	23,150	10,272	$69,624	298,194
Geothermal	15,190	3,926	$15,330	72,324
Biomass	21,760	12,020	$13,248	81,615
Total:	185,000	42,698	$160,541	850,603

Investment Allocation

Having identified components and a NAICS code for each, the next step in determining the potential involvement of this manufacturing base in the development is to determine how demand will flow into each industry based on component cost information. This cost information results in a dollar amount allocated to each industry. Each component is assigned a specific cost ($/MW) based on research by REPP into the most relevant current cost study for each technology. The table below summarizes the sources for cost information for each of the technologies.

Table 7: Sources for Component Cost Information

Energy Source	Component Cost Information Source
Wind	NREL WindPACT Study
Solar PV	Solar PV Industry Roadmap, as well as NREL Solar Energy Technologies Program
Geothermal	EPRI "Next Generation Geothermal Power Plants"
Biomass – Dedicated Steam	Capital costs for the McNeil Generating Station in Burlington, VT

The cost allocated to each component group is then allocated to states and geographic regions according to the number of employees working for companies with the technical potential to manufacture components in that component group. The number of employees is used rather than number of firms to account for variation in size of the firms. A firm employing 1,000 people will bring a larger investment to a region than one employing 10. To illustrate the allocation, consider the wind turbine gearbox, which has a specific cost of $80,000 per MW of wind capacity. Multiplying by the 124,900 MW of wind assumed as the driving development results in a total investment in gearbox manufacturing of approximately $10 billion. This $10 billion is now allocated geographically. Consider Wayne County in Michigan, which has 237 employees working at firms operating in the NAICS code for gearboxes (Speed Changer Industrial – 333612 NAICS), as compared to 63,698 employees in the entire U.S. Therefore, Wayne gets 237/63,698 or 0.37% of the $10 billion dollars, which means around $37 million goes to Wayne for the NAICS industry associated with gearboxes (it is possible to verify this by looking at the Wayne Wind breakdown in Section II of this report). To get the total investment for given county or state, we then simply sum up the investment for all of the NAICS codes.

Jobs Allocation

We are also interested in investigating the impact of the national development of renewable energy on job creation. To do this, we assign a manufacturing job creation ratio to each of the component industry, a number of jobs created manufacturing in a certain industry per MW of new capacity. This ratio is calculated, again using the NAICS census data in combination with the specific cost information discussed above. For each NAICS code, the census reports the number of employees working in that industry, as well as the total value of products shipped from that industry. We make the assumption that this shipped value of a product is the same value represented in the specific cost information used for the investment allocation (the $/MW for each component). Combining these two pieces of information results in a number of employees per MW. Because the census value of shipments is calculated on an annual basis, this "number of employees" is equivalent to number of annual jobs, or an amount of labor equal to the number of employees times 2000 hours. The table below shows the total jobs/MW number for each technology, summing over all of the component parts:

Table 8: Jobs per MW Development

Energy Source	Number of Jobs/MW
Wind	7.5
Solar	62.6
Geothermal	8.25
Biomass – Dedicated Steam	10.5

REPP recently completed a study of the labor that goes into manufacturing renewables, which included a detailed survey of employment related to wind and solar PV. The overall manufacturing jobs/MW numbers found using the NAICS census method and shown in the table above agree with the numbers found in the previous REPP study, giving confidence in the above method. Having obtained a jobs/MW number, the jobs are allocated geographically according to the census manufacturing in the exact same manner that the investment was allocated.

D. Identifying Potential Supply Bottlenecks

To identify potential bottlenecks in the component supply chain we first established for each NAICS code the current production capacity, then compared that to the maximum available production capacity. For each NAICS code we established an Available Production Capacity. Available Production Capacity is compared to the Incremental Demand for parts from that NAICS code. The Incremental Demand is the annual demand related to the installation of the wedge of 18,500 MW. If the Incremental Demand is greater than the total Available Production Capacity, there is a strong chance of a bottleneck developing. Identifying these bottlenecks should be met with a concerted effort to begin building industrial capacity to avoid the bottleneck.

Table 9: Bottlenecks in Wind Component Parts

Wind 10 Digit NAICS Codes	Incremental Demand	Available Production Capacity	Incremental Demand as a % of Available Production Capacity
Nacelle Case	$132,643	$55,931	237.15%
Rotor Blade	$1,133,332	$477,888	237.15%
Blade Extender	N/A	N/A	N/A
Tower Flange and Bolts	N/A	$25,554	N/A
Hub	$471,700	N/A	N/A
Nacelle Frame	$251,300	$248,692	101.05%
Towers	$1,476,550	$381,607	386.93%
Bearings	$145,075	$240,042	60.44%
Cooling System	$19,200	$137,235	13.99%
Generator	$551,900	$99,554	554.37%
Gear Box	$942,025	$14,593	6455.34%
Brakes	$33,606	$75,786	44.34%
Coupling	$16,015	$58,101	27.56%
Shafts	$135,254	$173,851	77.80%
Electronic Controller	$44,125	N/A	N/A
Sensors/Data Loggers	$117,525	$315,294	37.27%
Anemometer	$0	$315,294	0.00%
Pitch Drive	$262,942	$458,739	57.32%
Yaw Drive	$58,433	$101,945	57.32%
Power Electronics	$447,150	$191,626	233.34%

Table 9: Bottlenecks in PV Component Parts

PV 10 Digit NAICS Code	Incremental Demand	Available Production Capacity	Incremental Demand as a % of Available Production Capacity
Encapsulant	$248,575	$1,099,869	22.60%
Rear Layer	$260,300	$1,520,380	17.12%
Top surface	$479,950	$50,904	942.86%
Wiring	$241,550	$57,176	422.47%
Frame	$118,050	$116,924	100.96%
Blocking Diode	$93,327	$75,510	123.59%
Solar cells	$2,691,123	$1,282,194	209.88%
Complete Module	N/A	N/A	N/A
Meter	$111,900	$293,423	38.14%
Circuit Breakers and Fuses	$108,875	$343,195	31.72%
Switch Gear	$105,310	$861,303	12.23%
Electrical Connections	$400,388	$103,055	388.52%
Charge Controller	$477,569	$50,056	954.07%
Inverter	$643,392	$171,306	375.58%

As these two tables show, there are severe supply-chain bottlenecks in more than half of the crucial components for both wind and PV power. A successful program to take advantage of the benefits of renewables manufacturing will require enhanced coordination and investment to ensure that these bottlenecks do not shortchange the amount of economic benefits captured.

Appendix A – Component Descriptions and NAICS Codes

The following pages contain a detailed description of all of the components that make up a wind turbine, a photovoltaic system, a geothermal power plant, and a dedicated biomass steam generation plant. The 10-digit and 6-digit NAICS codes for each component are also listed.

Table of Contents:

Wind Components A2
Solar Components A12
Geothermal Components A20
Biomass Components A31

Wind Components

Bearings

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332991	Ball and Roller Bearings
Detailed Code: 3329915025	Other roller bearings, spherical roller bearings, including hourglass and barrel, double row

Description of Subcomponent:	A number of bearings are required for the shafts, gearbox, yaw mechanism, generator, and other rotating parts.	Source: http://www.timken.com/products/bearings/products/sphericals

A four-point contact ball bearing joins the nacelle and the tower, allowing the nacelle to slew about in order to face upwind and extract the maximum amount of energy from the wind. The main shaft rotates on large tapered roller bearings, or in some cases a large spherical bearing.

Blade Extender

NAICS Codes:	NAICS Descriptions:
Subsector Code: 331	Primary Metal Manufacturing
Industry Code: 331511	Iron Foundries
Detailed Code: 3315111116	Ductile iron fittings 14 in. or more

Description of Subcomponent:	These steel components serve as a means to support the rotor blades and secure them to the hub.	Source: http://www.state.sd.us/puc/2000/Wind/Wind%20Word%20

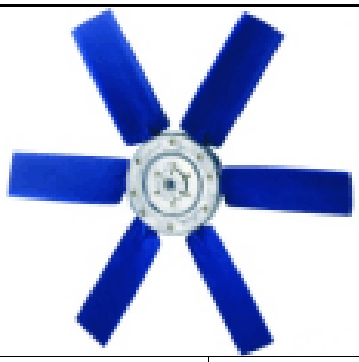
Typically weighing over a ton, each blade extender is mounted to a four-point ball bearing, which is then mounted to the hub. The structure of the extenders allows each blade maximize rotation while connected to the pitch mechanism.

Brakes

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 333	Machinery Manufacturing	
Industry Code: 333613	Power Transmission Equip.	
Detailed Code: 3336133111	Friction-type Clutches and Brakes	
Description of Subcomponent:	Mechanical brakes are used as auxiliary devices to insure that the rotors, gears and generator have stopped during maintenance of periods of inclement weather.	Source: http://www.windpower.org/en/tour/wtrb/safety.htm

The yaw mechanism typically halts any blade rotation by turning the rotors perpendicular to the wind direction. Should the rotors continue to turn, many turbines are equipped with either hydraulic or spring activated brake systems to prevent undesired rotation or fatigue on the turbine.

Cooling System

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 333	Machinery Manufacturing	
Industry Code: 333412	Industrial and Commercial fans and blowers	
Detailed Code: 33341204	Axial fans	
Description of Subcomponent:	A large fan drives air to convectively cool the generator and gearbox and exhausts waste heat from the nacelle assembly. Ducting directs cool air to the generator.	Source: http://www.continentalfan.com/product.htm

Most wind turbines have cooling and dehumidifying units set to maintain conditions within the nacelle at levels such that rust and corrosion is largely prevented.

Coupling

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 333	Machinery Manufacturing	
Industry Code: 333613	Power Transmission Equip.	
Detailed Code: 3336133329	Non-gear-type flexible couplings	
Description of Subcomponent:	The flexible coupling attaches to the high speed shaft and dampens out oscillating loads introduced by the gearbox. The reduction of these loads improves the quality of the electricity produced by the generator.	Source: http://www.mayr.de/english/p_old/sh_coupl/roba_ds/roba_ds

Modern couplings make use of composite materials for increased strength and flexibility. Use of these materials will increase and lighten the weight in a typical wind turbine.

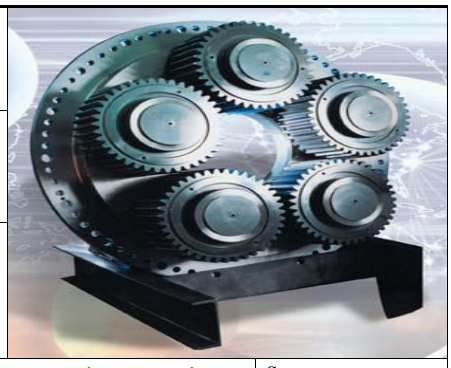
Electronic Controller

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 334	Computer and Electronic Product Manufacturing	
Industry Code: 334418	Printed circuits and electronics assemblies	
Detailed Code: 334418A015	Industrial process control board assemblies	
Description of Subcomponent:	The communications subsystem allows the wind turbines to monitor themselves and report performance to a control station. The controller also adjusts blade pitch and turbine yaw to adapt to wind conditions.	Source: www.newenergy.org.cn/english/guide/control.htm

Although there are typically controllers at the top and bottom of a tower, the increased data transfer capabilities of fiber optic wiring have provided the opportunity for a third controller to be placed in the hub of the rotor. The additional controller usually communicates with the nacelle unit using serial communications through a cable connected with slip rings and brushes on the main shaft.

Gear Box

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333612	Speed Changer, Industrial
Detailed Code: 3336127438	Enclosed concentric and parallel (Planetary) center distance 6 in. or more
Description of Subcomponent:	The gearbox employs a planetary gear system to convert low-speed rotation of the input shaft from the rotor to high-speed rotation which drives the high-speed shaft of the generator assembly.



Source: http://www.machinedesign.com/ASP/viewSelectedArticle.as

The gearboxes for larger wind turbines are more expensive per kilowatt (kW) of rated power than for smaller turbines because the torque increases more quickly than the power when increasing the rotor diameter. Hence, gearboxes have become one of the more expensive, critical components of a modern, utility-scale wind machine.

Generator

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333611	Turbines, and Turbine Generators, and Turbine Generator Sets
Detailed Code: 3336110871	Turbine generators
Description of Subcomponent:	This system converts high-speed shaft work into electrical energy by spinning the rotor around the magnetic stator and using the electromagnetism to produce AC electricity.

Source: http://seattlepi.nwsource.com/photos/photo.asp?PhotoID=274

Most modern wind turbines employ a doubly-fed, or induction, generator, which uses an electromagnet for both the stator and rotor magnets. This allows the generator to "slip" relative to the phasing of the electric grid, which both allows the wind turbine to operate at variable speed, as well as providing "reactive power" a feature which many utilities desire. However, this requires the use of power electronics to condition the generator output.

Hub

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 331	Primary Metal Manufacturing	
Industry Code: 331511	Iron Foundries	
Detailed Code: 3315113221	Other ductile iron casting for all other uses	
Description of Subcomponent:	The hub serves as a base for the rotor blades and extenders, as well as a means of housing the control systems for the pitch drive. It rotates freely and attaches to the nacelle using a shaft and bearing assembly.	Source: http://www.richter-ag.de/english/highlights/windkraftanlage.

The hub is often cast as a single steel part.

Nacelle Case

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 326	Plastics and Rubber Products Manufacturing	
Industry Code: 326199	All Other Plastics Product Manufacturing	
Detailed Code: 326199A141	Other fabricated fiberglass and reinforced products	
Description of Subcomponent:	The nacelle case encloses all of the major mechanical components of the wind turbine.	Source: http://www.middelgrunden.dk/MG_UK/project_info/turbine.h

The nacelle casing is composed of glass fiber-reinforced plastic with steel reinforcements. Through rubber dampers, the casing is mounted to the main frame with steel supports.

Nacelle Frame

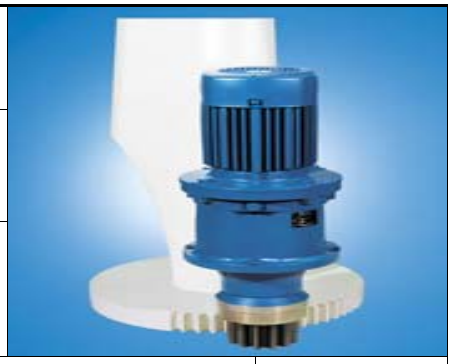
NAICS Codes:	NAICS Descriptions:
Subsector Code: 331	Primary Metal Manufacturing
Industry Code: 331511	Iron Foundries
Detailed Code: 3315113221	Other ductile iron casting for all other uses
Description of Subcomponent:	The nacelle frame is a steel bed to which all of the major components are bolted.

Source: www.cabinc.com/tgal.htm

Numerous holes are drilled into the frame of the nacelle for stability reasons. While the largest hole allows maintenance entry through the bottom of the nacelle, the other holes are precisely placed in order to ensure that the frame will not vibrate in step with the other components of the turbine. The nacelle frame is a single cast steel piece.

Pitch Drive

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335312	Motors and Generators
Detailed Code: 33531230	Integral horsepower motors and generators other than for land transportation equip. (746 watts or more)
Description of Subcomponent:	This system controls the pitch of the blades to achieve the optimum angle for the wind speed and desired rotation speed.



Source: http://www.boschrexroth.com/BoschRexroth/business_units/b

For variable-pitch wind turbines, a drive system is used to change the pitch of the blades to vary power output, and at high wind speeds to divert excess energy, thus reducing stress on the blades and keeping rotational speeds within design specifications. There are typically three motors used to perform this function, one for each blade. A hydraulic power package in the nacelle provides the power, and in case of power failure, a hydraulic accumulator provides backup power for the system. Fully-electric pitch drives may also be employed.

Power Electronics

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335999	Electronic Equipment and Components, NEC
Detailed Code: 3359993219	Other rectifying(power conversion) apparatus, except for electronic circuitry

Description of Subcomponent:	The power electronics match up the generator's output power with the electric grid.	Source: http://www.abb.com/global/abbzh/abbzh251.nsf!OpenDataba

With an induction generator (used in most modern wind turbines), the phase of the generator output must be synchronized to the phase of the utility grid. The power electronics do this by converting the AC signal from the generator to DC, and then re-inverting the DC back to AC at the correct phase.

