MACKINAC CENTER
FOR PUBLIC POLICY

ELECTRICITY IN MICHIGAN: A Primer

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Introduction

Electricity: An Essential Aspect of Human Flourishing

In a 2015 publication, the Institute for Energy Research argues that "affordable energy allows the economy to become more efficient, lowers the cost of goods, and saves us money."[1] The authors point out that easy access to energy improves our productivity and affords us additional free time that we otherwise would not have. This free time can then be used to further increase our productivity or be used for relaxing and spending time with friends and family, or for hobbies or other activities that generally make our lives more enjoyable.

This idea is key to understanding the value of easily accessible energy to our lives. Access to on-demand energy enables us to automate tasks that previously required significant manual effort, such as keeping warm, growing and harvesting food and traveling and transporting goods, among other things. With this perspective in mind, it's clear that, overall, access to energy improves human well-being and enhances our quality of life.

But public policy that guides the production, distribution and use of energy is a complex and complicated matter. The goal of this primer is to make it clear how we obtain the energy that powers our lives in Michigan. This report will cover how electricity gets generated, distributed, delivered to millions of homes and businesses, and, of course, paid for by taxpayers and consumers.

Reliable and affordable electricity powers, directly or indirectly, almost everything we do on a daily basis. In fact, it is difficult to overstate just how important it is to our modern lifestyles. Access to on-demand, reliable electricity has become such an integral part of our lives that we rarely give it much thought — much like the automatic systems that keep our lungs filled with air or the blood coursing through our veins.

Understanding how the essential energy we use to power our lives is created and transported requires some basic knowledge about how Michigan's electricity system works. Key parts of this system include the regulatory frameworks, electricity generation, the infrastructure used to distribute electricity to our homes and businesses, as well as the mix of public and private organizations that carry out these ends.

Large and dynamic, Michigan's electricity system is in an almost constant state of change and evolution. Old power plants are taken offline and new ones are built. New generation from natural gas plants and renewable energy installations are regularly coming online. Consumers are also constantly changing their consumption patterns — for their own personal reasons, as a result of changing prices, or because of a government mandate or law. We swap outdated appliances and machines for newer, more energy efficient ones. More efficient generation and appliances often lead to lower prices, which can lead to increased overall demand. And we are using more and more electricity to charge hybrid and electric cars, and to power the many connected devices, computers, flat screen TVs, and mobile technologies we have in and around our homes and businesses.

Michigan's electricity system has been organized into three distinct phases, largely as a result of various federal and state laws.[2] This report will address each phase in turn. They are:

1. **Generation:** This is how electricity is created and primarily involves combusting coal or

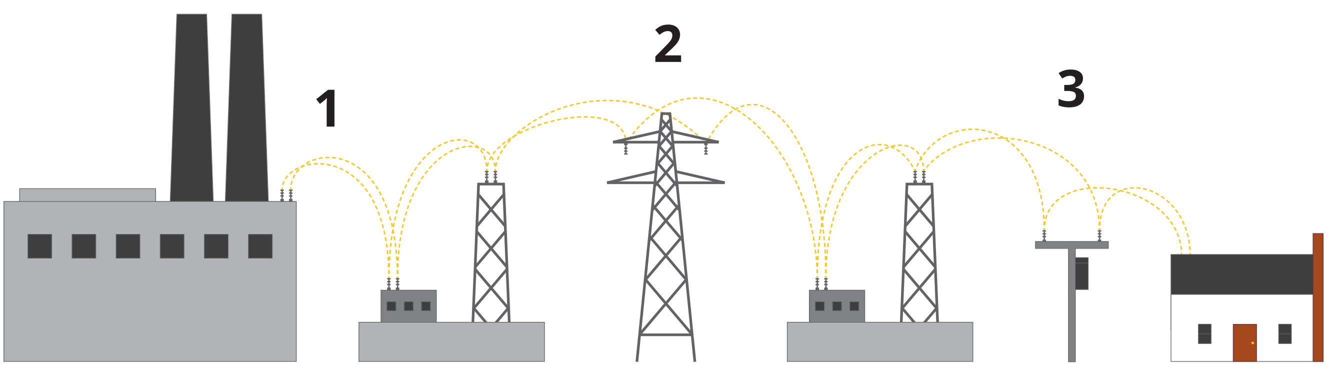
natural gas or splitting uranium atoms to make heat and steam that drives large turbines and generators. Electricity is also generated by capturing geothermal energy and energy from the sun, wind or stored water.

2. **Transmission:** This is how electricity is transferred from where it is produced to where it can be made ready for distribution to "end users," namely homes and businesses.

3. **Distribution:** This is the process of transporting electricity directly to residential or commercial customers for their individual use.

A clear description of how these phases work will help educate Michigan residents about the state's electricity system and hopefully make them better consumers and more informed voters. Reliable and affordable electricity is easy to take for granted, but its impact on our quality of life is immense. Knowing how the system operates is the first step toward fully appreciating the benefits we derive from it and the first step we take to help make it even better.

Figure 1. Electricity Transmission System

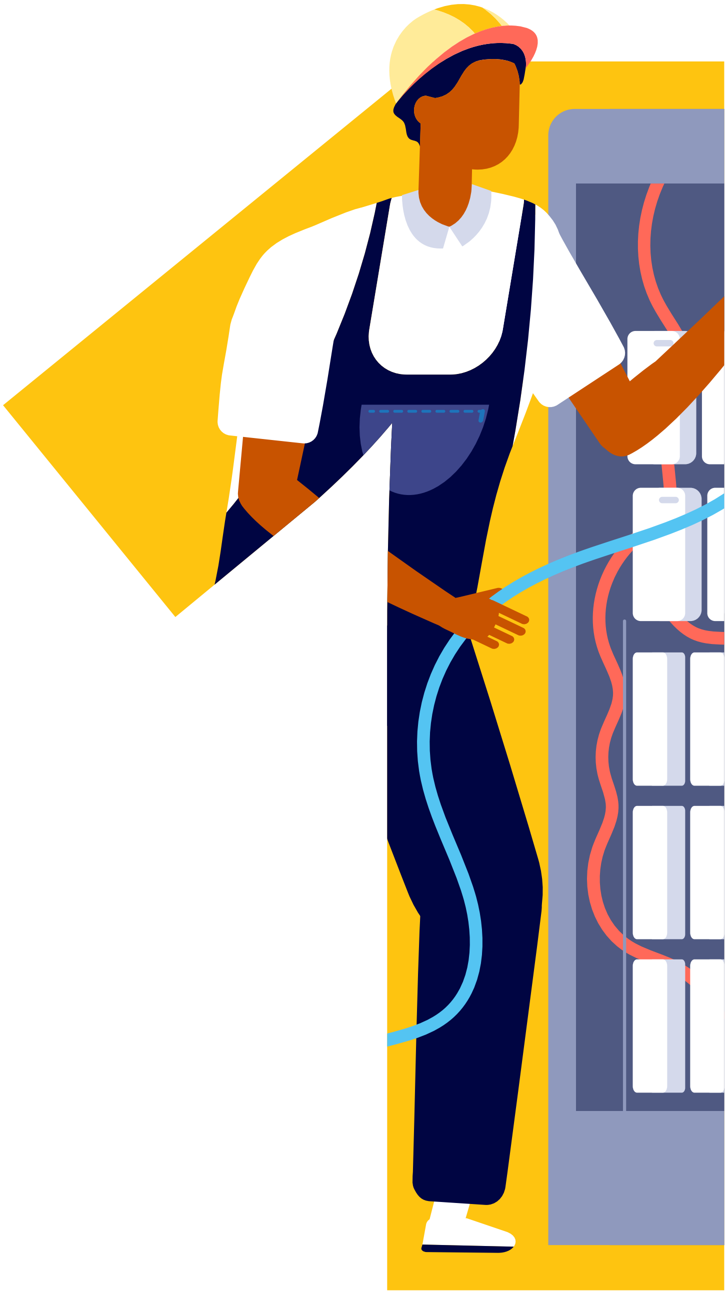


Electricity flows from power stations to homes and businesses through a network of substations and transmission lines.

1. Electricity is directed from the power plant to a substation en route to its destination.

2. The electricity is directed from the substation to the transmission network, which consists of heavy cables strung along towers.