Rotor Blade

NAICS Codes:	NAICS Descriptions:
Subsector Code: 326	Plastics and Rubber Products Manufacturing
Industry Code: 326199	All Other Plastics Product Manufacturing
Detailed Code: 326199A141	Other fabricated fiberglass and reinforced products

Description of Subcomponent:	Rotor blades convert the energy of the wind to mechanical energy by harnessing the principles of lift. Blades can have a stall regulated or variable-pitch design	Source: http://www.middelgrunden.dk/MG_UK/project_info/turbine.h

Currently the majority of blades are made of glass fiber-reinforced plastic. The profile of the blade is carefully designed to maximize lift over the entire length of the blade, while still providing structural integrity in maximum wind conditions.

Sensors/Data Loggers

NAICS Codes:	NAICS Descriptions:
Subsector Code: 334	Computer and Electronic Product Manufacturing
Industry Code: 334519	Measuring and Controlling Devices
Detailed Code: 3345197	Commercial, Meteorological, Geophysical, and General Purpose Instruments

Description of Subcomponent:	Sensors throughout turbines relay information to the electronic controllers, which automatically adjust turbine components to address changing conditions.	Source: http://www.fraunhofer.de/german/press/pi/pi2003/09/md_fo2.

A wind vane measures wind direction and relays data to the yaw mechanism, a cable twist counter monitors cables within the tower to determine if the turbine has been yawing in one direction for an extended period of time, the anemometer measures wind speed. Additionally, a thermocouple senses temperature within the nacelle and a vibration sensor monitors vibration to detect potential component failure.

Shafts

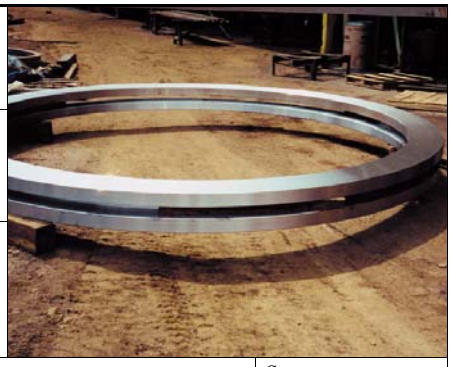
NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333613	Power Transmission Equip.
Detailed Code: 3336133792	Mechanical power transmission equipment, NEC, except parts

Description of Subcomponent:	The low speed shaft connects the rotor to the input of the gearbox, and the high speed shaft connects the output of the gearbox to the generator.	Source: http://www.middelgrunden.dk/MG_UK/project_info/turbine.h

The sizes of shafts have significantly decreased as component parts such as bearings have become smaller. Therefore, greater fatigue on smaller shafts has necessitated better handling of fatigue and possibly more regular maintenance.

Tower Flange and Bolts

NAICS Codes:	NAICS Descriptions:
Subsector Code: 331	Primary Metal Manufacturing
Industry Code: 331511	Iron Foundries
Detailed Code: 3315111116	Ductile iron fittings 14 in. or more
Description of Subcomponent:	These components join tower segments.



Source: www.cabinc.com/tgal.htm

A combination of bolting and welding is employed to join flanges and tower segments. To assure the stability of the tower welding seams, x-rays inspections are made of the adjoining segments.

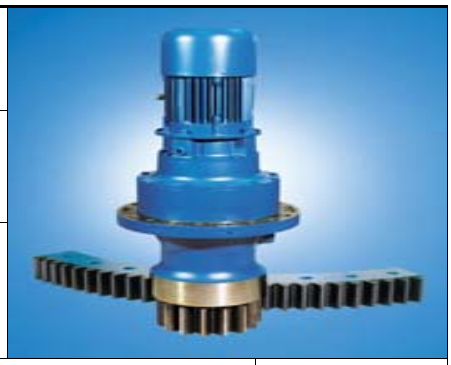
Towers

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332312	Fabricated Structural Metal
Detailed Code: 3323125106	Fabricated structural iron and steel for transmission towers, radio antenna, and supporting structures
Description of Subcomponent:	This large component of the turbine is made of rolled, tubular steel, and built in sections because of its size. For tubular towers, the most common type, a ladder is built in the hollow center to provide maintenance access.

Source: http://www.middelgrunden.dk/MG_UK/project_info/turbine.h

The size, both diameter and height, of the tower are restricted by transportation requirements.

Yaw Drive

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing	
Industry Code: 335312	Motors and Generators	
Detailed Code: 33531230	Integral horsepower motors and generators other than for land transportation equip. (746 watts or more)	
Description of Subcomponent:	The yaw drive slews the turbine directly into the wind in order to generate maximum power. Typically, four yaw drives monitor the wind direction and active the yaw motors to face the prevailing wind.	Source: http://www.boschrexroth.com/BoschRexroth/business_units/b

When the wind blows over 60 mph the mechanism turns 90 degrees from prevailing winds to reduce stress on internal components and to prevent stalling due to over-speed conditions.

Solar Components

Batteries

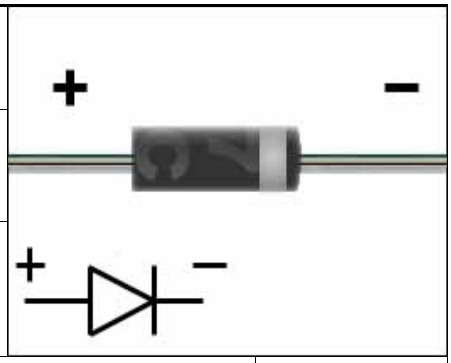
NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335911	Storage Batteries
Detailed Code: 3359114207	All other lead acid storage batteries, larger than BCI dimensional size group 8D (1.5 cu ft or .042 cu m and smaller), including starting, lighting, and ignition

Description of Subcomponent:	The batteries are used to store the electricity produced by the solar module, and then to provide power during times of insufficient sun.	Source: http://www.nrel.gov/data/pix/Jpegs/11663.jpg

For grid connected systems batteries can provide backup electricity in case of grid failure. For off-grid systems, batteries are necessary to provide energy during the night, or when it is cloudy and the sun is not shining. The vast majority of systems being installed currently are grid-tied, and batteries are only installed in approximately 2% of systems in the U.S. Given the nature of solar panels, only batteries designed for frequent charging and discharging (called deep-cycle batteries) will provide optimal performance. The most commonly used deep-cycle batteries are lead-acid and nickel-cadmium batteries.

Blocking Diode

NAICS Codes:	NAICS Descriptions:
Subsector Code: 334	Computer and Electronic Product Manufacturing
Industry Code: 334413	Semiconductors and Related Devices
Detailed Code: 3344137015	Semiconductor rectifiers - power diodes and assemblies



Description of Subcomponent:	The blocking diode is a semiconductor that keeps the battery from discharging through to the solar cells when there is no output from the cells to the battery.	Source: http://mediatheek.thinkquest.nl/~kl010/elektro/diodes.JPG

Blocking diodes are also referred to as "isolation diodes" when used to isolate cells from other cells in the array. This isolation allows the array to continue producing power when some of the cells are shaded.

Charge Controller

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335999	Electronic Equipment and Components, NEC
Detailed Code: 3359993104	Semiconductor battery chargers, industrial and railroad
Description of Subcomponent:	The charge controller regulates the flow of electricity to and from the battery in order to charge efficiently, and to protect the batteries from overcharging.

Source: http://www.nrel.gov/data/pix/Jpegs/06852.jpg

Applying a charging current to an already full battery produces gases in the battery that build up pressure and can damage the battery. Also, a mismatch in the voltage output from the solar array and the charging requirements of the battery can reduce the charging efficiency - requiring more time to reach full charge. The charge controller regulates the voltage and current to charge the battery quickly and efficiently. It also detects when the battery is full and switches to a trickle charge mode, which maintains the battery's full state without causing damage. Like batteries, charge controllers are only used in about 2% of systems today, but are included in this report for completeness.

Circuit Breakers and Fuses

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335313	Switchgear and Switchboard Apparatus Manufacturing
Detailed Code: 3353131100	Power circuit breakers, all voltages
Description of Subcomponent:	Both of these devices serve to protect the electronic circuitry, by breaking the connection to the system in the case of a current surge.

Source: http://www.nrel.gov/data/pix/Jpegs/07792.jpg

In a circuit breaker the current flows through an electromagnetic switch; when the current rises above a certain lever the electromagnet pulls the switch, breaking the circuit. The circuit breaker can then be reset.

Complete Module

NAICS Codes:	NAICS Descriptions:
Subsector Code: 334	Computer and Electronic Product Manufacturing
Industry Code: 334413	Semiconductors and Related Devices
Detailed Code: 334413A010	Photovoltaic modules

Description of Subcomponent:	The module consists of the PV cells, top surface, encapsulant, substrate, rear layer and frame. A photovoltaic module is a complete unit ready to be mounted and connected to the electrical equipment.	Source: http://www.nrel.gov/data/pix/Jpegs/09059.jpg

A module typically consists of several cells, connected in a combination of serial and/or parallel connections to achieve the desired current-voltage characteristics. Multiple modules are often connected together to create the complete PV system.

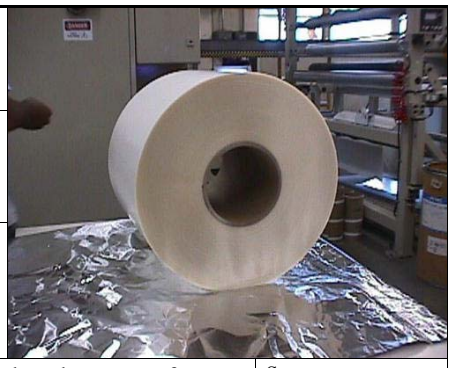
Electrical Connections

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335931	Current-Carrying Wiring Device Manufacturing
Detailed Code: 3359317100	Current-carrying metal contacts, including precious metal

Description of Subcomponent:	Metal conductors carry electrons out of the cells, connecting the cells in the module in series or parallel, and carry electricity out of the module to the rest of the system.	Source: http://www.partsonsale.com/pw1000boxsmall.jpg

Encapsulant

NAICS Codes:	NAICS Descriptions:
Subsector Code: 325	Chemical Manufacturing
Industry Code: 325211	Plastics Material and Resin Manufacturing
Detailed Code: 3252111160	Other thermoplastic resins and plastics materials
Description of Subcomponent:	The encapsulant protects the cells, and holds together the top surface, PV cells and rear surface.



Source: http://www.nrel.gov/data/pix/Jpegs/13424.jpg

Ethyl vinyl acetate (EVA) is the most common material used for the encapsulant. According to the Department of Energy, "thin sheets of EVA are inserted between the solar cells and the top and rear surfaces. Heating this "sandwich" causes the EVA to polymerize, thus bonding the module into one piece."

Frame

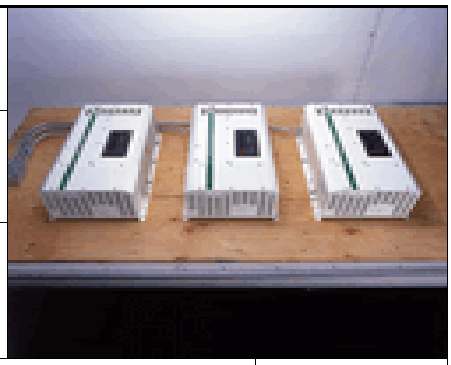
NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332322	Sheet Metal Work Manufacturing
Detailed Code: 332322G331	Other aluminum sheet metal work
Description of Subcomponent:	The frame adds structure, and can attach to the mounting structure.

Source: http://www.nrel.gov/data/pix/Jpegs/13384.jpg

Aluminum is a common material used for the frame. Thin-film modules are often flexible, having no frame, and are applied directly to the supporting structure. In building-integrated systems, the frame serves as roofing material and in other applications as well.

Inverter

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335999	Electronic Equipment and Components, NEC
Detailed Code: 3359993219	Other rectifying (power conversion) apparatus (except for electronic circuitry)
Description of Subcomponent:	The inverter converts direct-current (DC) electricity produced by the solar modules into alternating-current (AC) electricity to match the transmission grid.

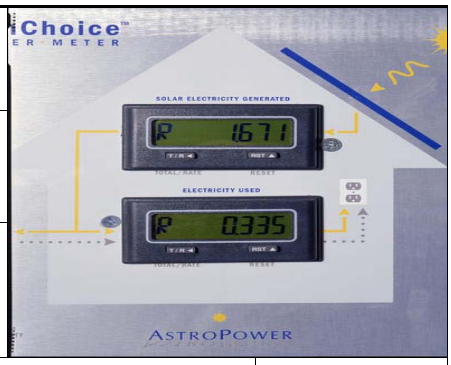


Source: http://www.nrel.gov/data/pix/Jpegs/10544.jpg

Inverters are sophisticated electronic devices, and account for a large part of the balance of system cost in grid-connected PV systems. They must be able to synchronize to the grid and meet interconnection requirements, as well as provide power to AC equipment such as appliances in a typical residential installation.

Meter

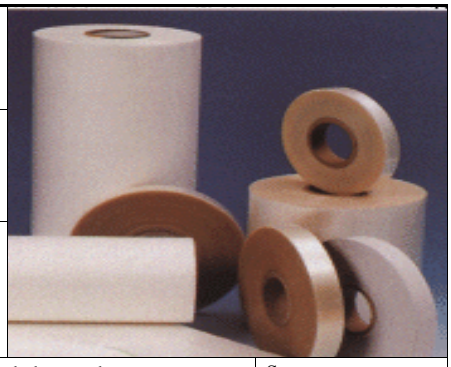
NAICS Codes:	NAICS Descriptions:
Subsector Code: 334	Computer and Electronic Product Manufacturing
Industry Code: 334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals
Detailed Code: 3345151105	Integrating instruments, electrical, demand meters, kW and kVA, combined watt-hour and demand meters (single phase and polyphase)
Description of Subcomponent:	The meter is used particularly in grid connected systems to track the amount of energy produced by the PV system.



Source: http://www.nrel.gov/data/pix/Jpegs/12244.jpg

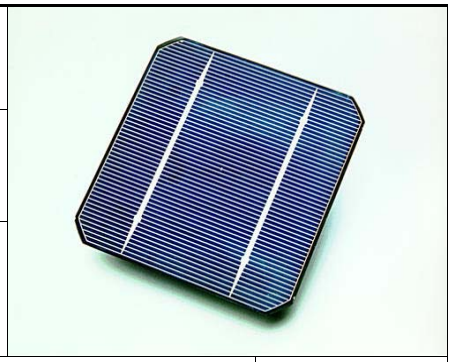
Some systems interface through a customer's existing utility meter, while others have additional equipment to display or report additional information or meet utility requirements.

Rear Layer

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 326	Plastics and Rubber Products Manufacturing	
Industry Code: 326113	Unlaminated Plastics Film and Sheet (Except Packaging) Manufacturing	
Detailed Code: 3261130453	Other unlaminated plastics film and sheet	
Description of Subcomponent:	The rear layer protects the back surface of the module, and prevents water and gases from entering the module.	Source: http://www.fluortek.se/Old%20homepage/bilder/tedlarg.gif

The rear layer must have low thermal resistance because the cell loses efficiency if its temperature is raised. Tedlar (a thin polymer sheet) is a common material for the rear layer.

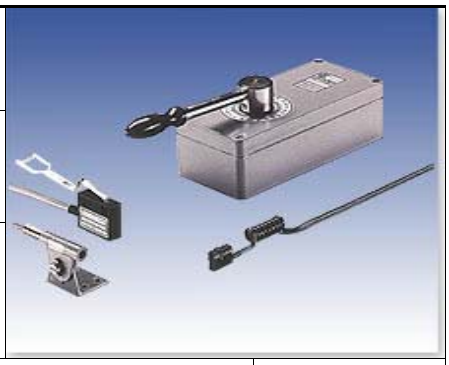
Solar cells

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 334	Computer and Electronic Product Manufacturing	
Industry Code: 334413	Semiconductors and Related Devices	
Detailed Code: 334413A005	Solar cells	
Description of Subcomponent:	A photovoltaic cell is any device that transforms light energy into electric energy. Current cells consist primarily of a semiconductor material, in which photons are absorbed from the incoming light to create free electrons.	Source: http://www.nrel.gov/data/pix/Jpegs/04065.jpg

Silicon solar cells are currently the most common, and can be single-crystal or multicrystalline. Single crystal silicon cells are the oldest commercial technology, and also the most efficient. Multicrystalline cells are less efficient due to grain boundaries between crystals blocking electron flow, but are also cheaper to produce. Amorphous silicon cells can be made in a thin, flexible film, making them ideal for building-integrated applications. They are less efficient than crystalline cells, and experience an initial decrease in performance, which later stabilizes. Thin-film cells made from copper indium diselenide (CIS) or cadmium telluride (CdTe) are also coming into use, because thin-film deposition can potentially be cheaper than silicon ingot growth. Several companies are also developing organic solar cells made using a dye-sensitizing process, or made from semiconducting polymers.