3. The electricity is directed from the substation to a distribution line, which delivers the power to home or business.



How Electricity is Produced in Michigan

Generation Technologies

In electricity generation, various technologies can be used with more than one fuel. Therefore, it is necessary, at least briefly, to distinguish between the technologies that are used to produce electricity and the fuels that can be used with each technology.

Steam Turbine

In this process, a fuel — coal, natural gas, oil, biomass, etc. — is fed into a boiler and combusted, or burned, to produce heat. Fission of radioactive isotopes — uranium, plutonium or thorium — can also be used to produce heat. This energy heats water in pipes that line the boiler or reactor. As heated water expands in this closed loop system, it becomes pressurized steam that moves through the pipes to a turbine. The force of the steam moving over the blades of the turbine causes it to spin, much like a waterwheel is turned by the force of water flowing past it.[*] The shaft connected to the turbine spins an electrical generator that has magnets surrounding a spinning copper coil, or coil surrounding spinning magnets. The electrons in the copper are excited by the changing magnetic field, created by the motion around the magnets, and this produces electricity.

After going past the turbine, the steam is cooled and condensed in a condenser and is recycled back through the system to be reheated into steam again. In some cases, the so-called "waste heat" from the condensation process can also be captured and used to heat adjacent buildings — a process called "district heating," or "combined heat and power."[3]

Steam turbines are a widely used and well-tested method of producing electricity and have been the primary means used to produce electricity around the world since the late 1800s. The U.S. Department of Energy refers to them as a "mature technology" and notes that they are used to produce the majority of electricity in the United States.[4]

The benefits of this technology are that it is extremely well understood and has been used extensively for centuries. It also uses steam as the primary force for moving the turbine to generate electricity. Water is typically inexpensive to access, widely available and very safe for people and the environment.

The challenges associated with this technology tend to be more related to the specific fuels chosen to drive the generator. Those challenges are discussed in specific fuel sections later on.

Simple-Cycle Combustion Turbine

In addition to steam turbines, single-cycle combustion turbines are also used to produce electricity. Functionally, these turbines are different than a steam turbine and are more like a jet engine. Combustion turbines combust compressed outside air with fuels, like natural gas, to directly drive a

* The process used in this setting is typically the Rankine cycle. For more information, see: Bethel Afework et al., "Rankine Cycle" (University of Calgary, July 21, 2018), https://perma.cc/QZX6-ZJX9.

Figure 2. Figure Steam Turbine (coal)

Source: Center for Climate and Energy Solutions

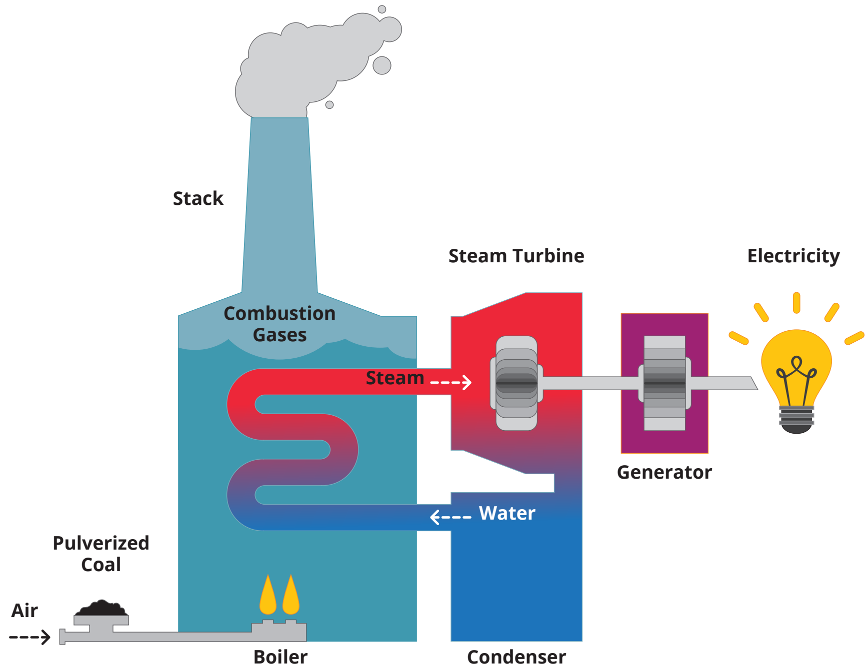
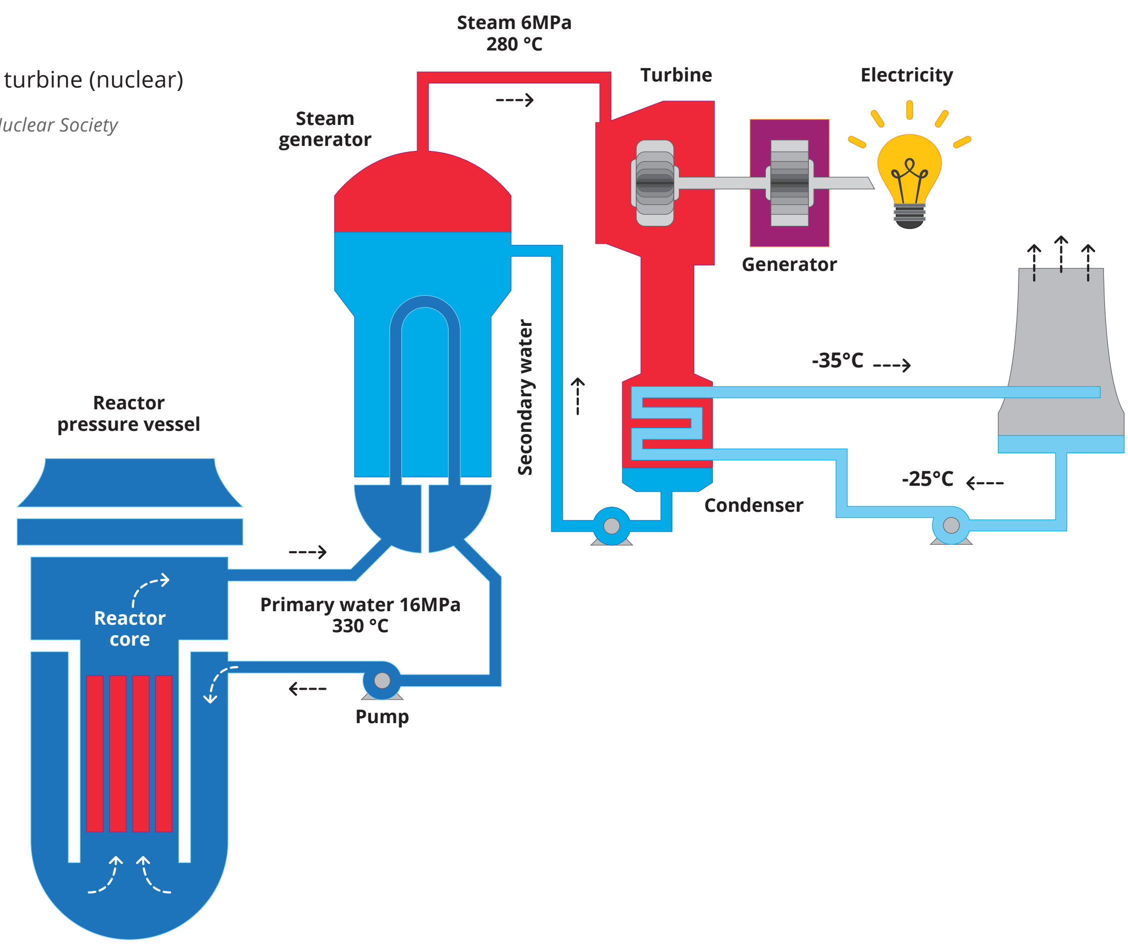


Figure 3. Steam turbine (nuclear)

Source: European Nuclear Society



turbine that also drives an electrical generator to produce electricity.*

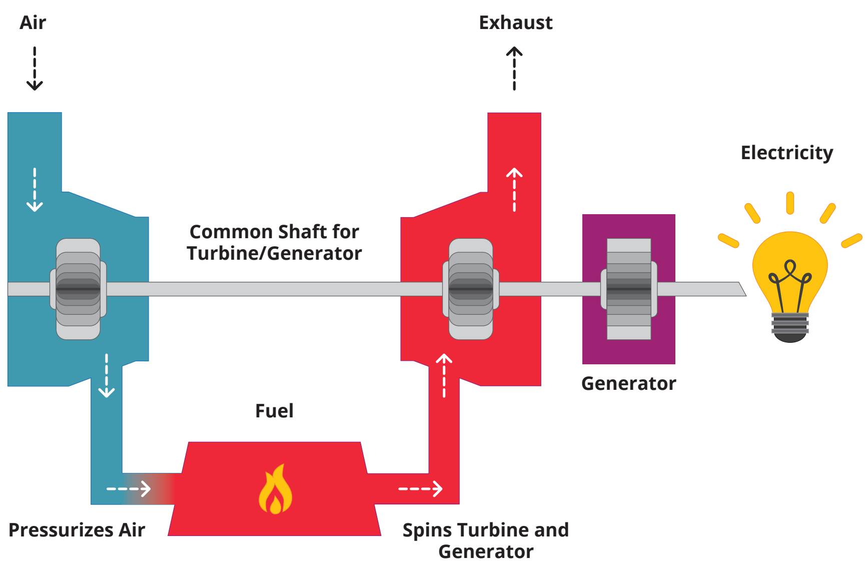
Combustion turbines are typically used in a "peaking" capacity and also provide a relatively fast ramping source of electricity to pair with the variable nature of renewable energy, or to effectively "top up" the grid during times of peak demand. They are relatively inexpensive to build and rely on relatively inexpensive natural gas to produce electricity at an affordable price.[5]

Due to the fact that they use fuel to drive a single turbine, they are less efficient than combined cycle turbines. In fact, they typically have 35-44% thermal efficiency, which is similar to traditional coal plants.† Additionally, since they can take 10 to 15 minutes to start up, they are often ramped up and left to run as "spinning reserve," which means they are left running to be able to respond immediately to changing demand across the grid, but are not necessarily always producing electricity.[6] This state is similar to an idling automobile.

Simple-cycle combustion turbines can be switched into and out of electricity producing mode, or run at varying loads — a process called cycling — when variable renewable generation comes on and goes offline.[7] Running these turbines continuously, even though they may not be producing electricity, produces emissions similar to having the turbine always producing electricity, which can negatively impact efficiency and emissions reductions goals.[8]

Figure 4.
Simple-Cycle Combustion Turbine

Source: Duke Energy



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* The process used in this setting is typically the Brayton cycle and can be either a closed or open cycle turbine. For more information, see: Jordan Hanania et al., "Brayton Cycle" (University of Calgary, July 21, 2018), https://perma.cc/U5PE-65XK.

† Thermal efficiency is the ratio of work completed by an engine to the amount of heat input into the engine. For more information, see: Bethel Afework et al., "Thermal Efficiency" (University of Calgary, May 18, 2018), https://perma.cc/8TXA-EUVU.

Combined-Cycle Gas Turbine

CCGT combine the previous two technologies — steam turbines and combustion turbines — together to produce electricity. They use the direct combustion of air and fuel — primarily natural gas — to drive a combustion turbine, as well as to produce pressurized steam. Water is heated by the exhaust, or waste heat, from the first turbine, to create the steam to drive a second steam turbine.[9]

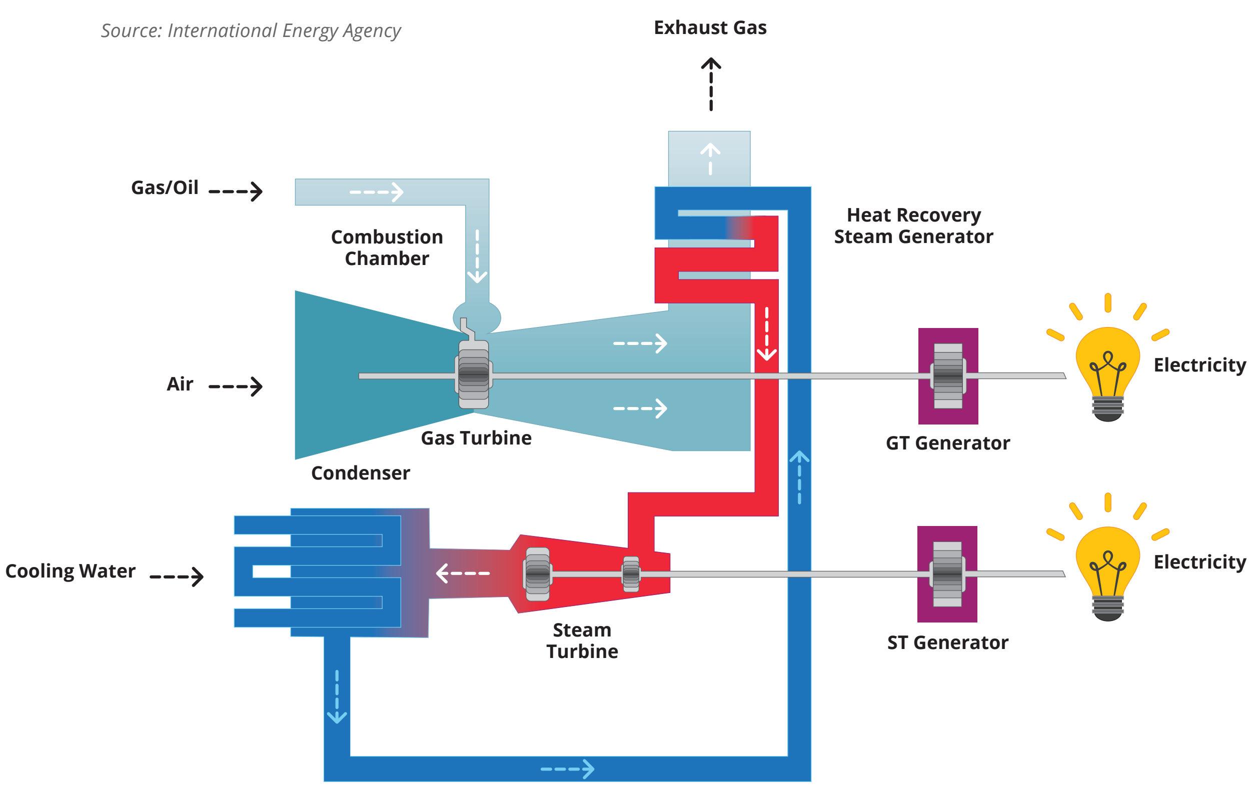
By combining the two systems like this, the overall result is improved efficiency. That is, generators are able to produce more electricity from the same amount of fuel than would be the case with a single-cycle turbine.[10] CCGT achieve thermal efficiencies of 52%-62%.[11] The benefits associated with using CCGT for power generation include capitalizing on the currently low cost of natural gas, increased thermal efficiencies, and the ability to operate this type of generation as baseload generation.

Internal Combustion Engine

Internal combustion engines operate in a manner similar to the engine in your automobile. Electricity generators burn some form of fuel, like natural gas, landfill gas, petroleum liquids or diesel in the engine. But, instead of turning a drive shaft that is connected to the wheels on your car, the shaft coming from the engine is connected to an electric generator. The

Figure 5. Simplified View of Combined-Cycle Gas Turbine

Source: International Energy Agency



generator operates in the same manner as the steam turbine described in a previous section, with copper coils located adjacent to a strong magnetic field as the means to generate electricity.

EIA numbers indicate that there are over 250 separate internal combustion engines operating in Michigan, but they tend to be very small, averaging 2.1 MW capacity.[12] As with combustion turbines, they tend to be used in a peaking capacity, providing electricity to "top up" electric production during periods of increased demand, or to provide energy when other sources are not available.

A key benefit of this technology is that it is relatively inexpensive to build, is very well understood and widely available, even for small or localized applications. This technology also fits well with the widely variable nature of generation from renewable technologies. Internal combustion engines are able to "ramp up" to full production in as little as five minutes, when the wind speeds drop below (or go above) the generation threshold for wind turbines, or when there is little sunlight to power solar generation.[13]

Challenges associated with using internal combustion engines include the emissions commonly associated with the combustion of fossil fuels, like nitrogen oxides, sulfur dioxide and particulate matter. Additionally, the fast-ramping and typically smaller generation capacities of these engines makes them less well suited to baseload operations than combined-cycle turbines, coal-fueled, nuclear options, or large hydroelectric options.