Switch Gear

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335931	Current-Carrying Wiring Device Manufacturing
Detailed Code: 3359315100	Current-carrying switches for electrical circuitry (including vehicular switches)
Description of Subcomponent:	A number of switches are used to open and close the route that the electricity can flow through. Allows components of the system to be disconnected from one another.



Source: http://www.asa-schalttechnik.de/jpgs/prod_spe.jpg

The switches are important in order to disconnect the PV system from the grid when utility contractors are working on the grid line, to avoid risk of electrocution.

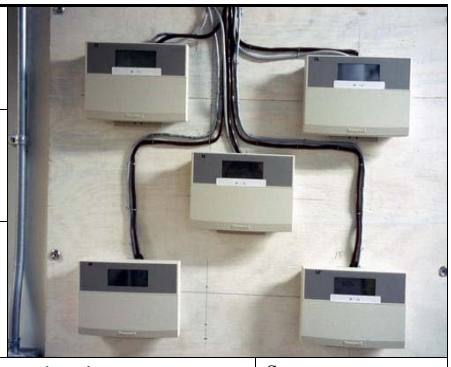
Top surface

NAICS Codes:	NAICS Descriptions:
Subsector Code: 327	Nonmetallic Mineral Product Manufacturing
Industry Code: 327211	Flat Glass
Detailed Code: 3272111041	Flat glass, nonautomotive, other than pyrolytically coated, clear, less than 5.0 mm thick
Description of Subcomponent:	The top surface allows light to enter the cell, while protecting the delicate cells from damage.

Source: http://www.sunarc.net/englisch/images/AR_Model01.jpg

Based on the materials used for the cell, the necessary wavelengths need to be able to pass through the top surface. Reflection from the top surface should be minimized either by adding texture to the material, or adding an antireflection coating. The top cover needs to be resistant to weather damage including rain, hail, strong winds and ultraviolet radiation and needs to be strong enough to protect the inside of the module from damage. Generally made of glass or plastic.

Wiring

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 331	Primary Metal Manufacturing	
Industry Code: 331422	Copper Wire (except Mechanical) Drawing	
Detailed Code: 3314224218	Copper apparatus wire and cord and flexible cord sets (except wiring harnesses and fiber optic), made in plants that draw wire	
Description of Subcomponent:	Wiring is necessary for connecting the modules together into an array, and connecting the PV system to the utility grid or battery and load and controlling the movement of electricity.	Source: http://www.nrel.gov/data/pix/Jpegs/13159.jpg

Geothermal Components

Accumulator

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332420	Metal Tank (Heavy Gauge) Manufacturing
Detailed Code: 3324209111	Other pressure tanks (including anhydrous ammonia tanks), ferrous and nonferrous metal, complete at factory (standard line pressure)
Description of Subcomponent:	In a binary plant, the accumulator stores a quantity of working fluid in order to damp out pressure fluctuations and handle changes in flow rate.

Source: http://www.unionsteel.co.kr/unihap/const/camera/4ccl/2001-

Typically a pressurized, steel vessel, 5,000 to 30,000 gallons depending on the capacity of the power plant and other variables.

Air-cooled Condenser

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333412	Industrial and Commercial fans and blowers
Detailed Code: 3334120573	Industrial propeller fans directly connected to driver
Description of Subcomponent:	In most binary plants, a large radiator with forced-air convection provides cooling for the condensers.

Source: http://www.geothermal.marin.org/GEOpresentation/images/

Due to the lower temperatures of a binary plant, it is often more cost-effective to use air-cooling rather than evaporative cooling. The working fluid is sent through an array of horizontally-mounted radiator and fan units that blow air vertically over the radiators.

Brine injection pump

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 333	Machinery Manufacturing	
Industry Code: 333911	Pump and Pumping Equipment Manufacturing	
Detailed Code: 333911148M	All other centrifugal pumps, over 6 in. discharge	
Description of Subcomponent:	The brine injection pump injects excess condensate and brine into the injection well at the pressure of the reservoir, in order to preserve the life of the reservoir.	Source: http://www.johnson-pump.com/

The brine injection pump is a centrifugal pump, but may have to be made of a special alloy to handle the corrosive brine.

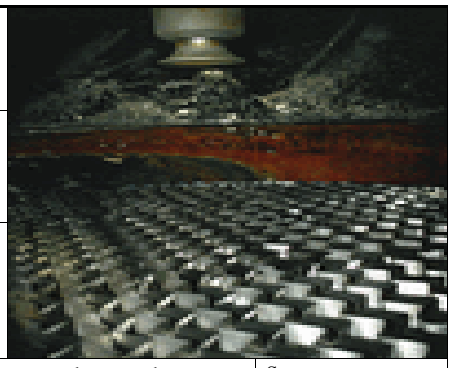
Condensate Pump

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 333	Machinery Manufacturing	
Industry Code: 333911	Pump and Pumping Equipment Manufacturing	
Detailed Code: 333911148M	All other centrifugal pumps, over 6 in. discharge	
Description of Subcomponent:	The condensate pump pumps condensed geothermal fluid to the cooling tower to makeup lost cooling water.	Source: http://www.johnson-pump.com/

This pump is a centrifugal pump.

Condenser

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324101311	Fabricated steam condensers (except nuclear applications)



Description of Subcomponent:	After expansion through the turbine, the condensor condenses the working or geothermal fluid to liquid phase. This creates a vacuum in the condenser, which improves the work output of the turbine.	Source: http://www.nrel.gov/data/pix/Gifs/01573.gif

Can be either "barometric" or "surface" type. In the barometric variety, cold water from the cooling tower is sprayed directly into the steam flow coming from the turbine, causing it to cool and condense to a liquid. The cooling water plus the condensate are pumped from the bottom of the condenser. The surface type is a shell-and-tube heat exchanger, with cooling water in tubes within a shell containing the steam. The steam condenses on contact with the cooled tubes, but the fluid streams do not mix.

Cooling water pumps

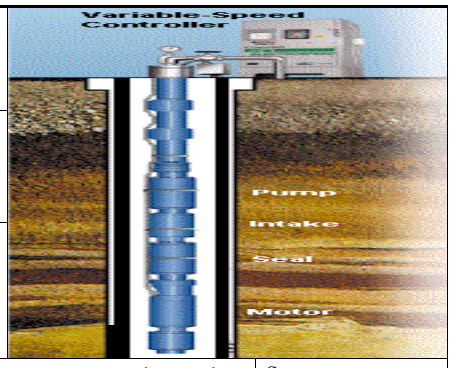
NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 333911148M	All other centrifugal pumps, over 6 in. discharge

Description of Subcomponent:	Circulating water pumps circulate cooling water in an evaporative cooling system, and a cooling water makeup pump replaces water that evaporates.	Source: http://www.johnson-pump.com/

Binary plants with an air cooled condenser (rather than an evaporative cooling tower) do not have a circulating cooling water pump. These pumps are typically centrifugal pumps.

Downhole Pump

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 3339111484	Centrifugal pumps, propeller and mixed flow, horizontal and vertical (including vertical turbine over 36 in.), over 36 in.
Description of Subcomponent:	Downhole pumps are used in binary cycle plants to pump geothermal fluid out of the well.



Source: http://www.bakerhughes.com/centrilift/images/photos/New

Downhole pumps are required in lower temperature binary applications where the geothermal fluid does not have sufficient energy to self-flow. They are also used in applications where flashing of the geothermal fluid must be avoided, for example to prevent well sealing. In the past, pumps have typically been line-shaft pumps (with the motor above ground connected by a shaft to the pump), but recent improvements in submersible pumps have increased their use.

Evaporative Cooling Tower

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing
Detailed Code: 3334159121	Evaporative air coolers
Description of Subcomponent:	The cooling tower cools hot water coming from the condenser so it can be returned for re-use as cooling water.

Source: http://www.eere.energy.gov/geothermal/images/photo_07658.

Hot water coming from the outlet of the condenser is sprayed from nozzles, and a fan blows air through the spray. Some of the water evaporates, cooling the remaining liquid, which collects in a pool at the bottom and is pumped back to the condenser.

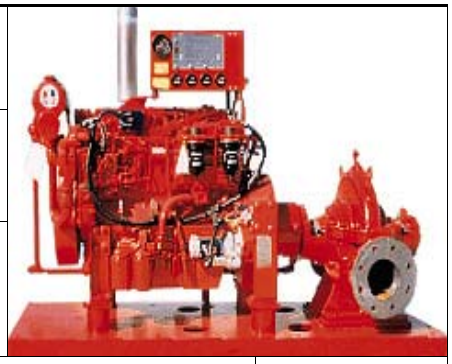
Evaporator

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324101206	Fabricated fin tube industrial heat exchangers, closed types (except nuclear applications)
Description of Subcomponent:	The evaporator, or vaporiser, evaporates the working fluid in a binary plant.
Source:	

This is typically a shell-and-tube heat exchanger, with hot geothermal fluid flowing through tubes within a shell, which contains the working fluid.

Fire Water Pump

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 333911148M	All other centrifugal pumps, over 6 in. discharge
Description of Subcomponent:	The fire water pump pumps pressurized water to the fire suppression sprinkler system.
Source:	http://www.gormanrupp.com/products/pat/images/fire1pic.jpg



The power plant buildings in a geothermal plant are required to have a fire suppression system of the overhead sprinkler type found in many buildings. Because the plants are typically not connected to a utility water system, a pump and tank is required to provide water for the fire system.

Flash vessel

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332420	Metal Tank (Heavy Gauge) Manufacturing
Detailed Code: 332420E106	Ferrous metal pressure tanks and vessels (more than 24 inch outside diameter and not less than 5 cu ft capacity), custom fabricated at the factory, for other processing industries
Description of Subcomponent:	The flash vessel flashes some of the liquid fluid into steam by means of a sudden pressure drop.

Source: http://www.stelform.com.au/Thumbs/pv01_small4.jpg

It is a metal pressure vessel with an inlet for the two-phase fluid, an outlet at the top for steam, and an outlet on the bottom for brine. The incoming fluid expands to a lower pressure in the vessel, causing some of the fluid to flash to steam.

Gantry Crane

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing
Detailed Code: 3339233116	Gantry type overhead traveling cranes (except construction power cranes)
Description of Subcomponent:	An overhead crane travels on the roof of the plant to lift and move heavy equipment.

Source: http://www.americancrane.com/assets/P0001932-sm.jpg

The overhead gantry crane is essential in installing the heavy turbine-generator equipment in the power plant, as well as during operation and maintenance throughout the lifetime of the plant.

Piping

NAICS Codes:	NAICS Descriptions:
Subsector Code: 331	Primary Metal Manufacturing
Industry Code: 331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel
Detailed Code: 33121001H0	Alloy steel pipe and tubes, miscellaneous (including standard and structural)
Description of Subcomponent:	The piping carries various fluids around the plant, including steam, brine, cooling water, and the working fluid in a binary plant.

Source: http://www.nrel.gov/data/pix/Jpegs/07208.jpg

Geothermal steam contains corrosive gases, and the pipes must be designed to withstand it. Often nickel-alloy or concrete-lined steel pipe is used.

Silencer

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333132	Oil and Gas Field Machinery and Equipment Manufacturing
Detailed Code: 3331325101	Oil and gas field production well Christmas tree assemblies (excluding subsea)
Description of Subcomponent:	The silencer reduces noise due to the rapid expansion of steam to the atmosphere.

Source: http://e-trade.ktc.ksrp.or.jp/en/seeds/kitakyu/ima

To start up the well before diverting fluid to the production lines, the well is vented to atmosphere through a silencer. Silencers are typically rock mufflers - a steel or concrete chamber filled with rock.

Steam cyclone separator

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332420	Metal Tank (Heavy Gauge) Manufacturing
Detailed Code: 332420E106	Ferrous metal pressure tanks and vessels (more than 24 inch outside diameter and not less than 5 cu ft capacity), custom fabricated at the factory, for other processing industries
Description of Subcomponent:	The steam separator centrifugally separates liquid and steam from two-phase geothermal fluid

Source: http://www.hydro-carbon.nl/img/cyclone/cyclone-2-

The fluid is injected tangentially into a cylindrical vessel, the liquid phase centrifuges to the outer wall and flows to the bottom Low pressure created in the center of the vortex, causing the steam to flash and rise to the top, where it is withdrawn.

Steam-jet Ejectors

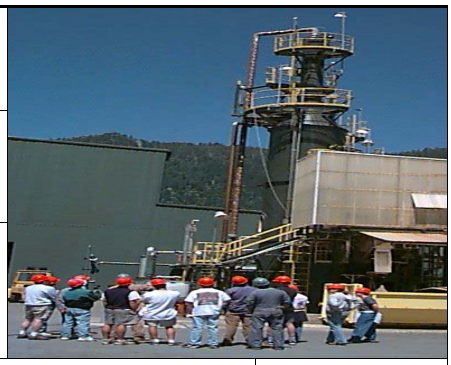
NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333912	Air and Gas Compressor Manufacturing
Detailed Code: 3339121220	Vacuum pumps (compressors) (including value of the driver if shipped as a complete unit), except laboratory
Description of Subcomponent:	The steam-jet ejectors remove noncondensable gases that would otherwise accumulate in the condenser.

Source: http://www.artisanind.com/images/ejector_20.jpg

Because the condenser operates at a vacuum, a lower vacuum must be created to extract the NCGs. High pressure steam extracted upstream of the turbine is accelerated through a nozzle in the steam-jet ejector, creating a vacuum and entraining NCGs from the condenser. The steam/NCG mixture is then diffused to high pressure again, and usually condensed.

Sulfur Plant

NAICS Codes:	NAICS Descriptions:
Subsector Code: xxx	No Description Available
Industry Code: xxxxxx	No NAICS Description
Detailed Code:	



Description of Subcomponent:	The sulfur plant removes excess hydrogen sulfide from the NCG exhaust stream to comply with emmission standards.	Source: http://ekofisk.stanford.edu/geysers99/07.jpg

Liquid redox sulfur plants are commonly used in geothermal plants because they are optimal for the low concentrations of H2S found in geothermal plant exhaust. The most common type of liquid redox is "chelated iron redox" in which ferric iron ions are held in solution by chelating agents and serve as electron donors and acceptors in the hydrogen sulfide redox reaction. This process is also desirable because it is efficient and produces innocuous byproducts.

Turbine Generator Set

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333611	Turbines, and Turbine Generators, and Turbine Generator Sets
Detailed Code: 3336110101	Turbine generator sets

Description of Subcomponent:	The turbine generator extracts energy from the geothermal fluid (or the working fluid in a binary cycle plant) by expansion through a series of blades.	Source: http://www.geothermal.marin.org/GEOpresentation/images/

Turbines consist of a series of blades that are made to rotate as the vapor expands through them. Steam turbines must be made of materials that can handle the corrosive gases, adding to their cost and complexity. In a dual-flash geothermal plant, the turbine will often have two inlets, one at the first stage of the turbine for the high pressure steam, and one at a later stage for lower pressure steam from the second flash system. In a binary plant, the turbine is designed for the working fluid that has been chosen, usually an organic hydrocarbon in an organic Rankine cycle plant, or an ammonia-water mixture for the Kalina cycle.

Vacuum Pump

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 333	Machinery Manufacturing	
Industry Code: 333912	Air and Gas Compressor Manufacturing	
Detailed Code: 3339121277	Vacuum pumps (excluding laboratory), high vacuum, 29.6 in. mercury vacuum and over, 5 hp and over	
Description of Subcomponent:	In cases where a steam-jet ejector is not practical, a vacuum pump is used to remove noncondensable gases from the condenser.	Source: http://www.zbbz.com/en/images/cpzs/2bv2061.jpg

Well casing

NAICS Codes:	NAICS Descriptions:	
Subsector Code: 331	Primary Metal Manufacturing	
Industry Code: 331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	
Detailed Code: 33121001H0	Alloy steel pipe and tubes, miscellaneous (including standard and structural)	
Description of Subcomponent:	The well casing is inserted into the well bore to provide structure and stability to the well hole.	Source:

For most geothermal applications, this is a welded steel pipe that forms the structural wall of the well bore.