Hydroelectric

Conventional hydroelectric plants use gravity and the potential energy stored in an elevated reservoir of water to force water through a turbine and generator. There are over 225 small conventional hydroelectric generators that are in operation across the state of

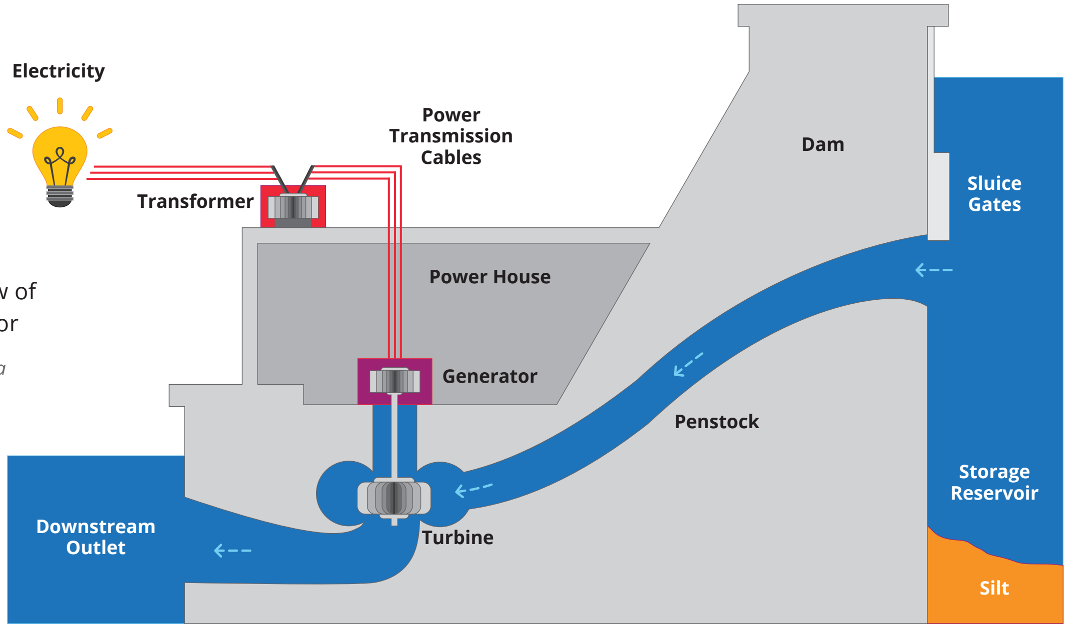


Figure 6. Simplified View of Hydroelectric Generator

Source: Environment Canada

Michigan.* The Ludington Pumped Storage Plant is a much larger hydroelectric facility — reported by Consumers Energy as having a total nameplate capacity of 1,875 MW — that is in the midst of an upgrade and expansion.[14] Consumers Energy reports that, when completed, the station's capacity will be expanded to 2,172 MW.[15]

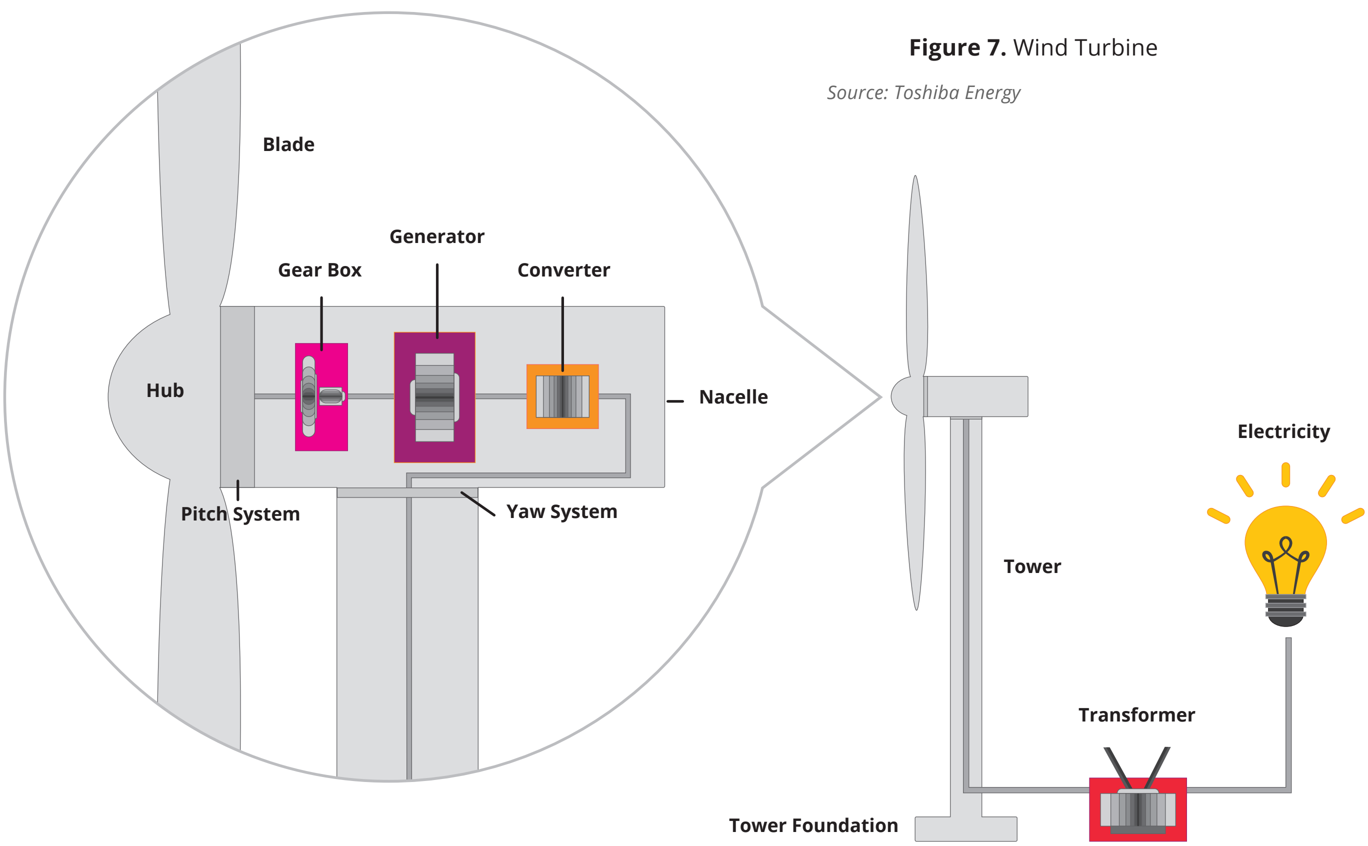
In the evening, when electricity prices are relatively low, the Ludington Pumped Storage Plant reverses its turbines and consumes electricity to run pumps and move water from Lake Michigan, uphill and into a 1.3 square mile reservoir. That water is held in the reservoir until the next day, when electricity prices are higher, or there is a need for additional generation capacity. Then, the water is released, and run back through the generators to produce electricity that is fed into the state's grid. The water in the reservoir effectively acts like a big battery that is recharged when electricity prices are low and depleted when they are higher.

Wind

As water spins the turbine in hydroelectric generation, wind spins the blades on a wind

Figure 7. Wind Turbine

Source: Toshiba Energy



* The average nameplate capacity of Michigan's conventional hydroelectric generation is 1.6 MW. The largest producer is 11.5 MW. Source: U.S. Energy Information Administration, Form EIA-860.

turbine, which in turn spins a generator within the turbine housing — also called a nacelle — to produce electricity. Wind turbines come in a mix of sizes, shapes and generation capacities. The U.S. Department of Energy and Lawrence Berkeley National Laboratory reports that the average hub height of newly installed wind turbines in the U.S. in 2017 was 282 feet. The average rotor diameter of those newly installed turbines was 370 feet.[16] Together, they would give these new turbines an average total height of about 468 feet.

As one specific example of the technology, the Vestas V90, a widely used turbine model, has a 2.0 to 2.2 MW maximum capacity, a 295-foot rotor diameter, and sits atop of a tower that is between 262 to 344 feet — for a total height of as much as 492 feet.[17] This is roughly the height of a 40-story building. To provide some contrast, the Statue of Liberty is 305 feet, about two-thirds the height of the taller Vestas V90 installations.

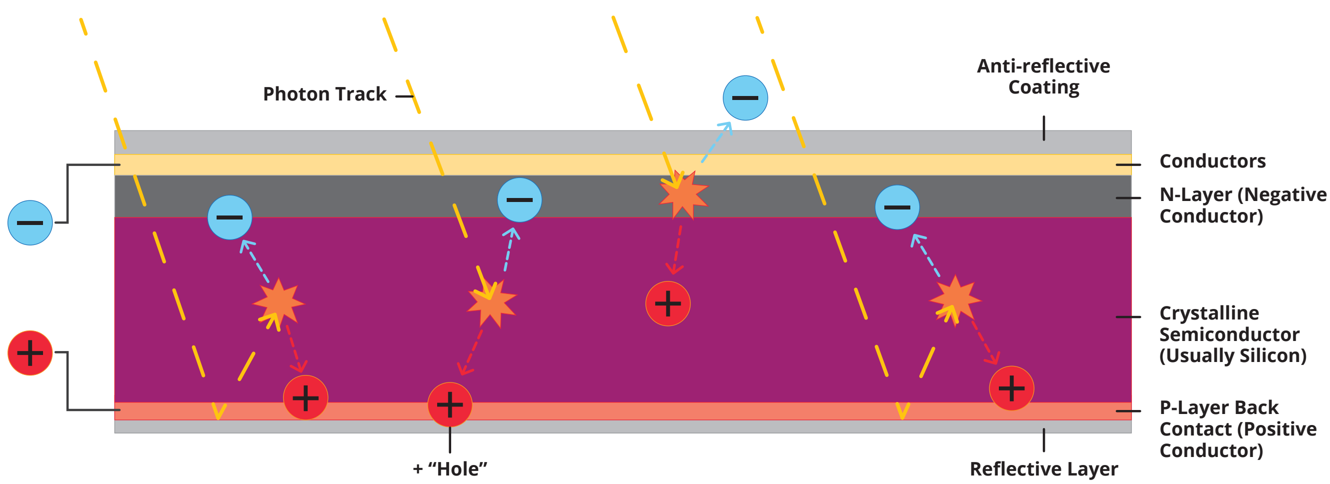
As wind power development expands, larger turbines on taller towers are being used. A 2015 Iowa news article described a 554-foot tall turbine — a 377 foot tall tower paired with a 177 foot blade — that is almost as tall as the Washington Monument, which is 555 feet tall.[18] Another massive turbine was installed at Texas A&M University in May 2018 that had a blade tip height of 654 feet.[19]

Solar Photovoltaic

Solar photovoltaic, or solar PV, electricity differs from other generation options in that it does not spin a turbine and generator to produce electricity; it produces electricity directly. As light strikes a

Figure 8. Electricity generation within a photovoltaic solar cell

Source: UMR Geothermal



solar cell, electrons within the cell are excited into movement. That movement creates a current within the crystalline semiconductor that makes up the bulk of the solar cell. That current is then collected and transmitted as electricity.[20]

Solar energy is typically produced by small, individual cells that are grouped together in panels or modules. Many of these modules are grouped together in larger units called arrays. Small groups of arrays are often installed in distributed generation setups on individual homes and businesses. These are often called “rooftop” or “residential” solar.[21]

At the utility-scale, many arrays can be grouped together in larger industrial power stations. The largest, and most productive, of these solar generation facilities are in southwestern states.[22] However, solar facilities are also being constructed in Michigan. The Turrill and Demille Solar facilities in Lapeer went online in 2017 with a maximum capacity rating of 19.7 MW and 28.6 MW respectively.[23] Utility plans indicate their intention to build many thousands of megawatts more solar over the next several years.[24]

Resources Used to Generate Michigan's Electricity

Electricity in Michigan is generated from several different sources. In 2018, coal represented the largest single source, providing more than a one third of the state's total production. Natural gas and nuclear both generate more than a quarter of all energy generated in Michigan. Together, these three sources account for nearly 90% of all the electricity generation in the state.

The map on the following page shows where electricity is generated in Michigan. Most generation happens in the lower part of the Lower Peninsula, somewhat unsurprising as this is where most of the state's population resides. Most of the state's coal plants are located near coastlines, which allow access to water for cooling. Both nuclear power plants are also located on coastlines. Natural gas power plants are more evenly distributed, although many are located along major interstate highways, such as I-94 and US-31/I-196 and along existing pipeline routes. Most of the hydroelectric plants are in the

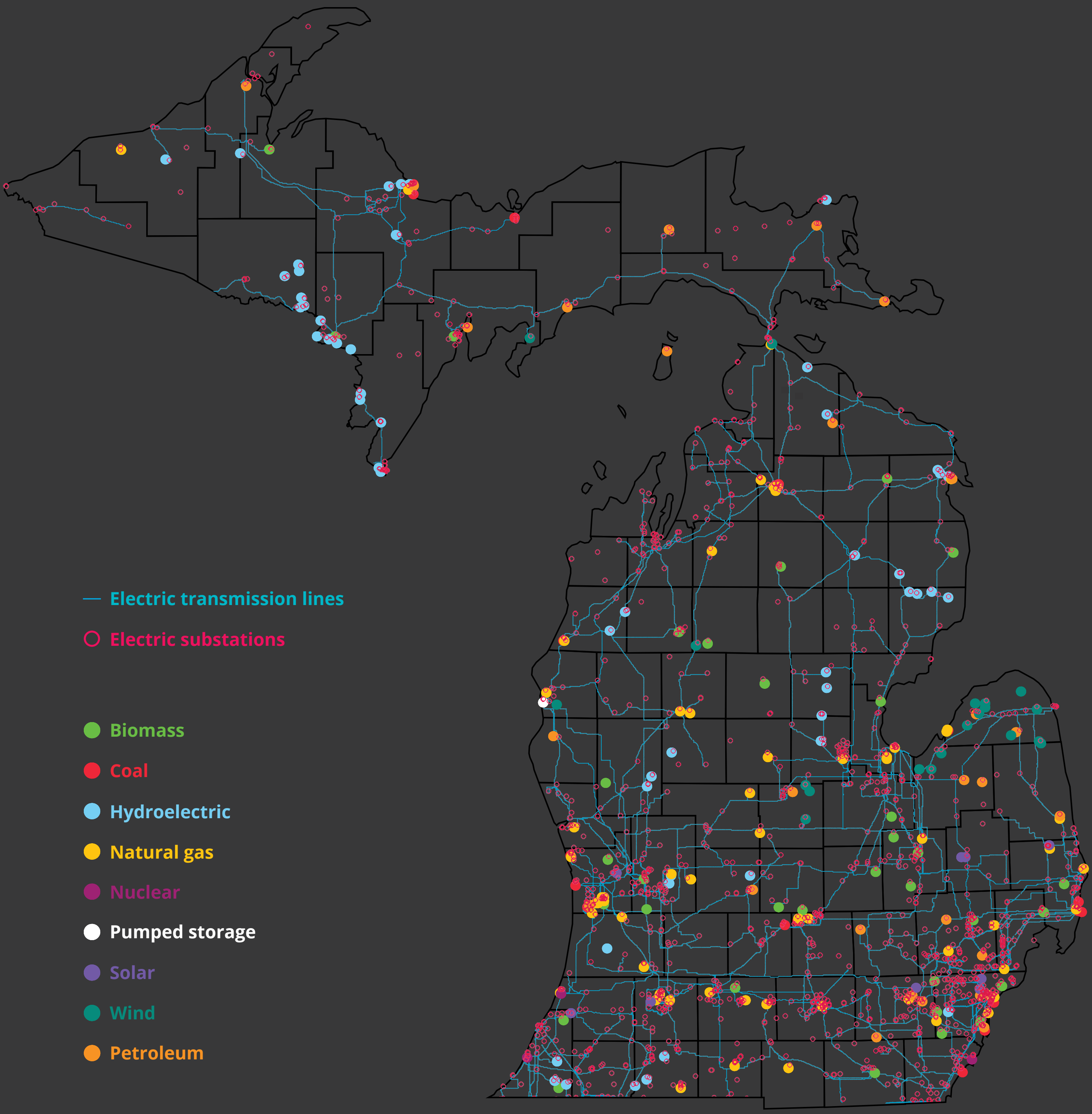
Michigan Net Generation All Fuels for All Sectors, 2018

Category	MW hours (x1,000)	Percent
Coal	42,331	36.5%
Petroleum liquids	117	0.1%
Petroleum coke	1,096	0.9%
Natural Gas	30,987	26.8%
Other Gases	1,598	1.4%
Nuclear	30,479	26.3%
Conventional hydroelectric	1,569	1.4%
Hydroelectric pumped storage	-698	-0.6%
Wind	5,457	4.7%
Solar	197	0.2%
All Biomass	2,531	2.2%
Other	252	0.2%
Total	**115,837**	**100.00%**

Source: U.S. Energy Information Administration, Dec. 2019. Figures do not sum due to rounding.