Wellhead valves and controls

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333132	Oil and Gas Field Machinery and Equipment Manufacturing
Detailed Code: 3331325101	Oil and gas field production well Christmas tree assemblies (excluding subsea)
Description of Subcomponent:	The wellhead assembly controls pressure and flow of the fluid exiting the geothermal well.

Source: http://www.geothermal.marin.org/GEOpresentation/images/

It is a collection of manual and automatic valves mounted to the head of the surface casing, consisting of master valve, crown valve, and side/wing valves.

Working Fluid Pump

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 3339111484	Centrifugal pumps, propeller and mixed flow, horizontal and vertical (including vertical turbine over 36 in.), over 36 in.
Description of Subcomponent:	In a binary plant, the working fluid pump pumps the condensed working fluid from the condenser back through the vaporizers.

Source: http://www.nrel.gov/data/pix/Jpegs/02209.jpg

These are typically vertical/can type pumps.

Biomass Components

Air Compressors

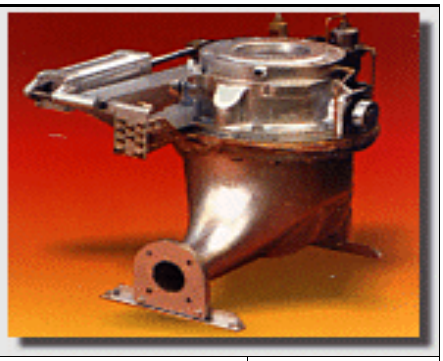
NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333912	Air and Gas Compressor Manufacturing
Detailed Code: 3339121166	Air compressors, new, stationary, centrifugal and axial
Description of Subcomponent:	Air compressors provide pressurized air as required for various processes around the plant.

Source: http://www.meco-equipment.com/images/air-compressors-

These are typically large, diesel-engine driven compressor units.

Ash Handling System

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333922	Conveyor and Conveying Equipment Manufacturing
Detailed Code: 3339228316	Bulk material handling pneumatic conveyors and conveying systems, except
Description of Subcomponent:	The ash handling system collects ash from the precipitator and the boiler and transfers it to a storage location where it awaits removal from the plant.



Source: http://www.mecgale.com/flyash.html

Most of the ash is captured from the exhaust stream by the precipitator and/or cyclone. A large blower supplies sufficient air to convey the ash pneumatically from the precipitator and keep it fluidized as it flows through ducts to the storage location. Ash from the boiler is removed by a mechanical conveyor, either screw-type or drag-chain.

Boiler Equipment

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324105126	Water tube steel power boilers (stationary and marine), more than 15 p.s.i. steam working pressure, 100,001 lb per hour or more, saturated (except nuclear applications)

Description of Subcomponent:	The boiler is the place where the biomass is burned, causing incoming water to boil and create steam.	Source: http://www.becllcusa.com/5_steam_boiler.html

There are many different boiler designs, but the most common for biomass plants is a "spreader-stoker" boiler. A stoker, either mechanical or pneumatic, distributes the fuel as evenly as possible onto a grate, where the flame is sustained. Then a spreading mechanism, often either a traveling grate or a vibrating grate works to further distribute the fuel as well as to assist in ash removal. Overfire air is injected into the flue above the grate to ensure that all of the fuel is combusted. Heat and exhaust gases rise and flow over an array of tubes carrying the feedwater, which boils as a result of the heat transfer.

Boiler Feed Pumps

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 333911146H	Centrifugal pumps, multistage, single or double suction, volute or diffuser design, axially split case, over 8 in. discharge

Description of Subcomponent:	The boiler feed pumps pump water through the feedwater heaters and into the boiler.	Source: http://www.stiweb.com/applications/images/boiler_feed_pu

These pumps are typically multi-stage centrifugal pumps. Reliability is of particular importance as these pumps must run continously at high flow rates during the operation of the plant, and a failure of a feed pump could cause the plant to shut down temporarily.

Boiler Feedwater System

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332911	Industrial Valve Manufacturing
Detailed Code:	

Description of Subcomponent:	The boiler feedwater system controls the supply of water to the boiler to create steam.	Source: http://www.becllcusa.com/6_feed_water_pumps.html

If the water level in the boiler becomes too low, the boiler is in danger of overheating and will shutdown. The feedwater system automatically monitors the water level in the boiler and adjusts the flow rate of the feedwater pumps to ensure a constant water level.

Boiler Feedwater Tank

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332420	Metal Tank (Heavy Gauge) Manufacturing
Detailed Code: 332420C121	Other ferrous metal nonpressure storage tanks, complete at factory (including tanks for trailers, metal septic tanks, etc.)

Description of Subcomponent:	The feedwater tank stores the water that is supplied to the boiler to create steam.	Source: http://www.becllcusa.com/newsite/7_feed_water_storage.htm

The tank must be sized large enough to ensure that sufficient water can be supplied for continuous operation of the plant.

Boiler House Feed Conveyor

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333922	Conveyor and Conveying Equipment Manufacturing
Detailed Code: 3339228101	Bulk material handling belt conveyors and conveying systems, except hoists and farm elevators
Description of Subcomponent:	The boiler house conveyor transfers biomass fuel into the boiler.

Source: http://www.gtsenergy.com/products/solid_fuel/wood_fired.as

Like the reclaim conveyor, this conveyor is also typically a belt-type continuous feed system.

Breeching and Precipitator

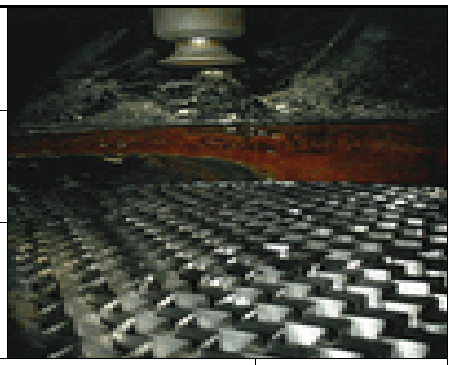
NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333411	Air Purification Equipment Manufacturing
Detailed Code: 3334111110	Dust collection and other air purification equipment for industrial gas cleaning systems (for cleaning outgoing air), except parts
Description of Subcomponent:	The breeching carries the flue gas out of the boiler, while the precipitator removes ash and other particulates from the gas.

Source: http://www.tri-mer.com/images/ccs-vs-electrostatic-

The electrostatic precipitator is a pollution control device designed to remove particulates without creating a flow restriction like a filter would. It functions by creating an electrostatic field in the breeching which attracts particles to the electrode, which then flow by gravity into a collection bin.

Condenser

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324101311	Fabricated steam condensers (except nuclear applications)
Description of Subcomponent:	The condenser cools the steam exiting the turbine, causing to condense back to a liquid phase.



Source: http://www.nrel.gov/data/pix/Gifs/01573.gif

Condensing the steam after the turbine creates a vacuum in the condenser downstream of the turbine, allowing more energy extraction from the turbine. The condenser is essentially just a heat exchanger, transfering heat from the steam to the cooling water, which is then either re-cooled in a cooling tower, or returned to a source such as a river or lake.

Cooling Tower

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing
Detailed Code: 3334159121	Evaporative air coolers
Description of Subcomponent:	The cooling tower cools hot water coming from the condenser so it can be returned for re-use as cooling water.

Source: http://www.nrel.gov/data/pix/Jpegs/06875.jpg

Hot water coming from the outlet of the condenser is sprayed from nozzles, and a fan blows air through the spray. Some of the water evaporates, cooling the remaining liquid, which collects in a pool at the bottom and is pumped back to the condenser.

Deaerating Feedwater Heater

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324101101	Fabricated bar tube industrial heat exchangers, closed types (except nuclear applications)

Description of Subcomponent:	The deaerating feedwater heater removes noncondensable gases such as oxygen and carbon dioxide from the boiler feedwater.	Source: http://www.wabashpower.com/deaerator3.html

Noncondensable gases can cause corrosion in pumps and piping if it is not removed. The deaerator works by spraying the water into a thin film and then heating to near the steam temperature. This causes the gases to come out of the liquid, without losing very much of the water to steam.

Draft Equipment

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333412	Industrial and Commercial fans and blowers
Detailed Code:	

Description of Subcomponent:	Source: http://www.gravitaexim.com/Airpollution.htm

Dumper Hydraulic Unit

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333995	Fluid Power Cylinder and Actuator Manufacturing
Detailed Code: 3339951100	Nonaerospace type hydraulic fluid power cylinders and actuators, linear and rotary
Description of Subcomponent:	The dumper unit lifts the entire truck carrying a load of biomass fuel, causing the biomass to dump off the back of the truck.

Source: http://www.goldbell.com/chanpin/images/zcs-30-yfz.gif

This unit provides a quick and easy method of unloading incoming biomass supply from trucks.

Equipment Insulation

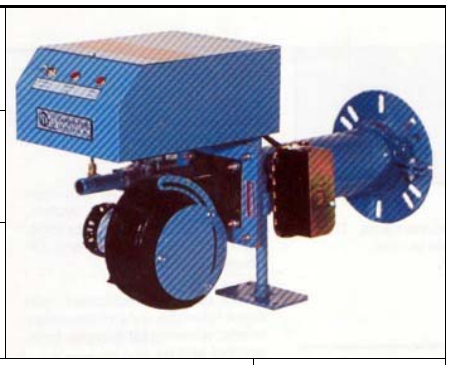
NAICS Codes:	NAICS Descriptions:
Subsector Code: 327	Nonmetallic Mineral Product Manufacturing
Industry Code: 327993	Mineral Wool Manufacturing
Detailed Code: 3279934321	Mineral wool for industrial, equipment, and appliance pipe insulation
Description of Subcomponent:	Most equipment and piping in the plant carrying high-temperature steam is insulated to reduce heat loss and improve the efficiency of the plant.

Source: http://www.koivet.com/heating/insulation2.jpg

Glass or mineral wool is a common material for the insulation.

Forced Draft Fan

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333412	Industrial and Commercial fans and blowers
Detailed Code: 3334120324	Industrial centrifugal fans, excluding blowers, turboblowers, and multistage blowers

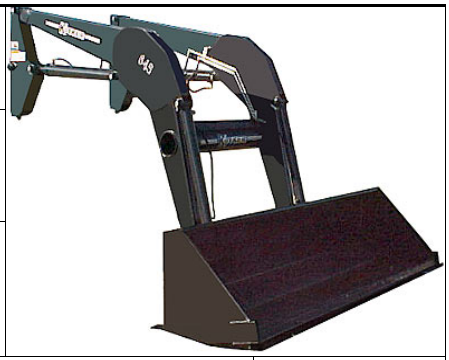


Description of Subcomponent:	The draft fan forces air into the boiler to provide oxygen for combustion of the biomass fuel.	Source: http://www.wichitaburner.com/images/forceddraftgasburner.J

The fan is typically a large centrifugal blower. It must be sized appropriately to deliver the needed amount of air to complete the combustion process in the boiler.

Front End Loaders

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333120	Construction Machinery Manufacturing
Detailed Code: 3331201479	Wheel loaders, rear engine mount, integral design, 4-wheel drive, non-skid steer, 150 to 249 NEHP



Description of Subcomponent:	Front end loaders are used to move biomass fuel into the storage pile.	Source: http://www.free-tractor-manuals.com/consu

They are common construction-site equipment, essentially a tractor with a hydraulically activitated bucket mounted on the front.

High Pressure Feedwater Heaters

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324101101	Fabricated bar tube industrial heat exchangers, closed types (except nuclear applications)
Description of Subcomponent:	The high pressure feedwater heater transfers heat from the steam exiting the high-pressure turbine stage into the feedwater.

Source: http://www.khei.com/product_tubular.html

Capturing excess heat from the turbine exhaust to raise the feedwater temperature reduces the heat required in the boiler to create steam, thus increasing the plant efficiency. The feedwater heater itself is a shell and tube heat exchanger, designed to handle the high-pressure steam.

Induced Draft Fan

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333412	Industrial and Commercial fans and blowers
Detailed Code: 3334120324	Industrial centrifugal fans, excluding blowers, turboblowers, and multistage blowers
Description of Subcomponent:	

Source: http://www.alternateheatingsystems.com/woodboilers.htm

Instrumentation

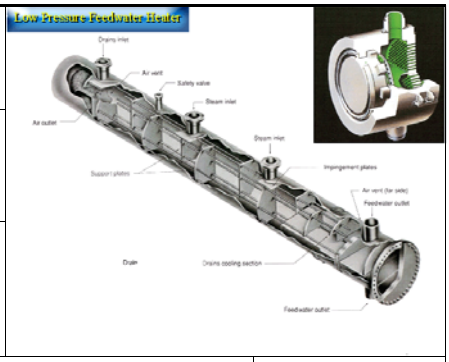
NAICS Codes:	NAICS Descriptions:
Subsector Code: 334	Computer and Electronic Product Manufacturing
Industry Code: 334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
Detailed Code: 3345130100	Process control instruments
Description of Subcomponent:	An array of instruments monitor and report to the operator of the plant the status of each component, and allow control of the plant.

Source: http://www.nrel.gov/data/pix/Jpegs/03818.jpg

Instrumentation could include pressure and temperature sensors, flow-rate sensors, and power meters, as well as controls for the boiler, the turbine generator and electrical equipment, and the various pumps and valves to control fluid flow.

Low Pressure Feedwater Heaters

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332410	Power Boiler and Heat Exchanger Manufacturing
Detailed Code: 3324101101	Fabricated bar tube industrial heat exchangers, closed types (except nuclear applications)
Description of Subcomponent:	Similar to the high pressure feedwater heater, the low-pressure feedwater heater transfers heat from the steam exiting the low-pressure turbine stage into the feedwater.



Source: http://www.khei.com/images/Low-pressure-feedwater-

This heater is also a heat exchanger, but is simpler in design due to the lower pressure requirements.

Main Transformer

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335311	Power, Distribution, and Specialty Transformer Manufacturing
Detailed Code: 3353117111	Commercial, institutional, and industrial general-purpose transformers, single- and three-phase, 100.01 kVA and above, all voltages
Description of Subcomponent:	The main transformer steps up the voltage output of the power plant to match the high voltage of the transmission grid.

Source: http://science.howstuffworks.com/power.htm/printable

The transformer consists of an array of coils that step up the voltage from the 100s of volts range at which generators operate, to the 10 kV up to 100s of kVs at which transmission grids operate.

Oil Burning Equipment

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333414	Heating Equipment (except Warm Air Furnaces) Manufacturing
Detailed Code: 333414A101	Oil burners
Description of Subcomponent:	The oil burner is used to start up the boiler after it has been shut down.

Source: http://www.alternateheatingsystems.com/woodboilers.htm

One or more oil burners located beneath the boiler grate create a flame in order to ignite the biomass during the initial start-up phase of boiler operation, and also to ensure that the entire boiler area is evenly ignited.

Oil Storage Tank

NAICS Codes:	NAICS Descriptions:
Subsector Code: 332	Fabricated Metal Product Manufacturing
Industry Code: 332420	Metal Tank (Heavy Gauge) Manufacturing
Detailed Code: 332420C121	Other ferrous metal nonpressure storage tanks, complete at factory (including tanks for trailers, metal septic tanks, etc.)
Description of Subcomponent:	The oil storage tank stores fuel oil for various uses in the plant.

Source: http://www.agrium.com/investmentrecovery/4404.jsp

It is a simple, unpressurized steel or aluminum tank.

Other Water Pumps

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 333911146H	Centrifugal pumps, multistage, single or double suction, volute or diffuser design, axially split case, over 8 in. discharge units
Description of Subcomponent:	Besides the main feedwater pumps, various other water pumps pump condensate from the condenser back to the beginning of the cycle, transfer make-up water from the supply source, provide service water, and circulate water at various points in the plant.

Source: http://www.americanlewa.com/PR-Condensate.htm

All of these pumps are typically multi-stage centrifugal pumps, with the drive motor attached directly to the pump.

Piping

NAICS Codes:	NAICS Descriptions:
Subsector Code: 331	Primary Metal Manufacturing
Industry Code: 331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel
Detailed Code: 3312100100	Iron and steel pipes and tubes, made from purchased iron and steel
Description of Subcomponent:	Piping carries steam and water between the various components of the plant.

Source: http://www.nrel.gov/data/pix/Jpegs/07708.jpg

Almost all of the piping in the plant will be some type of steel, with some variation in thickness and type of alloy, depending on the pressure and temperature requirements of that particular section of piping.