Figure 9. A broad overview of Michigan's electricity generation and transmission system.

Source: United States Energy Information Administration



northern part of the Lower Peninsula and in the Upper Peninsula, while most of the wind production happens in the state's Thumb region.

As shown in the table below, while the total amount of generated electricity in Michigan in any given year remains relatively unchanged year to year, the makeup of the resources used to generated that electricity regularly varies. Since 2001, Michigan's reliance on coal for electricity generation has declined significantly, with natural gas, nuclear and petroleum sources comprising a larger share of the total. Over the period, wind and solar went from barely used to a regularly contributor, although they still combined to produce approximately 5% of all electricity generated in Michigan in 2018.

Michigan Net Electricity Generation by Source, 2001-2018
(in thousands of megawatt hours)

	Total Electric Industry	Natural Gas	Nuclear	Coal	Wind	All Solar	Conventional Hydro	Biomass	Petroleum & Other Gas
2001	111,846	13,174	26,711	68,263	0	0	1,562	2,361	756
2002	117,889	15,853	31,087	66,700	0	0	1,669	2,229	1,114
2003	111,347	11,375	27,954	67,777	3	0	1,386	2,495	1,066
2004	118,487	14,548	30,562	68,606	2	0	1,540	2,557	1,495
2005	121,620	13,764	32,872	70,323	2	0	1,462	2,492	1,250
2006	112,557	11,410	29,066	67,780	2	0	1,520	2,440	814
2007	119,310	13,141	31,517	70,811	3	0	1,270	2,414	981
2008	114,990	9,602	31,484	69,855	141	0	1,364	2,450	722
2009	101,203	8,420	21,851	66,848	300	0	1,372	2,323	602
2010	111,551	12,249	29,625	65,604	360	0	1,251	2,472	681
2011	109,170	12,982	32,889	58,948	456	0	1,357	2,506	612
2012	108,166	21,748	28,020	53,136	1,132	0	1,215	2,654	640
2013	105,418	12,341	28,921	56,291	2,800	0	1,419	2,715	1,489
2014	106,817	12,523	31,246	52,884	3,868	0	1,600	2,806	2,171
2015	113,008	20,045	29,334	52,884	4,797	1	1,499	2,485	2,039
2016	112,122	29,295	31,552	40,527	4,696	9	1,564	2,495	2,434
2017	112,314	26,131	32,381	42,021	5,191	63	1,679	2,494	2,769
2018	115,837	30,987	30,479	42,331	5,457	118	1,569	2,531	2,811

Source: United States Energy Information Administration

Fossil Fuels

Natural Gas

EIA reports that, in 2018, total dry gas, or consumer-grade natural gas, production in Michigan was 89.525 million cubic feet, ranking Michigan as the 18th largest producer of natural gas in the nation.[25] Declining natural gas prices have impacted the profitability of drilling across the nation, and as a result, many companies have reduced the number of conventional drill rigs they have in service. In their place, oil and gas producers are focusing more on hydraulic fracturing, also known as "fracking." Michigan appears to have been similarly impacted as the number of active conventional drills in the state have decreased by just under 10% since the 2009 high of 10,600.[26] Fracking activity in Michigan remains relatively "limited overall compared to the volume of activities in other states."[27]

Despite declining production in Michigan, as in the rest of the nation, natural gas is playing an increasingly important role in electricity generation. In 2018, it was used to produce over 27% of Michigan's electricity. Michigan's utilities have committed to closing the vast majority of the state's coal-fired electricity generation capacity, and they expect to replace that lost capacity with a mix of natural gas and renewable capacity.[28]

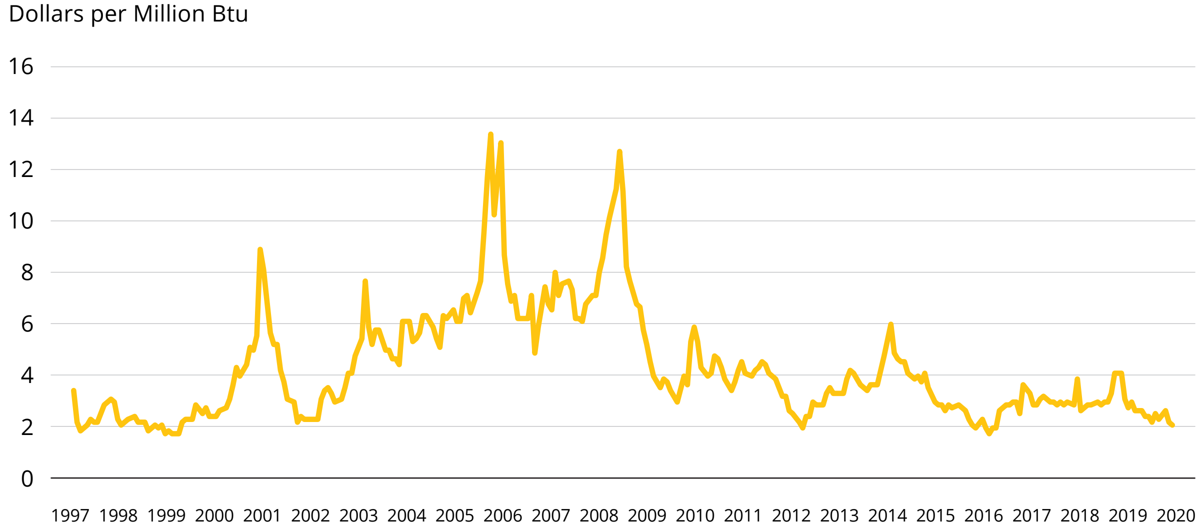
This expectation is being pursued by DTE in the form of its 1.1 GW natural gas plant, the Blue Water Energy Center[29], that is scheduled to be completed in 2022, in St. Clair County's East China Township, approximately 50 miles northeast of Detroit.[30] DTE predicts that by 2040 they will rely on a mix of natural gas, nuclear, and renewable sources to cut their CO2 emissions to net-zero by 2050.[31] Consumers Energy has announced plans to close all their remaining coal plants by 2040, and to rely on a mix of renewable energy, demand response, energy efficiency and a reduced amount of natural gas.[32] In February 2020, they announced a further goal to achieve net-zero CO2 emissions by 2040.[33] WEC Energy has closed the coal-fired plant near Marquette and that plant has been replaced with two natural gas plants.[34]

These utility plans are a substantial change for the state. For many years, Michigan relied heavily on coal-fired generation to supply the majority of its electricity, but public concern over climate change, increasingly strict environmental regulation, renewable mandates, heavily subsidized renewable generation and changing market conditions that significantly reduced natural gas prices have pushed Michigan's utilities to move away from coal.