Reclaim Conveyor

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333922	Conveyor and Conveying Equipment Manufacturing
Detailed Code: 3339228101	Bulk material handling belt conveyors and conveying systems, except hoists and farm elevators
Description of Subcomponent:	The reclaim conveyor transfers biomass fuel from the storage pile to the power plant.

Source: http://www.nrel.gov/data/pix/Jpegs/03820.jpg

The conveyor is a belt-type continuous conveyer.

Switchgear

NAICS Codes:	NAICS Descriptions:
Subsector Code: 335	Electrical Equipment, Appliance, and Component Manufacturing
Industry Code: 335313	Switchgear and Switchboard Apparatus Manufacturing
Detailed Code: 335313A101	Switchgear (except ducts), automatic and manual control panels (generators, transformers, feed-controls, etc.)
Description of Subcomponent:	The switchgear connects the power plant to the transformer, and the transformer to the grid.

Source: http://www.buhlerusa.com/AEWeb/Graphics/switchgear.jpg

The switchgear consists of manual and automatic switches and circuit breakers to isolate the plant components from the grid for maintenance, when the plant is not operating, or in case of a grid fault or other failure.

Truck Scale

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333997	Scale and Balance (except Laboratory) Manufacturing
Detailed Code: 3339971101	Motor truck scales
Description of Subcomponent:	The truck scale is used to quantify the amount of biomass fuel being delivered to the plant by truck.

Source: http://www.samhing.com.hk/Truck.htm

Trucks are weighed full when entering the plant, and then weighed empty upon leaving, the difference being equal to the mass of fuel delivered. This allows the plant to keep track of deliveries and to pay the suppliers for the fuel.

Turbine Generator

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333611	Turbines, and Turbine Generators, and Turbine Generator Sets
Detailed Code: 3336110101	Turbine generator sets
Description of Subcomponent:	Steam expands and cools as it passes through a series of turbine blades, causing the turbine to rotate. The generator converts this rotational energy into electricity.

Source: http://www.becllcusa.com/10_steam_turbine_generators.htm

The turbine often has a high-pressure stage and a low pressure stage, with steam being fed to the feedwater pre-heaters in between stages. The final turbine stage feeds into the condensor, which is well below atmospheric pressure. The turbine is connected by a shaft to the generator, which is designed to run at a fixed RPM, in order to generate AC electricity that is in sync with the electric grid.

Turbine Overhead Crane

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing
Detailed Code: 3339233116	Gantry type overhead traveling cranes (except construction power cranes)
Description of Subcomponent:	The overhead crane travels on the roof of the plant to lift and move heavy equipment.

Source: http://www.americancrane.com/assets/P0001932-sm.jpg

The overhead gantry crane is essential in installing the heavy turbine-generator equipment in the power plant, as well as during operation and maintenance throughout the lifetime of the plant.

Water Purification

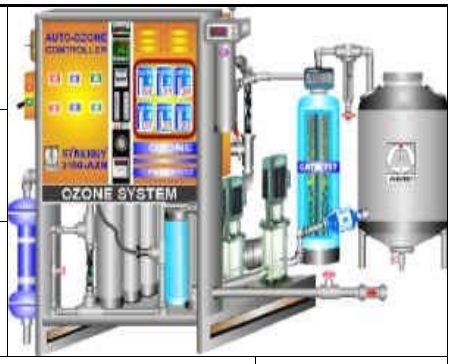
NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333999	All Other Miscellaneous General Purpose Machinery Manufacturing
Detailed Code: 3339991104	Filter and strainer assemblies (containment or housing devices), with or without filter element installed, for water; except parts and accessories (except for fluid power systems)
Description of Subcomponent:	The water purification system filters and purifies the water as it comes into the plant.

Source: http://www.becllcusa.com/9_feed_water_treatment.html

Particulates and other matter in the incoming water could damage pumps and other equipment over time. The water purification system prevents this by filtering out particles over a certain size from the incoming water stream.

Well Water Supply System

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333911	Pump and Pumping Equipment Manufacturing
Detailed Code: 3339111440	Industrial pumps, except hydraulic fluid power pumps, automotive circulating pumps, and measuring and dispensing pumps
Description of Subcomponent:	The well water system supplies make-up water to replace water lost to evaporation in the cooling tower.

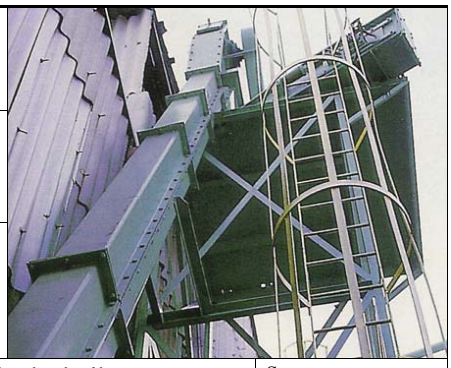


Source: http://www.agioabadi.com/images/well_water1.jpg

This system consists primarily of a pump and piping to carry the water into the plant. A plant located on a river or lake would likely have a water supply system from the river or lake rather than from a well.

Wood Handling

NAICS Codes:	NAICS Descriptions:
Subsector Code: 333	Machinery Manufacturing
Industry Code: 333210	Sawmill and Woodworking Machinery Manufacturing
Detailed Code: 3332103126	Other woodworking sawmill equipment
Description of Subcomponent:	The wood handling system prepares fuel for use in the boiler.



Source: http://www.ec21.com/company/s/seungwoon/upimg/Wood_

The extent of the wood handling system depends on the quality of the fuel supply. For many plants, wood chips are provided in a form that is already almost ready for use. A grinding or hogging machine may be used to grind up oversized chips, and a magnet is used to remove stray metal.

Woodchip Railcars

NAICS Codes:	NAICS Descriptions:
Subsector Code: 336	Transportation Equipment Manufacturing
Industry Code: 336510	Railroad Rolling Stock Manufacturing
Detailed Code: 3365103100	Freight train and passenger train cars, new (excluding parts)
Description of Subcomponent:	In some biomass plants, fuel is delivered via railcars.

Source: http://www.portofgraysharbor.com/photos/Train_WoodChip

The woodchip railcars are typically have an open top and enclosed sides, such as the kind also used for carrying gravel, coal or other bulk solids. This type of railroad car is also sometimes referred to as a "gondola" type car.

Appendix B – Complete List of Results for Michigan Counties

Appendix B consists of two tables listing all of the counties in Michigan. The first table lists the number of firms operating in all relevant NAICS codes in each county, as well as the amount of manufacturing investment for each county that would result from the national development of each technology. The second table lists the firms in relevant NAICS codes again, and then shows the amount of job creation for each county resulting from the national development of each technology.

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Investment County Table B2
Jobs County Table B4

Location	# of Firms	Millions $ Wind	Millions $ Solar	Millions $ Geothermal	Millions $ Biomass	Total Millions $
Alcona, MI	2	$0.2	$0.0	$0.0	$0.0	$0.2
Alger, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Allegan, MI	37	$42.5	$28.3	$1.7	$2.0	$74.5
Alpena, MI	7	$14.4	$0.0	$0.0	$2.9	$17.3
Antrim, MI	4	$0.0	$0.0	$0.7	$1.1	$1.8
Arenac, MI	4	$2.4	$0.0	$0.0	$0.8	$3.2
Baraga, MI	8	$0.4	$0.0	$0.0	$0.3	$0.7
Barry, MI	10	$3.7	$0.9	$0.0	$4.2	$8.8
Bay, MI	11	$8.6	$7.2	$0.0	$5.4	$21.2
Benzie, MI	7	$5.0	$12.6	$0.0	$0.2	$17.8
Berrien, MI	62	$52.7	$6.2	$66.4	$13.5	$138.8
Branch, MI	13	$26.4	$0.5	$1.1	$0.3	$28.3
Calhoun, MI	33	$80.8	$3.0	$9.5	$2.7	$96.0
Cass, MI	10	$10.9	$0.1	$2.3	$7.8	$21.1
Charlevoix, MI	8	$88.4	$0.0	$0.0	$2.7	$91.1
Cheboygan, MI	2	$0.4	$0.7	$0.0	$0.0	$1.1
Chippewa, MI	3	$9.8	$0.0	$0.0	$0.0	$9.8
Clare, MI	5	$0.9	$1.8	$0.0	$0.0	$2.7
Clinton, MI	8	$82.0	$0.0	$1.1	$0.5	$83.6
Crawford, MI	1	$0.0	$1.4	$0.0	$0.0	$1.4
Delta, MI	6	$4.1	$0.1	$0.0	$0.1	$4.3
Dickinson, MI	4	$44.5	$0.4	$0.0	$0.0	$44.9
Eaton, MI	13	$34.0	$3.3	$0.0	$0.1	$37.4
Emmet, MI	8	$4.9	$32.9	$0.0	$1.0	$38.8
Genesee, MI	30	$52.2	$0.5	$0.0	$6.6	$59.3
Gladwin, MI	7	$3.4	$2.0	$0.1	$0.1	$5.6
Gogebic, MI	2	$5.0	$0.0	$0.0	$0.0	$5.0
Grand	30	$283.2	$148.6	$1.1	$6.2	$439.1
Gratiot, MI	8	$3.9	$1.8	$0.0	$0.6	$6.3
Hillsdale, MI	15	$18.8	$2.8	$0.0	$0.1	$21.7
Houghton, MI	4	$0.4	$0.0	$0.0	$0.2	$0.6
Huron, MI	16	$31.2	$0.0	$0.3	$0.3	$31.8
Ingham, MI	23	$41.9	$4.3	$15.8	$2.1	$64.1
Ionia, MI	13	$7.7	$0.7	$0.0	$0.7	$9.1
Iosco, MI	7	$2.1	$0.0	$3.3	$1.3	$6.7
Iron, MI	3	$0.9	$0.0	$0.0	$0.0	$0.9
Isabella, MI	9	$6.5	$0.0	$1.1	$0.4	$8.0
Jackson, MI	41	$36.8	$8.5	$2.3	$10.3	$57.9
Kalamazoo, MI	61	$39.4	$12.4	$40.6	$13.8	$106.2
Kalkaska, MI	2	$0.1	$0.0	$0.0	$0.8	$0.9
Kent, MI	172	$336.7	$104.5	$22.0	$50.8	$514.0
Keweenaw, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Lake, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Lapeer, MI	18	$47.4	$0.9	$0.0	$0.3	$48.6
Leelanau, MI	1	$0.0	$0.0	$0.0	$0.0	$0.0
Lenawee, MI	33	$18.7	$12.3	$5.6	$7.9	$44.5
Livingston, MI	44	$62.7	$3.3	$1.3	$3.8	$71.1
Luce, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0

Location	# of Firms	Millions $ Wind	Millions $ Solar	Millions $ Geothermal	Millions $ Biomass	Total Millions $
Mackinac, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Macomb, MI	260	$357.7	$75.3	$9.4	$22.7	$465.1
Manistee, MI	3	$2.0	$0.0	$0.0	$0.0	$2.0
Marquette, MI	1	$0.0	$3.1	$0.0	$0.0	$3.1
Mason, MI	5	$20.4	$0.0	$0.0	$5.0	$25.4
Mecosta, MI	5	$0.0	$8.6	$0.0	$0.1	$8.7
Menominee, MI	5	$23.8	$0.0	$0.3	$0.2	$24.3
Midland, MI	13	$10.9	$15.6	$0.1	$1.0	$27.6
Missaukee, MI	2	$0.7	$0.0	$0.0	$0.0	$0.7
Monroe, MI	33	$17.0	$365.1	$6.4	$7.9	$396.4
Montcalm, MI	13	$12.9	$0.0	$0.0	$0.1	$13.0
Montmorency,	1	$0.0	$0.0	$0.0	$1.9	$1.9
Muskegon, MI	45	$132.7	$35.3	$5.0	$3.5	$176.5
Newaygo, MI	4	$2.2	$50.8	$0.0	$0.0	$53.0
Oakland, MI	306	$278.9	$128.1	$38.0	$35.1	$480.1
Oceana, MI	2	$19.8	$0.0	$0.0	$0.0	$19.8
Ogemaw, MI	4	$3.0	$0.8	$0.0	$0.0	$3.8
Ontonagon, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Osceola, MI	7	$23.0	$0.0	$1.0	$0.4	$24.4
Oscoda, MI	1	$0.1	$0.0	$0.0	$0.0	$0.1
Otsego, MI	12	$30.1	$0.0	$7.8	$1.6	$39.5
Ottawa, MI	65	$93.8	$6.5	$4.9	$25.5	$130.7
Presque Isle, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Roscommon,	2	$4.1	$0.0	$0.0	$0.0	$4.1
Saginaw, MI	29	$164.2	$12.5	$1.4	$2.0	$180.1
Sanilac, MI	16	$30.5	$2.0	$0.0	$0.7	$33.2
Schoolcraft, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Shiawassee, MI	24	$58.1	$0.2	$2.7	$19.8	$80.8
St. Clair, MI	47	$62.2	$7.9	$4.9	$2.9	$77.9
St. Joseph, MI	31	$103.1	$0.8	$0.0	$2.6	$106.5
Statewide, MI	0	$0.0	$0.0	$0.0	$0.0	$0.0
Tuscola, MI	4	$47.8	$0.0	$0.0	$0.0	$47.8
Van Buren, MI	17	$62.1	$0.4	$0.2	$0.3	$63.0
Washtenaw, MI	56	$75.2	$17.5	$4.0	$25.4	$122.1
Wayne, MI	228	$300.8	$193.5	$28.9	$33.8	$557.0
Wexford, MI	4	$41.6	$0.0	$0.0	$0.0	$41.6

Location	# of Firms	New Jobs Wind	New Jobs Solar	New Jobs Geothermal	New Jobs Biomass	Total New Jobs
Alcona, MI	2	2	0	0	0	2
Alger, MI	0	0	0	0	0	0
Allegan, MI	37	267	144	12	12	435
Alpena, MI	7	97	0	0	18	115
Antrim, MI	4	0	0	5	8	13
Arenac, MI	4	19	0	0	6	25
Baraga, MI	8	3	0	0	2	5
Barry, MI	10	28	7	0	29	64
Bay, MI	11	56	10	0	40	106
Benzie, MI	7	33	82	0	1	116
Berrien, MI	62	382	45	411	85	923
Branch, MI	13	155	2	6	1	164
Calhoun, MI	33	588	19	50	15	672
Cass, MI	10	86	1	17	55	159
Charlevoix, MI	8	626	0	0	20	646
Cheboygan, MI	2	2	3	0	0	5
Chippewa, MI	3	67	0	0	0	67
Clare, MI	5	6	7	0	0	13
Clinton, MI	8	536	0	5	3	544
Crawford, MI	1	0	2	0	0	2
Delta, MI	6	28	1	0	0	29
Dickinson, MI	4	312	4	0	0	316
Eaton, MI	13	224	7	0	0	231
Emmet, MI	8	39	217	0	8	264
Genesee, MI	30	365	2	0	41	408
Gladwin, MI	7	27	8	1	1	37
Gogebic, MI	2	39	0	0	0	39
Grand	30	1,917	1,032	5	45	2,999
Gratiot, MI	8	29	7	0	4	40
Hillsdale, MI	15	127	21	0	0	148
Houghton, MI	4	2	0	0	1	3
Huron, MI	16	230	0	1	1	232
Ingham, MI	23	260	12	114	15	401
Ionia, MI	13	61	3	0	5	69
Iosco, MI	7	12	0	17	7	36
Iron, MI	3	6	0	0	0	6
Isabella, MI	9	41	0	5	2	48
Jackson, MI	41	271	40	16	72	399
Kalamazoo, MI	61	303	37	216	77	633
Kalkaska, MI	2	1	0	0	6	7
Kent, MI	172	2,478	648	117	332	3,575
Keweenaw, MI	0	0	0	0	0	0
Lake, MI	0	0	0	0	0	0
Lapeer, MI	18	376	5	0	2	383
Leelanau, MI	1	0	0	0	0	0
Lenawee, MI	33	141	29	29	54	253
Livingston, MI	44	425	15	7	24	471

Location	# of Firms	New Jobs Wind	New Jobs Solar	New Jobs Geothermal	New Jobs Biomass	Total New Jobs
Luce, MI	0	0	0	0	0	0
Mackinac, MI	0	0	0	0	0	0
Macomb, MI	260	2,603	437	43	144	3,227
Manistee, MI	3	14	0	0	0	14
Marquette, MI	1	0	4	0	0	4
Mason, MI	5	139	0	0	20	159
Mecosta, MI	5	0	37	0	1	38
Menominee, MI	5	171	0	2	2	175
Midland, MI	13	85	21	0	8	114
Missaukee, MI	2	4	0	0	0	4
Monroe, MI	33	104	1,518	22	49	1,693
Montcalm, MI	13	95	0	0	0	95
Montmorency,	1	0	0	0	13	13
Muskegon, MI	45	915	231	28	21	1,195
Newaygo, MI	4	13	388	0	0	401
Oakland, MI	306	1,927	738	168	230	3,063
Oceana, MI	2	138	0	0	0	138
Ogemaw, MI	4	20	3	0	0	23
Ontonagon, MI	0	0	0	0	0	0
Osceola, MI	7	182	0	5	2	189
Oscoda, MI	1	1	0	0	0	1
Otsego, MI	12	183	0	56	11	250
Ottawa, MI	65	701	52	35	178	966
Presque Isle, MI	0	0	0	0	0	0
Roscommon,	2	26	0	0	0	26
Saginaw, MI	29	1,135	43	7	12	1,197
Sanilac, MI	16	234	16	0	4	254
Schoolcraft, MI	0	0	0	0	0	0
Shiawassee, MI	24	396	1	9	143	549
St. Clair, MI	47	466	25	19	13	523
St. Joseph, MI	31	769	5	0	16	790
Statewide, MI	0	0	0	0	0	0
Tuscola, MI	4	342	0	0	0	342
Van Buren, MI	17	470	3	1	2	476
Washtenaw, MI	56	541	53	21	178	793
Wayne, MI	228	1,976	1,055	174	226	3,431
Wexford, MI	4	291	0	0	0	291

Appendix C – Detailed Results by NAICS for Michigan Counties

Appendix C consists of detailed information for each county in Michigan. For each county there are four tables, one each for wind, solar, geothermal, and biomass listing the relevant NAICS codes for each technology. For each NAICS code, the table shows the number of firms in the county operating in that NAICS code, and the manufacturing investment and job creation resulting from the national development, for that particular NAICS Code and county. *The counties are listed in alphabetical order.

*The following counties were dropped from the NAICS for Michigan due to zero activity.

- Alger
- Keweenaw
- Lake
- Luce
- Mackinac
- Ontonagon
- Presque Ilse
- Schoolcraft

Alcona, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332991	Ball and Roller Bearings	1	$0.0	0
326199	All Other Plastics Product Manufacturing	1	$0.0	0
Total:		2	$0.0	0
Grand Total for Alcona, MI:		**2**	**$0.0**	**0**

Allegan, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	3	$11.1	63
326199	All Other Plastics Product Manufacturing	8	$3.3	26
335999	Electronic Equipment and Components, NEC	1	$1.7	11
335312	Motors and Generators	1	$0.8	5
331511	Iron Foundries	1	$0.1	1
333412	Industrial and Commercial fans and blowers	1	$0.0	0
Total:		15	$17.0	106

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	1	$4.2	27
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	3	$4.0	16
327211	Flat Glass	1	$2.8	12
332322	Sheet Metal Work Manufacturing	3	$0.3	3
Total:		8	$11.3	58

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	1	$0.6	4
333912	Air and Gas Compressor Manufacturing	1	$0.1	0
Total:		2	$0.7	4

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	3	$0.4	2
333999	All Other Miscellaneous General Purpose Machinery	3	$0.2	2
335999	Electronic Equipment and Components, NEC	1	$0.1	0
333412	Industrial and Commercial fans and blowers	1	$0.1	1
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
333120	Construction Machinery Manufacturing	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		12	$0.8	5

Grand Total for Allegan, MI:	**37**	**$29.8**	**173**

Alpena, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$3.2	23
333613	Power Transmission Equip.	1	$1.5	10
332312	Fabricated Structural Metal	1	$0.8	5
335312	Motors and Generators	1	$0.2	1
326199	All Other Plastics Product Manufacturing	1	$0.0	0
Total:		5	$5.7	39

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	2	$1.2	7
Total:		2	$1.2	7

Grand Total for Alpena, MI:	**7**	**$6.9**	**46**

Antrim, MI

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.3	2
333132	Oil and Gas Field Machinery and Equipment Manufacturing	1	$0.0	0
Total:		2	$0.3	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.2	1
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.2	1
Total:		2	$0.4	2

Grand Total for Antrim, MI:	**4**	**$0.7**	**4**

Arenac, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	2	$1.0	8
Total:		2	$1.0	8

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	1	$0.3	2
333120	Construction Machinery Manufacturing	1	$0.0	0
Total:		2	$0.3	2

Grand Total for Arenac, MI:	**4**	**$1.3**	**10**

Baraga, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	3	$0.2	1
Total:		3	$0.2	1

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333120	Construction Machinery Manufacturing	3	$0.1	0
327993	Mineral Wool Manufacturing	1	$0.1	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		5	$0.2	0

Grand Total for Baraga, MI:	**8**	**$0.4**	**1**

Barry, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	4	$1.3	10
332312	Fabricated Structural Metal	1	$0.1	1
Total:		5	$1.4	11

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	2	$0.4	3
Total:		2	$0.4	3

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	1	$1.6	11
333120	Construction Machinery Manufacturing	1	$0.0	0
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
Total:		3	$1.6	11

Grand Total for Barry, MI:	**10**	**$3.4**	**25**

Bay, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$2.0	11
326199	All Other Plastics Product Manufacturing	3	$1.1	8
335312	Motors and Generators	2	$0.4	2
Total:		6	$3.5	21

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	1	$2.9	4
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		2	$2.9	4

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$2.0	15
332911	Industrial Valve Manufacturing	1	$0.1	1
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		3	$2.1	16

Grand Total for Bay, MI:	**11**	**$8.5**	**41**

Benzie, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	2	$2.0	13
Total:		2	$2.0	13

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	2	$5.0	33
Total:		2	$5.0	33

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	2	$0.1	0
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
Total:		3	$0.1	0

Grand Total for Benzie, MI:	**7**	**$7.1**	**46**

Berrien, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	14	$13.0	104
332312	Fabricated Structural Metal	6	$6.0	34
333412	Industrial and Commercial fans and blowers	3	$1.3	10
331511	Iron Foundries	2	$0.7	5
Total:		25	$21.0	153

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335931	Current-Carrying Wiring Device Manufacturing	1	$1.9	14
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.3	1
332322	Sheet Metal Work Manufacturing	6	$0.3	2
Total:		8	$2.5	17

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	3	$16.6	120
333912	Air and Gas Compressor Manufacturing	4	$7.7	33
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.9	5
333911	Pump and Pumping Equipment Manufacturing	1	$0.7	4
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.6	2
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	0
Total:		11	$26.6	164

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	3	$2.2	16
333922	Conveyor and Conveying Equipment Manufacturing	1	$1.2	7
333999	All Other Miscellaneous General Purpose Machinery	3	$0.4	3
333912	Air and Gas Compressor Manufacturing	4	$0.4	2
333210	Sawmill and Woodworking Machinery Manufacturing	1	$0.3	2
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.3	1
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.3	2
333911	Pump and Pumping Equipment Manufacturing	1	$0.2	1
336510	Railroad Rolling Stock Manufacturing	1	$0.1	0
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
Total:		18	$5.4	34

Grand Total for Berrien, MI:	**62**	**$55.5**	**368**

Branch, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	2	$10.2	59
326199	All Other Plastics Product Manufacturing	1	$0.4	3
Total:		3	$10.6	62

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.1	1
332322	Sheet Metal Work Manufacturing	2	$0.1	0
Total:		3	$0.2	1

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	2	$0.4	2
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.1	0
Total:		3	$0.5	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	2	$0.1	1
332911	Industrial Valve Manufacturing	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		4	$0.1	1

Grand Total for Branch, MI:	**13**	**$11.4**	**66**

Calhoun, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	3	$20.2	142
326199	All Other Plastics Product Manufacturing	10	$10.6	85
332312	Fabricated Structural Metal	3	$1.4	8
333613	Power Transmission Equip.	1	$0.1	1
Total:		17	$32.3	236

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.8	4
332322	Sheet Metal Work Manufacturing	5	$0.4	3
Total:		6	$1.2	7

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333911	Pump and Pumping Equipment Manufacturing	1	$3.7	20
333912	Air and Gas Compressor Manufacturing	1	$0.1	0
Total:		2	$3.8	20

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333911	Pump and Pumping Equipment Manufacturing	1	$0.8	5
327993	Mineral Wool Manufacturing	2	$0.1	0
332911	Industrial Valve Manufacturing	2	$0.1	1
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.1	0
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		8	$1.1	6

Grand Total for Calhoun, MI:	**33**	**$38.4**	**269**

Cass, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	3	$4.0	32
331511	Iron Foundries	1	$0.3	2
Total:		4	$4.3	34

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.1	0
Total:		1	$0.1	0

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332410	Power Boiler and Heat Exchanger Manufacturing	1	$0.9	6
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	0
Total:		2	$1.0	6

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332410	Power Boiler and Heat Exchanger Manufacturing	1	$3.0	21
333999	All Other Miscellaneous General Purpose Machinery	1	$0.1	0
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
Total:		3	$3.1	21

Grand Total for Cass, MI:	**10**	**$8.5**	**61**

Charlevoix, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$32.7	229
326199	All Other Plastics Product Manufacturing	2	$2.7	22
Total:		3	$35.4	251

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
Total:		1	$0.0	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$0.9	6
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.2	1
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
Total:		4	$1.1	7

Grand Total for Charlevoix, MI:	**8**	**$36.5**	**258**

Cheboygan, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.1	1
Total:		1	$0.1	1

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
334515	Instrument Manufacturing for Measuring and Testing	1	$0.3	1
Total:		1	$0.3	1

Grand Total for Cheboygan, MI:	**2**	**$0.4**	**2**

Chippewa, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$2.0	11
326199	All Other Plastics Product Manufacturing	1	$1.9	15
Total:		2	$3.9	26

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
Total:		1	$0.0	0

Grand Total for Chippewa, MI:	**3**	**$3.9**	**26**

Clare, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$0.1	1
332312	Fabricated Structural Metal	1	$0.1	1
326199	All Other Plastics Product Manufacturing	1	$0.1	1
Total:		3	$0.3	3

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.7	3
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		2	$0.7	3

Grand Total for Clare, MI:	**5**	**$1.0**	**6**

Clinton, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333613	Power Transmission Equip.	1	$32.6	213
332312	Fabricated Structural Metal	2	$0.3	2
Total:		3	$32.9	215

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333912	Air and Gas Compressor Manufacturing	1	$0.4	2
Total:		1	$0.4	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	2	$0.1	1
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		4	$0.1	1
Grand Total for Clinton, MI:		**8**	**$33.4**	**218**

Crawford, MI

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	1	$0.6	1
Total:		1	$0.6	1
Grand Total for Crawford, MI:		**1**	**$0.6**	**1**

Delta, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.8	5
326199	All Other Plastics Product Manufacturing	1	$0.8	7
Total:		2	$1.6	12

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		1	$0.0	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333120	Construction Machinery Manufacturing	2	$0.0	0
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
Total:		3	$0.0	0

Grand Total for Delta, MI:	**6**	**$1.6**	**12**

Dickinson, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	2	$17.8	125
Total:		2	$17.8	125

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	1	$0.1	0
335931	Current-Carrying Wiring Device Manufacturing	1	$0.1	1
Total:		2	$0.2	1

Grand Total for Dickinson, MI:	**4**	**$18.0**	**126**

Eaton, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335312	Motors and Generators	1	$8.8	54
326199	All Other Plastics Product Manufacturing	4	$3.9	31
332312	Fabricated Structural Metal	1	$0.8	5
Total:		6	$13.5	90

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	2	$1.1	2
332322	Sheet Metal Work Manufacturing	3	$0.1	1
Total:		5	$1.2	3

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333120	Construction Machinery Manufacturing	1	$0.0	0
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
Total:		2	$0.0	0

Grand Total for Eaton, MI:	**13**	**$14.7**	**93**

Emmet, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	2	$1.9	16
Total:		2	$1.9	16

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335931	Current-Carrying Wiring Device Manufacturing	1	$9.4	72
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$3.7	15
332322	Sheet Metal Work Manufacturing	1	$0.1	0
Total:		3	$13.2	87

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		1	$0.0	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$0.4	3
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		2	$0.4	3

Grand Total for Emmet, MI:	**8**	**$15.5**	**106**

Genesee, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	11	$11.8	94
332312	Fabricated Structural Metal	8	$9.0	52
Total:		19	$20.8	146

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	2	$0.1	1
325211	Plastics Material and Resin Manufacturing	1	$0.1	0
Total:		3	$0.2	1

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	2	$2.5	16
332911	Industrial Valve Manufacturing	1	$0.1	0
333999	All Other Miscellaneous General Purpose Machinery	2	$0.1	1
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
334513	Instruments and Related Products Manufacturing for	2	$0.0	0
Total:		8	$2.7	17

Grand Total for Genesee, MI:	**30**	**$23.7**	**164**

Gladwin, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	3	$1.4	11
Total:		3	$1.4	11

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	2	$0.8	3
Total:		2	$0.8	3

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	0
Total:		1	$0.1	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
Total:		1	$0.0	0

Grand Total for Gladwin, MI:	**7**	**$2.3**	**14**

Gogebic, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	1	$1.9	15
334418	Printed circuits and electronics assemblies	1	$0.1	0
Total:		2	$2.0	15

Grand Total for Gogebic, MI:	**2**	**$2.0**	**15**

Grand Traverse,

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333612	Speed Changer, Industrial	1	$107.1	725
326199	All Other Plastics Product Manufacturing	6	$2.4	19
332312	Fabricated Structural Metal	1	$2.0	11
334519	Measuring and Controlling Devices	3	$1.1	7
335999	Electronic Equipment and Components, NEC	1	$0.3	2
335312	Motors and Generators	1	$0.3	2
334418	Printed circuits and electronics assemblies	1	$0.1	0
Total:		14	$113.3	766

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335931	Current-Carrying Wiring Device Manufacturing	3	$50.1	383
334413	Semiconductors and Related Devices	3	$8.1	20
335999	Electronic Equipment and Components, NEC	1	$0.8	6
332322	Sheet Metal Work Manufacturing	3	$0.4	4
Total:		10	$59.4	413

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333912	Air and Gas Compressor Manufacturing	1	$0.4	2
Total:		1	$0.4	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$2.0	15
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.2	1
333999	All Other Miscellaneous General Purpose Machinery	1	$0.1	1
335999	Electronic Equipment and Components, NEC	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		5	$2.3	17

Grand Total for Grand Traverse, MI:	**30**	**$175.4**	**1,198**

Gratiot, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	4	$1.1	9
332312	Fabricated Structural Metal	1	$0.4	2
Total:		5	$1.5	11

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.7	3
Total:		1	$0.7	3

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.1	1
333999	All Other Miscellaneous General Purpose Machinery	1	$0.1	1
Total:		2	$0.2	2

Grand Total for Gratiot, MI:	**8**	**$2.4**	**16**

Hillsdale, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	2	$4.0	23
326199	All Other Plastics Product Manufacturing	7	$3.5	28
Total:		9	$7.5	51

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335931	Current-Carrying Wiring Device Manufacturing	1	$0.8	6
332322	Sheet Metal Work Manufacturing	2	$0.3	2
Total:		3	$1.1	8

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	2	$0.0	0
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
Total:		3	$0.0	0

Grand Total for Hillsdale, MI:	**15**	**$8.6**	**59**

Houghton, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.1	1
Total:		1	$0.1	1

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333120	Construction Machinery Manufacturing	2	$0.1	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		3	$0.1	0

Grand Total for Houghton, MI:	**4**	**$0.2**	**1**

Huron, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	7	$6.7	53
333612	Speed Changer, Industrial	1	$4.1	28
331511	Iron Foundries	1	$1.5	11
332312	Fabricated Structural Metal	1	$0.1	1
Total:		10	$12.4	93

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.1	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		2	$0.1	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	1	$0.1	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.0	0
Total:		4	$0.1	0

Grand Total for Huron, MI:	**16**	**$12.6**	**93**

Ingham, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	4	$13.1	75
326199	All Other Plastics Product Manufacturing	10	$3.2	25
333412	Industrial and Commercial fans and blowers	1	$0.5	4
Total:		15	$16.8	104