The benefits associated with using natural gas to produce electricity include a growing supply of a relatively clean and low-cost domestic fuel. As a result of the fracking revolution, natural gas reserves in the United States have grown rapidly. In fact, official estimates were reporting as little as seven to 10 years of remaining natural gas reserves in the early 2000's. But, the advent and widespread application of fracking technologies in North America have expanded measured natural gas reserves to just under 90 years in the United States.[35] Where the nation had been planning to site liquified natural gas, or LNG, terminals to import LNG in the early 2000's, we are now building export terminals to supply world markets with American natural gas.[36]

The massive growth of natural gas production in the

Henry Hub Natural Gas Spot Price



Source: United States Energy Information Administration

U.S. has led to a reversal in supply and, as a result, prices for gas have dropped substantially. In the U.S., natural gas prices in July 2008 had peaked at over $13 per MMbtu (one million btus) and typically ranged between $5 to $9 per MMbtu. In the closing months of 2020, natural gas prices have been consistent at around $2.15 per MMbtu.[37]

Natural gas is also a very clean fossil fuel generation option. When used in electricity generation, natural gas emits almost zero particulate matter, and — compared to other fuel options — substantially lower nitrogen oxides, sulfur dioxide or mercury.[38] For those concerned about climate change, natural gas also presents a good option as it emits approximately half as much CO2 as coal-fueled generation, while still ensuring reliable, baseload electric supply.[39]

Some of the challenges associated with using natural gas are that the state is moving in the direction of relying so heavily on this one fuel that there are reasonable concerns about pricing and supply. As the graph above shows, natural gas has historically had a volatile price structure. While the massive increase in natural gas supply has moved the electricity market toward a longer-term commitment to using natural gas, a disruption in supply could potentially cause an upward price swing or force restrictions on energy availability. Given that Michigan's utilities are all planning to expand their use natural gas as their primary generation fuel, even a small uptick in price could have a large impact on electricity prices or supply for the entire state.

The state had a real-life example of just this type of situation in January 2019. A sudden restriction in supply during an extreme cold spell forced Gov. Gretchen Whitmer to ask Michigan residents to restrict their use of natural gas by lowering their thermostats to 65°F. Extreme cold weather had pushed demand much higher when a fire and explosion at a major natural gas facility compelled

utilities to drastically curtail natural gas use across the state. This accident introduced the state to the concept of "demand response," a situation that occurs when utility customers must reduce overall energy demand to avoid system instability or shutdowns.[40]

Coal

Coal provided approximately 60% of Michigan's electricity from 2001 to 2010, and peaked in 2009 at 66%. But a mix of increased competition from less expensive natural gas, a blend of subsidies and state-level mandates for renewable energy sources and increasingly heavy environmental regulation all took a heavy toll on coal use in Michigan.[41] These pressures, along with increasing public pressure to switch to different fuels, caused total coal-fired generation in the state to decrease to 36.5% in 2018.

Michigan's coal use began to drop in 2010 off as utility planning committed to close the state's coal-fired generation capacity and replace it with a mix of energy efficiency, demand response, conservation measures and the construction of new natural gas and renewable capacity. Citing a mix of regulatory, market and social pressures, DTE has stated that it plans to close all of its coal plants by 2040 as part of its efforts to achieve net-zero CO2 emissions by 2050.[42]

Consumers Energy made similar reductions in its coal-fueled generation fleet when, in 2016, it closed its "Classic Seven" coal plants, representing 950 megawatts — two units at the B.C. Cobb Plant, three units at the J.R. Whiting Plant and two units at the Karn-Weadock Plant.[43] They have expanded on this plan with the MPSC's approval of their Integrated Resource Plan in June 2019. Now referred to as their 2019 Clean Energy Plan, this document commits the utility to closing all of their coal-fired generation by 2040, the construction of over 6,800 MW of solar and wind generation facilities, and implementing an aggressive mix of demand response, conservation and energy efficiency measures.[44] As noted above, the company has also committed to achieving net-zero CO2 emissions by the year 2040.[45]

As also noted above, WEC Energy closed the coal-fired Presque Isle plant near Marquette in April 2019.[46] Upper Michigan Energy Resources has completed construction of two natural gas generation stations to replace Presque Isle.[47]

The benefits of using coal include its abundance, ease of shipping and use, and relatively low cost, with currently operating plants producing substantial amounts of reliable electricity at rates as low as $38.40 per megawatt-hour.[48]

Coal-fueled generation units have also provided a substantial level of system stability to the state and national electrical grid, due to their size and the fact that they are designed to run almost continuously — as baseload generation resources, with capacity factors as high as 80%, significantly more than wind or solar.[49] Energy industry and government experts have expressed concerns that the rapid closure of numerous coal plants could cause problems with overall grid stability, especially during times of high demand such as extreme hot or cold weather.[50]

The challenges associated with using coal to produce electricity primarily relate to addressing the fuel's environmental impacts. Just like when a homeowner heats their home with a fireplace,

smoke is released from the burning wood, and goes up the chimney, the combustion of coal to produce electricity has similar results. Emissions from coal can include:

- Oxides of sulfur and nitrogen — commonly called NO_X and SO_X,
- Carbon monoxide,
- Particulate matter ($PM_{2.5}$ and PM_{10}),
- Trace heavy metals, like mercury and selenium,
- Carbon dioxide,
- Water vapor, and
- Nitrous oxide.[51]

Pollutants and GHGs are both heavily regulated at state and federal levels and must be monitored and limited by the companies that produce electricity. There are various compendiums of information on these technologies on the DOE, EPA, and National Energy Technology Laboratories websites.

There are also a variety of clean coal technologies and methods of combustion designed to capture pollutants and reduce emissions during and after combustion. A few of these include carbon capture utilization and storage — also called CCUS, low NOX boilers, flue-gas desulfurization, selective catalytic reduction, chemical/gas/wet/dry scrubbers, gasification, and others.[52] However, installing these emissions reductions technologies to coal-fueled generation plants can add many millions of dollars to the cost of a plant and make the electricity produced by the plant more expensive and relatively less competitive with other generation options.[53]

Coal use for energy production is also subject to a host of strict environmental regulations, such as the Cross State Air Pollution Rule, the Mercury and Air Toxics Standard, New Source Review, the New Source Performance Standards implemented under the authority of Section 111 of the Clean Air Act, the Affordable Clean Energy Rule and others. It is not possible to fully cover the breadth of these regulations in this paper. But, it is possible to note that the creation of these and other regulations have, regardless of market pressures or public opinion, effectively made it impossible to build any new coal-fired power plant in the U.S.

Petroleum

Petroleum fuels — gasoline, diesel, fuel oil, kerosene, etc. — are used to a limited extent in steam turbines, combustion turbines or combined-cycle turbines.

The vast majority of petroleum products — not natural gas — that are consumed in Michigan are used for transportation or domestic uses, such as home heating and cooking.[54] All petroleum sources — including petroleum liquids, petroleum coke, and other gases — made up less than 3% of electricity generation in 2018 in Michigan.[55]

Nuclear

Nuclear energy has had a varied history across the nation. Once marketed as the means to make electricity too cheap to meter, later concerns over radiation and spent fuel storage have helped to reduce the push for new nuclear construction. After experiencing an extended lull in the development of new nuclear facilities in the U.S., the industry has only very recently been able to obtain approvals for the construction of new plants in other states.[56] Despite that difficulty, nuclear energy has been a remarkably stable generation source for Michigan, providing an average of almost 27% of Michigan's electricity from 2001 to 2016. In 2018, nuclear energy provided Michigan with 26% of its net electric power generation. This stability is associated with the fact that, once built and operating, nuclear plants can effectively run for years at a time with only basic supervision and maintenance required.[57]

There are currently four nuclear reactors operating at three generation plants in the state of Michigan. Together, they provide almost 82% of the state's CO2-free electricity.[*] One of these plants — the Palisades plant, located near Covert — is scheduled to close in 2022. Currently owned and operated by Entergy Corp., Consumers Energy has a power purchase agreement that commits them to purchasing almost all of the electricity produced by the plant — approximately 6,800 GWh of electricity each year — until April 2022.[†]

DTE has also stated that, after a six-year, $100 million investment, the utility will hold onto its Nuclear Regulatory Commission license to expand its nuclear power investments by building the Fermi 3 nuclear plant. They received NRC approval for Fermi 3 in 2015. However, the economics of a new nuclear plant are not currently motivating the utility to build. Their decisions to close other baseload coal assets makes it possible that they could still require new baseload capacity (above and beyond the Blue Water Energy Center).[58]

As with all other energy sources, there are benefits and costs associated with using nuclear energy to produce electricity. The benefits include electric energy that does not produce the pollutants associated with other fuels. The products of combustion — NO_X, SO_X, particulate matter, carbon dioxide, etc. — are not associated with nuclear energy because nuclear fuels are not burned to produce heat.