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	1	$1.2	2
332322	Sheet Metal Work Manufacturing	2	$0.3	3
334413	Semiconductors and Related Devices	1	$0.2	0
Total:		4	$1.7	5

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	1	$6.3	45
Total:		1	$6.3	45

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	1	$0.8	6
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
333120	Construction Machinery Manufacturing	1	$0.0	0
Total:		3	$0.8	6

Grand Total for Ingham, MI:	**23**	**$25.6**	**160**

Ionia, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	8	$3.1	24
Total:		8	$3.1	24

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	2	$0.1	1
325211	Plastics Material and Resin Manufacturing	1	$0.1	0
Total:		3	$0.2	1

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	2	$0.3	2
Total:		2	$0.3	2

Grand Total for Ionia, MI:	**13**	**$3.6**	**27**

Iosco, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.8	5
Total:		1	$0.8	5

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	2	$1.3	7
Total:		2	$1.3	7

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	2	$0.5	3
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		4	$0.5	3

Grand Total for Iosco, MI:	**7**	**$2.6**	**15**

Iron, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335312	Motors and Generators	1	$0.2	1
332312	Fabricated Structural Metal	1	$0.1	1
326199	All Other Plastics Product Manufacturing	1	$0.0	0
Total:		3	$0.3	2
Grand Total for Iron, MI:		**3**	**$0.3**	**2**

Isabella, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333613	Power Transmission Equip.	1	$1.5	10
332312	Fabricated Structural Metal	1	$0.8	5
334519	Measuring and Controlling Devices	1	$0.2	1
326199	All Other Plastics Product Manufacturing	1	$0.0	0
Total:		4	$2.5	16

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	2	$0.4	2
Total:		2	$0.4	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	2	$0.2	1
333120	Construction Machinery Manufacturing	1	$0.0	0
Total:		3	$0.2	1
Grand Total for Isabella, MI:		**9**	**$3.1**	**19**

Jackson, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	11	$8.1	64
333613	Power Transmission Equip.	1	$3.2	21
331511	Iron Foundries	3	$2.4	17
332312	Fabricated Structural Metal	3	$1.0	5
Total:		18	$14.7	107

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335313	Switchgear and Switchboard Apparatus Manufacturing	3	$2.8	15
325211	Plastics Material and Resin Manufacturing	1	$0.6	1
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		5	$3.4	16

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332410	Power Boiler and Heat Exchanger Manufacturing	1	$0.9	6
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		2	$0.9	6

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332410	Power Boiler and Heat Exchanger Manufacturing	1	$3.0	21
333999	All Other Miscellaneous General Purpose Machinery	5	$0.7	5
333922	Conveyor and Conveying Equipment Manufacturing	2	$0.2	2
335313	Switchgear and Switchboard Apparatus Manufacturing	3	$0.2	1
333995	Fluid Power Cylinder and Actuator Manufacturing	3	$0.0	0
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		16	$4.1	29

Grand Total for Jackson, MI:	**41**	**$23.1**	**158**

Kalamazoo, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	16	$13.8	110
332312	Fabricated Structural Metal	2	$1.0	6
335312	Motors and Generators	2	$0.9	5
335999	Electronic Equipment and Components, NEC	1	$0.1	1
Total:		21	$15.8	122

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	3	$3.3	4
332322	Sheet Metal Work Manufacturing	10	$0.7	6
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.7	3
335999	Electronic Equipment and Components, NEC	1	$0.3	2
334515	Instrument Manufacturing for Measuring and Testing	1	$0.0	0
Total:		16	$5.0	15

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333911	Pump and Pumping Equipment Manufacturing	3	$16.1	86
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.1	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		5	$16.2	86

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333911	Pump and Pumping Equipment Manufacturing	3	$3.7	20
333999	All Other Miscellaneous General Purpose Machinery	5	$0.9	6
333922	Conveyor and Conveying Equipment Manufacturing	4	$0.7	5
332911	Industrial Valve Manufacturing	1	$0.1	1
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	1	$0.0	0
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
333120	Construction Machinery Manufacturing	1	$0.0	0
335999	Electronic Equipment and Components, NEC	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		19	$5.4	32

Grand Total for Kalamazoo, MI:	**61**	**$42.4**	**255**

Kalkaska, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
334519	Measuring and Controlling Devices	1	$0.0	0
Total:		1	$0.0	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	1	$0.3	2
Total:		1	$0.3	2

Grand Total for Kalkaska, MI:	**2**	**$0.3**	**2**

Kent, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	62	$73.2	583
333612	Speed Changer, Industrial	1	$21.3	144
331511	Iron Foundries	8	$19.6	137
332312	Fabricated Structural Metal	11	$9.6	55
335999	Electronic Equipment and Components, NEC	3	$9.3	60
334519	Measuring and Controlling Devices	4	$1.5	10
335312	Motors and Generators	1	$0.2	1
332991	Ball and Roller Bearings	1	$0.1	1
334418	Printed circuits and electronics assemblies	1	$0.0	0
Total:		92	$134.8	991

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	3	$23.2	151
335931	Current-Carrying Wiring Device Manufacturing	1	$9.4	72
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	3	$5.0	20
334413	Semiconductors and Related Devices	1	$2.3	6
335313	Switchgear and Switchboard Apparatus Manufacturing	2	$0.9	5
335911	Storage Batteries	1	$0.5	3
332322	Sheet Metal Work Manufacturing	9	$0.4	3
334515	Instrument Manufacturing for Measuring and Testing	1	$0.1	0
Total:		21	$41.8	260

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333911	Pump and Pumping Equipment Manufacturing	1	$7.9	42
333415	Air-Conditioning and Warm Air Heating Equipment and	4	$0.5	3
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.3	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
Total:		8	$8.8	46

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	9	$7.7	48
333411	Air Purification Equipment Manufacturing	2	$4.1	30
333210	Sawmill and Woodworking Machinery Manufacturing	6	$4.0	27
333999	All Other Miscellaneous General Purpose Machinery	13	$1.9	13
333911	Pump and Pumping Equipment Manufacturing	1	$1.8	10
335999	Electronic Equipment and Components, NEC	3	$0.3	2
333415	Air-Conditioning and Warm Air Heating Equipment and	4	$0.2	1
335313	Switchgear and Switchboard Apparatus Manufacturing	2	$0.1	0
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.1	1
336510	Railroad Rolling Stock Manufacturing	1	$0.0	0
333120	Construction Machinery Manufacturing	2	$0.0	0
334513	Instruments and Related Products Manufacturing for	2	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	1	$0.0	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	2	$0.0	0
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
Total:		51	$20.2	132

Grand Total for Kent, MI: 172 $205.6 1,429

Lapeer, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	9	$18.7	149
335999	Electronic Equipment and Components, NEC	1	$0.1	1
332312	Fabricated Structural Metal	1	$0.1	1
Total:		11	$18.9	151

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	1	$0.3	2
334515	Instrument Manufacturing for Measuring and Testing	2	$0.0	0
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		4	$0.3	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333210	Sawmill and Woodworking Machinery Manufacturing	1	$0.1	1
335999	Electronic Equipment and Components, NEC	1	$0.0	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		3	$0.1	1

Grand Total for Lapeer, MI: 18 $19.3 154

Leelanau, MI

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		1	$0.0	0
Grand Total for Leelanau, MI:		**1**	**$0.0**	**0**

Lenawee, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	12	$5.7	46
332312	Fabricated Structural Metal	2	$1.2	7
334519	Measuring and Controlling Devices	1	$0.5	3
Total:		15	$7.4	56

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	1	$2.9	4
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$1.6	6
334413	Semiconductors and Related Devices	1	$0.5	1
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.0	0
Total:		4	$5.0	11

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	4	$2.2	12
Total:		4	$2.2	12

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$2.0	15
333415	Air-Conditioning and Warm Air Heating Equipment and	4	$0.9	5
333999	All Other Miscellaneous General Purpose Machinery	2	$0.2	1
332911	Industrial Valve Manufacturing	1	$0.1	0
333120	Construction Machinery Manufacturing	1	$0.0	0
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.0	0
Total:		10	$3.2	21
Grand Total for Lenawee, MI:		**33**	**$17.8**	**100**

Livingston, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	2	$10.2	59
326199	All Other Plastics Product Manufacturing	11	$10.2	81
335312	Motors and Generators	2	$2.6	16
333612	Speed Changer, Industrial	1	$2.0	14
334519	Measuring and Controlling Devices	3	$0.1	1
Total:		19	$25.1	171

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	2	$1.0	4
332322	Sheet Metal Work Manufacturing	3	$0.2	2
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.1	0
Total:		6	$1.3	6

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.2	1
333912	Air and Gas Compressor Manufacturing	1	$0.2	1
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.2	1
Total:		3	$0.6	3

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	3	$1.2	8
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.1	0
333999	All Other Miscellaneous General Purpose Machinery	4	$0.1	1
335311	Power, Distribution, and Specialty Transformer Manufacturing	2	$0.1	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
334513	Instruments and Related Products Manufacturing for	3	$0.0	0
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		16	$1.5	9

Grand Total for Livingston, MI:	**44**	**$28.5**	**189**

Macomb, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	81	$80.7	642
333612	Speed Changer, Industrial	4	$24.6	166
332312	Fabricated Structural Metal	29	$20.5	118
335999	Electronic Equipment and Components, NEC	5	$7.7	50
333613	Power Transmission Equip.	5	$4.9	32
331511	Iron Foundries	4	$3.2	23
334519	Measuring and Controlling Devices	5	$1.5	10
334418	Printed circuits and electronics assemblies	2	$0.1	0
335312	Motors and Generators	1	$0.1	0
Total:		136	$143.3	1,041

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	5	$19.3	125
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	2	$3.8	15
335313	Switchgear and Switchboard Apparatus Manufacturing	7	$2.4	13
334413	Semiconductors and Related Devices	2	$2.4	6
332322	Sheet Metal Work Manufacturing	22	$1.1	9
335931	Current-Carrying Wiring Device Manufacturing	1	$0.8	6
334515	Instrument Manufacturing for Measuring and Testing	4	$0.2	1
325211	Plastics Material and Resin Manufacturing	1	$0.1	0
Total:		44	$30.1	175

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	2	$1.6	6
333911	Pump and Pumping Equipment Manufacturing	1	$1.6	8
333923	Overhead Traveling Crane, Hoist, and Monorail System	3	$0.3	2
333912	Air and Gas Compressor Manufacturing	1	$0.1	0
333415	Air-Conditioning and Warm Air Heating Equipment and	3	$0.1	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
Total:		11	$3.7	17

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	9	$3.5	21
333411	Air Purification Equipment Manufacturing	2	$2.2	16
333999	All Other Miscellaneous General Purpose Machinery	19	$1.5	10
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	2	$0.8	3
333911	Pump and Pumping Equipment Manufacturing	1	$0.4	2
335999	Electronic Equipment and Components, NEC	5	$0.3	2
335313	Switchgear and Switchboard Apparatus Manufacturing	7	$0.2	1
333415	Air-Conditioning and Warm Air Heating Equipment and	3	$0.1	0
334513	Instruments and Related Products Manufacturing for	8	$0.1	0
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	2	$0.1	1
333923	Overhead Traveling Crane, Hoist, and Monorail System	3	$0.1	0
333210	Sawmill and Woodworking Machinery Manufacturing	1	$0.1	1
332911	Industrial Valve Manufacturing	2	$0.0	0
335311	Power, Distribution, and Specialty Transformer Manufacturing	1	$0.0	0
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
333120	Construction Machinery Manufacturing	1	$0.0	0
Total:		69	$9.4	57
Grand Total for Macomb, MI:		**260**	**$186.5**	**1,290**

Manistee, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.4	2
326199	All Other Plastics Product Manufacturing	2	$0.4	3
Total:		3	$0.8	5
Grand Total for Manistee, MI:		**3**	**$0.8**	**5**

Marquette, MI

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	1	$1.2	2
Total:		1	$1.2	2
Grand Total for Marquette, MI:		**1**	**$1.2**	**2**

Mason, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$7.6	53
334418	Printed circuits and electronics assemblies	1	$0.4	2
332312	Fabricated Structural Metal	1	$0.1	1
Total:		3	$8.1	56

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
336510	Railroad Rolling Stock Manufacturing	1	$2.0	8
327993	Mineral Wool Manufacturing	1	$0.0	0
Total:		2	$2.0	8

Grand Total for Mason, MI:	**5**	**$10.1**	**64**

Mecosta, MI

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331422	Copper Wire (except Mechanical) Drawing	1	$3.4	15
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		2	$3.4	15

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
Total:		1	$0.0	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		2	$0.0	0

Grand Total for Mecosta, MI:	**5**	**$3.4**	**15**

Menominee, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$7.6	53
326199	All Other Plastics Product Manufacturing	1	$1.9	15
Total:		2	$9.5	68

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	1
Total:		1	$0.1	1

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	1
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
Total:		2	$0.1	1

Grand Total for Menominee, MI:	**5**	**$9.7**	**70**

Midland, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	2	$3.8	31
333613	Power Transmission Equip.	1	$0.3	2
331511	Iron Foundries	2	$0.2	2
Total:		5	$4.3	35

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	1	$6.2	8
Total:		1	$6.2	8

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		2	$0.0	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$0.4	3
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
334513	Instruments and Related Products Manufacturing for	2	$0.0	0
Total:		5	$0.4	3

Grand Total for Midland, MI:	**13**	**$10.9**	**46**

Missaukee, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.1	1
334519	Measuring and Controlling Devices	1	$0.1	1
Total:		2	$0.2	2

Grand Total for Missaukee, MI:	**2**	**$0.2**	**2**

Monroe, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	7	$2.8	22
332312	Fabricated Structural Metal	3	$2.3	13
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$1.6	5
335999	Electronic Equipment and Components, NEC	1	$0.1	1
Total:		12	$6.8	41

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
327211	Flat Glass	1	$145.3	602
335999	Electronic Equipment and Components, NEC	1	$0.3	2
332322	Sheet Metal Work Manufacturing	1	$0.3	2
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.1	0
334515	Instrument Manufacturing for Measuring and Testing	1	$0.1	0
Total:		5	$146.1	606

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$2.3	8
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.3	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		5	$2.6	9

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	1	$2.0	15
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$0.6	2
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.3	2
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.1	1
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	1	$0.0	0
335313	Switchgear and Switchboard Apparatus Manufacturing	1	$0.0	0
335999	Electronic Equipment and Components, NEC	1	$0.0	0
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
Total:		11	$3.0	20

Grand Total for Monroe, MI:	**33**	**$158.5**	**676**

Montcalm, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	8	$3.1	25
331511	Iron Foundries	1	$1.5	11
332312	Fabricated Structural Metal	2	$0.5	3
Total:		11	$5.1	39

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332911	Industrial Valve Manufacturing	1	$0.0	0
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
Total:		2	$0.0	0
Grand Total for Montcalm, MI:		**13**	**$5.1**	**39**

Montmorency,

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	1	$0.7	5
Total:		1	$0.7	5
Grand Total for Montmorency, MI:		**1**	**$0.7**	**5**

Muskegon, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	4	$31.2	218
326199	All Other Plastics Product Manufacturing	8	$7.8	62
332312	Fabricated Structural Metal	4	$5.4	31
335999	Electronic Equipment and Components, NEC	2	$5.3	34
332991	Ball and Roller Bearings	1	$3.4	21
Total:		19	$53.1	366

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	2	$13.2	86
332322	Sheet Metal Work Manufacturing	7	$0.5	4
335931	Current-Carrying Wiring Device Manufacturing	1	$0.4	3
Total:		10	$14.1	93

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$1.9	11
333911	Pump and Pumping Equipment Manufacturing	1	$0.1	0
333415	Air-Conditioning and Warm Air Heating Equipment and	2	$0.0	0
Total:		4	$2.0	11

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.5	3
333999	All Other Miscellaneous General Purpose Machinery	3	$0.4	2
332911	Industrial Valve Manufacturing	1	$0.3	2
335999	Electronic Equipment and Components, NEC	2	$0.2	1
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.1	1
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	2	$0.0	0
333911	Pump and Pumping Equipment Manufacturing	1	$0.0	0
Total:		12	$1.5	9

Grand Total for Muskegon, MI:	**45**	**$70.7**	**479**

Newaygo, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.8	5
326199	All Other Plastics Product Manufacturing	1	$0.0	0
Total:		2	$0.8	5

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335931	Current-Carrying Wiring Device Manufacturing	1	$20.3	155
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		2	$20.3	155

Grand Total for Newaygo, MI:	**4**	**$21.1**	**160**

Oakland, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333612	Speed Changer, Industrial	4	$56.6	383
326199	All Other Plastics Product Manufacturing	60	$29.8	238
332312	Fabricated Structural Metal	11	$7.2	41
335999	Electronic Equipment and Components, NEC	9	$6.8	44
334519	Measuring and Controlling Devices	13	$4.9	32
334418	Printed circuits and electronics assemblies	7	$2.8	12
331511	Iron Foundries	3	$2.2	16
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$0.8	3
335312	Motors and Generators	4	$0.5	3
Total:		112	$111.6	772

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	9	$16.9	110
335931	Current-Carrying Wiring Device Manufacturing	2	$10.2	78
335911	Storage Batteries	2	$7.9	42
334413	Semiconductors and Related Devices	5	$5.8	15
332322	Sheet Metal Work Manufacturing	23	$3.0	25
325211	Plastics Material and Resin Manufacturing	4	$2.6	3
335313	Switchgear and Switchboard Apparatus Manufacturing	10	$2.5	14
327211	Flat Glass	1	$1.4	6
334515	Instrument Manufacturing for Measuring and Testing	7	$0.7	3
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.1	1
Total:		64	$51.1	297

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333912	Air and Gas Compressor Manufacturing	3	$11.9	52
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$1.1	4
333415	Air-Conditioning and Warm Air Heating Equipment and	6	$0.8	4
332410	Power Boiler and Heat Exchanger Manufacturing	3	$0.4	3
333923	Overhead Traveling Crane, Hoist, and Monorail System	2	$0.4	2
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	3	$0.3	1
333911	Pump and Pumping Equipment Manufacturing	1	$0.1	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	1
Total:		20	$15.1	68

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	29	$6.4	44
333922	Conveyor and Conveying Equipment Manufacturing	10	$2.1	13
332410	Power Boiler and Heat Exchanger Manufacturing	3	$1.4	10
333411	Air Purification Equipment Manufacturing	3	$1.2	9
333912	Air and Gas Compressor Manufacturing	3	$0.7	3
335311	Power, Distribution, and Specialty Transformer Manufacturing	1	$0.3	2
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$0.3	1
333415	Air-Conditioning and Warm Air Heating Equipment and	6	$0.3	2
335999	Electronic Equipment and Components, NEC	9	$0.3	2
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	3	$0.2	1
334513	Instruments and Related Products Manufacturing for	16	$0.2	1
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	6	$0.2	1
335313	Switchgear and Switchboard Apparatus Manufacturing	10	$0.2	1
333923	Overhead Traveling Crane, Hoist, and Monorail System	2	$0.1	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	1
332911	Industrial Valve Manufacturing	1	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	4	$0.0	0
333911	Pump and Pumping Equipment Manufacturing	1	$0.0	0
336510	Railroad Rolling Stock Manufacturing	1	$0.0	0
Total:		110	$14.0	92
Grand Total for Oakland, MI:		**306**	**$191.8**	**1,229**

Oceana, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	2	$7.9	55
Total:		2	$7.9	55
Grand Total for Oceana, MI:		**2**	**$7.9**	**55**

Ogemaw, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$0.8	5
326199	All Other Plastics Product Manufacturing	1	$0.4	3
Total:		2	$1.2	8

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.3	1
332322	Sheet Metal Work Manufacturing	1	$0.0	0
Total:		2	$0.3	1

Grand Total for Ogemaw, MI:	**4**	**$1.5**	**9**

Osceola, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	4	$9.0	72
332312	Fabricated Structural Metal	1	$0.1	1
Total:		5	$9.1	73

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.4	2
Total:		1	$0.4	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.2	1
Total:		1	$0.2	1

Grand Total for Osceola, MI:	**7**	**$9.7**	**76**

Oscoda, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335312	Motors and Generators	1	$0.1	0
Total:		1	$0.1	0
Grand Total for Oscoda, MI:		**1**	**$0.1**	**0**

Otsego, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	1	$10.1	58
326199	All Other Plastics Product Manufacturing	2	$1.2	10
334519	Measuring and Controlling Devices	1	$0.5	3
333412	Industrial and Commercial fans and blowers	2	$0.3	2
Total:		6	$12.1	73

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	2	$3.1	23
Total:		2	$3.1	23

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	2	$0.4	3
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.2	1
333120	Construction Machinery Manufacturing	1	$0.0	0
Total:		4	$0.6	4
Grand Total for Otsego, MI:		**12**	**$15.8**	**100**

Ottawa, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	21	$26.9	214
333612	Speed Changer, Industrial	1	$4.1	28
332312	Fabricated Structural Metal	5	$3.3	19
333613	Power Transmission Equip.	1	$1.5	10
332991	Ball and Roller Bearings	1	$0.7	4
334519	Measuring and Controlling Devices	3	$0.6	4
334418	Printed circuits and electronics assemblies	1	$0.4	2
Total:		33	$37.5	281

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	12	$1.8	15
335931	Current-Carrying Wiring Device Manufacturing	1	$0.8	6
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	1	$0.1	0
334515	Instrument Manufacturing for Measuring and Testing	1	$0.0	0
Total:		15	$2.7	21

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332410	Power Boiler and Heat Exchanger Manufacturing	1	$1.9	13
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.1	0
Total:		2	$2.0	13

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332410	Power Boiler and Heat Exchanger Manufacturing	1	$6.5	46
333922	Conveyor and Conveying Equipment Manufacturing	3	$1.4	9
333210	Sawmill and Woodworking Machinery Manufacturing	1	$1.4	10
333999	All Other Miscellaneous General Purpose Machinery	6	$1.0	7
334513	Instruments and Related Products Manufacturing for	1	$0.0	0
332911	Industrial Valve Manufacturing	1	$0.0	0
327993	Mineral Wool Manufacturing	1	$0.0	0
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.0	0
Total:		15	$10.3	72

Grand Total for Ottawa, MI:	**65**	**$52.5**	**387**

Roscommon, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333613	Power Transmission Equip.	1	$1.5	10
332312	Fabricated Structural Metal	1	$0.1	1
Total:		2	$1.6	11
Grand Total for Roscommon, MI:		**2**	**$1.6**	**11**

Saginaw, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	3	$60.5	424
332312	Fabricated Structural Metal	7	$5.0	29
326199	All Other Plastics Product Manufacturing	4	$0.2	1
Total:		14	$65.7	454

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	2	$3.5	5
332322	Sheet Metal Work Manufacturing	3	$1.5	13
Total:		5	$5.0	18

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.4	2
333911	Pump and Pumping Equipment Manufacturing	1	$0.1	1
Total:		2	$0.5	3

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	3	$0.5	3
333210	Sawmill and Woodworking Machinery Manufacturing	1	$0.1	1
333923	Overhead Traveling Crane, Hoist, and Monorail System	1	$0.1	1
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.0	0
333911	Pump and Pumping Equipment Manufacturing	1	$0.0	0
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
Total:		8	$0.7	5
Grand Total for Saginaw, MI:		**29**	**$71.9**	**480**

Sanilac, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	9	$10.5	84
332312	Fabricated Structural Metal	2	$1.7	10
Total:		11	$12.2	94

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335931	Current-Carrying Wiring Device Manufacturing	2	$0.5	4
332322	Sheet Metal Work Manufacturing	1	$0.3	2
Total:		3	$0.8	6

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
327993	Mineral Wool Manufacturing	1	$0.2	1
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
Total:		2	$0.2	1

Grand Total for Sanilac, MI:	**16**	**$13.2**	**101**

Shiawassee, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335312	Motors and Generators	3	$12.5	76
326199	All Other Plastics Product Manufacturing	9	$9.9	79
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$0.8	3
Total:		13	$23.2	158

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	1	$0.1	0
325211	Plastics Material and Resin Manufacturing	1	$0.0	0
Total:		2	$0.1	0

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$1.1	4
Total:		1	$1.1	4

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	4	$7.5	55
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	1	$0.3	1
333120	Construction Machinery Manufacturing	1	$0.1	0
333922	Conveyor and Conveying Equipment Manufacturing	1	$0.0	0
333999	All Other Miscellaneous General Purpose Machinery	1	$0.0	0
Total:		8	$7.9	56

Grand Total for Shiawassee, MI:	**24**	**$32.3**	**218**

St. Clair, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	24	$18.5	147
332312	Fabricated Structural Metal	4	$3.1	18
333613	Power Transmission Equip.	2	$3.0	20
335999	Electronic Equipment and Components, NEC	1	$0.3	2
Total:		31	$24.9	187

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
325211	Plastics Material and Resin Manufacturing	4	$2.2	3
335999	Electronic Equipment and Components, NEC	1	$0.8	6
332322	Sheet Metal Work Manufacturing	3	$0.2	1
Total:		8	$3.2	10

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$1.5	5
333912	Air and Gas Compressor Manufacturing	1	$0.4	2
Total:		2	$1.9	7

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	1	$0.7	3
333999	All Other Miscellaneous General Purpose Machinery	3	$0.4	2
335999	Electronic Equipment and Components, NEC	1	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
Total:		6	$1.1	5

Grand Total for St. Clair, MI:	**47**	**$31.1**	**209**

St. Joseph, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	19	$22.8	181
331511	Iron Foundries	2	$10.8	76
333613	Power Transmission Equip.	1	$7.6	50
335999	Electronic Equipment and Components, NEC	1	$0.1	1
Total:		23	$41.3	308

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	1	$0.3	2
Total:		1	$0.3	2

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332911	Industrial Valve Manufacturing	3	$0.6	3
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	1	$0.3	2
333999	All Other Miscellaneous General Purpose Machinery	2	$0.2	1
335999	Electronic Equipment and Components, NEC	1	$0.0	0
Total:		7	$1.1	6

Grand Total for St. Joseph, MI:	**31**	**$42.7**	**316**

Tuscola, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$16.3	114
326199	All Other Plastics Product Manufacturing	3	$2.8	22
Total:		4	$19.1	136

Grand Total for Tuscola, MI:	**4**	**$19.1**	**136**

Van Buren, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	6	$19.3	154
333613	Power Transmission Equip.	1	$3.2	21
332312	Fabricated Structural Metal	1	$2.0	11
332991	Ball and Roller Bearings	1	$0.3	2
Total:		9	$24.8	188

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332322	Sheet Metal Work Manufacturing	2	$0.2	1
Total:		2	$0.2	1

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.1	0
Total:		1	$0.1	0

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333922	Conveyor and Conveying Equipment Manufacturing	2	$0.0	0
333415	Air-Conditioning and Warm Air Heating Equipment and	1	$0.0	0
333999	All Other Miscellaneous General Purpose Machinery	2	$0.0	0
Total:		5	$0.0	0

Grand Total for Van Buren, MI:	**17**	**$25.1**	**189**

Washtenaw, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
326199	All Other Plastics Product Manufacturing	12	$17.5	140
332991	Ball and Roller Bearings	3	$9.5	57
334519	Measuring and Controlling Devices	3	$2.9	19
335999	Electronic Equipment and Components, NEC	1	$0.1	1
334418	Printed circuits and electronics assemblies	2	$0.0	0
Total:		21	$30.0	217

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
334413	Semiconductors and Related Devices	3	$5.3	13
325211	Plastics Material and Resin Manufacturing	1	$0.6	1
334515	Instrument Manufacturing for Measuring and Testing	3	$0.4	2
335999	Electronic Equipment and Components, NEC	1	$0.3	2
335313	Switchgear and Switchboard Apparatus Manufacturing	4	$0.3	2
335931	Current-Carrying Wiring Device Manufacturing	1	$0.1	1
332322	Sheet Metal Work Manufacturing	2	$0.0	0
Total:		15	$7.0	21

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333911	Pump and Pumping Equipment Manufacturing	1	$1.6	8
Total:		1	$1.6	8

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333999	All Other Miscellaneous General Purpose Machinery	5	$4.9	34
333411	Air Purification Equipment Manufacturing	1	$4.4	33
333911	Pump and Pumping Equipment Manufacturing	1	$0.4	2
332911	Industrial Valve Manufacturing	1	$0.3	2
334513	Instruments and Related Products Manufacturing for	4	$0.1	1
333997	Scale and Balance (except Laboratory) Manufacturing	2	$0.1	0
335999	Electronic Equipment and Components, NEC	1	$0.0	0
335313	Switchgear and Switchboard Apparatus Manufacturing	4	$0.0	0
Total:		19	$10.2	72

Grand Total for Washtenaw, MI:	**56**	**$48.8**	**318**

Wayne, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
332312	Fabricated Structural Metal	27	$49.5	284
326199	All Other Plastics Product Manufacturing	43	$26.8	214
333612	Speed Changer, Industrial	2	$14.0	95
335999	Electronic Equipment and Components, NEC	3	$10.2	66
333613	Power Transmission Equip.	6	$10.2	67
331511	Iron Foundries	4	$4.4	31
334519	Measuring and Controlling Devices	6	$3.9	26
335312	Motors and Generators	3	$0.6	3
333412	Industrial and Commercial fans and blowers	1	$0.5	4
334418	Printed circuits and electronics assemblies	1	$0.2	1
Total:		96	$120.3	791

Solar

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
335999	Electronic Equipment and Components, NEC	3	$25.7	166
335931	Current-Carrying Wiring Device Manufacturing	1	$20.3	155
325211	Plastics Material and Resin Manufacturing	3	$14.9	20
326113	Unlaminated Plastics Film and Sheet (Except Packaging)	4	$9.6	38
334515	Instrument Manufacturing for Measuring and Testing	4	$3.1	14
332322	Sheet Metal Work Manufacturing	30	$2.7	22
335313	Switchgear and Switchboard Apparatus Manufacturing	3	$1.1	6
Total:		48	$77.4	421

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333412	Industrial and Commercial fans and blowers	1	$6.3	45
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	4	$3.4	12
332410	Power Boiler and Heat Exchanger Manufacturing	2	$1.1	7
333415	Air-Conditioning and Warm Air Heating Equipment and	3	$0.3	1
333923	Overhead Traveling Crane, Hoist, and Monorail System	3	$0.2	1
333911	Pump and Pumping Equipment Manufacturing	1	$0.1	1
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.1	0
333912	Air and Gas Compressor Manufacturing	1	$0.1	0
Total:		16	$11.6	67

Biomass

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333411	Air Purification Equipment Manufacturing	2	$5.2	39
332410	Power Boiler and Heat Exchanger Manufacturing	2	$3.6	26
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased	4	$1.7	6
333922	Conveyor and Conveying Equipment Manufacturing	11	$1.1	7
333412	Industrial and Commercial fans and blowers	1	$0.8	6
335999	Electronic Equipment and Components, NEC	3	$0.4	3
333999	All Other Miscellaneous General Purpose Machinery	17	$0.3	2
333923	Overhead Traveling Crane, Hoist, and Monorail System	3	$0.1	0
333415	Air-Conditioning and Warm Air Heating Equipment and	3	$0.1	1
335313	Switchgear and Switchboard Apparatus Manufacturing	3	$0.1	0
333997	Scale and Balance (except Laboratory) Manufacturing	1	$0.1	0
332420	Metal Tank (Heavy Gauge) Manufacturing	1	$0.0	0
335311	Power, Distribution, and Specialty Transformer Manufacturing	1	$0.0	0
334513	Instruments and Related Products Manufacturing for	5	$0.0	0
333995	Fluid Power Cylinder and Actuator Manufacturing	6	$0.0	0
333912	Air and Gas Compressor Manufacturing	1	$0.0	0
333911	Pump and Pumping Equipment Manufacturing	1	$0.0	0
333120	Construction Machinery Manufacturing	3	$0.0	0
Total:		68	$13.5	90

Grand Total for Wayne, MI: 228 $222.8 1,369

Wexford, MI

Wind

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
331511	Iron Foundries	1	$16.3	114
326199	All Other Plastics Product Manufacturing	1	$0.2	1
332312	Fabricated Structural Metal	1	$0.1	1
Total:		3	$16.6	116

Geothermal

NAICS	NAICS Description	# of Firms in NAICS	Millions $ Investment	New FTE Jobs
333132	Oil and Gas Field Machinery and Equipment Manufacturing	1	$0.0	0
Total:		1	$0.0	0

Grand Total for Wexford, MI: 4 $16.6 116