Another benefit of using nuclear energy includes a near limitless supply of affordable electricity with very little fuel. According to the Nuclear Energy Institute, a nuclear industry trade education and advocacy organization, the energy contained in a quarter-inch by quarter-inch pellet of uranium

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* "Fact Sheet: Michigan and Nuclear Energy" (Nuclear Energy Institute, April 2019), https://perma.cc/PK9N-7RUF.; Noting that an energy resource is "emissions-free" only refers to the actual generation component. Mining and processing of fuel, construction of the generation facility and transmission lines, as well as maintenance of the infrastructure, and the resources needed for these endeavors all involve the use of energy and emissions of CO2, and other pollutants. No energy source is completely emissions-free.

† Both Consumers and Entergy had agreed to terminate the power purchase agreement early and to close the plant in 2018. However, Entergy had sought $172 million in recovery costs for the early closure. The Michigan Public Service Corporation ruled that the recovery costs sought by Entergy for the early closure were too high and approved $136.6 million in recovery, causing both companies to rethink the early closure. Malachi Barrett, "Palisades Contract Buy-Out Could Save Consumers Energy Customers Millions" (MLive Media Group, May 9, 2017), https://perma.cc/932L-BQB6; "Company Delays Planned Closure of Michigan Nuclear Plant" (AP News, Sept. 28, 2017), https://perma.cc/W86P-8UV5.

fuel — about the size of a pencil eraser — holds the same energy potential as 17,000 cubic feet of natural gas, one ton of coal, or a bit more than 3.5 barrels of oil equivalent.[59] While the numbers will change markedly, depending on the type of coal or oil tested, this equates to a very rough measure of 5,000 to 7,000 kWh, the same energy as would be used to power the average American home for about six months.[60]

In his 2014 book, "Smaller Faster Lighter Denser Cheaper," researcher Robert Bryce further explains that nuclear energy "has 2,100 times as much power density as wind energy," meaning replacing a single 2,069 MW nuclear plant would require covering an area "three-quarters the size of the state of Rhode Island" with wind turbines.[61]

However, there are environmental challenges and safety issues associated with nuclear fuels that are removed from a reactor. Radioactive wastes, such as iodine-129, can present a health and environmental hazard, for literally millions of years, due to their radioactive nature.[62] But the federal government has not yet established a national, long-term storage plan for spent nuclear waste. This means that nuclear plants currently store their used fuel in large concrete and steel casks on the sites of nuclear plants.[63] Some storage and recycling options have been considered. But as is the case with other countries that use nuclear energy, no long-term storage, reprocessing or recycling solution has been adopted.[64]

Another challenge associated with nuclear energy is the costs. While they are very efficient and cost-effective once they are completed, initial construction costs have a marked impact on decisions to build any new reactors.[65] Heavy regulatory compliance costs and safety concerns have tended to push their already high initial cost even higher.[66]

On a more positive note, a great deal of research is being carried out into new, safer, and far more cost-efficient nuclear technologies. These generation IV, or "Gen. 4," technologies employ fail-safe designs, meaning they cannot melt down. They will use a wider variety of fuels and will even be able to recycle existing nuclear waste. As they will be much smaller than current reactors and will be built on modular design, they are expected to cost far less to build. Companies like NuScale, are currently building operational plants and expecting that Gen. 4 technologies will become more widely available in the very near future.[67]

Renewable Energy Sources

Renewable energy sources are currently receiving a great deal of attention in Michigan's electricity markets. Utilities are relying on a mix of solar, wind, and biomass to make up a signification portion of any new generation capacity that they build.

Generous federal subsidies and state mandates have played a significant role in this renewable market boom.[68] Changing societal views on energy and the natural environment have also influenced energy decisions. But, the planned phase out of federal subsidies for renewable wind and solar by 2021* will have an impact on the economic case to build renewable generation.[69]

At the state level, Michigan has implemented a state mandate, or renewable portfolio standard, requiring utilities to supply 15% of their electricity from renewable sources by 2021.[70] The two major regulated utilities in Michigan's Lower Peninsula have also stated their intentions to move well beyond the requirements of the state renewable mandate, rapidly expanding their renewable energy generation capacity as they also close their existing coal-fired generation capacity in an attempt to meet their net-zero emissions targets as described above.[71]

Wind

In Michigan, wind generation has grown rapidly over the past decade and is expected to continue growing for the foreseeable future. DTE and Consumers Energy, have indicated that they intend build additional wind generation capacity over the next few years.† Despite public interest and rapid recent growth, wind provided less than 5% of Michigan's net electricity generation in 2018.

A benefit associated with using wind power is that it provides an alternate form of electricity generation and helps to diversify the overall electrical grid. Additionally, wind turbines do not emit greenhouse gases or other pollutants into the atmosphere at the point of electricity production, that is, without considering the dispatchable backup generation needed due to the wind's intermittency. The price to install industrial wind has come down over the past decade, if not including the costs imposed on the rest of the electric grid for the necessary backup generation and increased transmission infrastructure. The 2019 Lazard's Levelized Cost of Energy Analysis 13.0 Report estimates the levelized cost of energy and lists the current unsubsidized price of wind between $28 and $54 per MWh.[72]

Some challenges associated with wind generation include the substantial financial and policy support

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* The actual phase out dates for the PTC and ITC can be difficult to determine. As phase out dates approach and interest in construction of wind and solar wanes, the renewable industry and its supporters in the Congress typically push to extend the tax credits and subsidies. For example, in December 2019, Congress once again extended the Production Tax Credit for an additional year and stepped the tax credit back up to 60% of the original credit amount for wind projects that begin during 2020. See: Cooper and Tingle, "House Passes PTC, NMTC Extension Bill" (Energy Business Law, 2019), https://perma.cc/X2NK-K2GX

† DTE plans to generate 50% of its energy from a mix of renewable sources, as well as energy waste reduction and demand response by 2030, with the majority of this new clean energy production coming from wind and solar. Consumers Energy plans to spend almost $5 billion from 2010 to 2024 on new production of renewable energy, most of which will come from wind. Jason Hayes, "Public Comments by Jason Hayes, director of environmental policy at the Mackinac Center for Public Policy," Michigan Public Service Case #U-20471, File #U-20471-0455, Sept. 30, 2019, https://perma.cc/LF7E-NCZ2.

it receives in the form of government subsidies and mandates that require some energy to be produced by wind.* Wind also is hampered by the fact that it is not a dispatchable resource. Wind turbines can only produce power when the wind is blowing within a specific range of speeds.[73] This means they cannot be relied on to produce electricity at any one specific moment.

In Michigan, wind has a 36% annual capacity factor, meaning that it produces electricity in unpredictable surges 36% of the time, which roughly equates to 8.6 hours per day.[74] The remainder of the time, wind must be "firmed up," where electricity is provided by other energy sources, like natural gas internal combustion and simple-cycle turbines, or the still scarce and very expensive supply of utility-scale batteries.

Wind developments also can have substantial impacts on bird and bat populations.[75] For example, a 2013 Wildlife Society Bulletin study, using a total installed wind capacity of 51.6 GW, estimated 888,000 bat fatalities and 573,000 bird fatalities annually.[76] But the American Wind Energy Association estimated that there was about double that amount — over 100 GW — of installed wind capacity in the U.S. at the end of the third quarter of 2019.[77] Additionally, while they admit that they only have "very rough" estimates, the American Bird Conservancy claims that collisions and electrocutions associated with wind infrastructure — power lines and towers — kills between 8 million to 57 million birds each year in the U.S.[78] The wind industry defends itself by pointing out that they are using updated technologies and timing turbine operations to reduce collisions. They also note that collisions with windows and automobiles, and predation by feral and domestic cats kills more birds each year than the wind industry.[79] The birds that are killed by cats, home windows, etc. tend to be widely distributed and non-threatened species. The U.S. Fish and Wildlife Service reports that while wind turbines do have a substantial impact on over 200 species of domestic passerine (perching) birds, they also have a significant impact on many threatened and endangered species of large raptors — hawks, eagles and falcons, which are not impacted by homes, and cats.[80]

As they are designed to gather a very diffuse energy source, wind developments also necessarily take up a very large amount of area. There is no one specific, established measure of area required for a single turbine, or that describes the MW per acre that a wind generation project produces. This is because there are a variety of patterns in which wind turbines can be installed on a variety of different types of terrain. However, the National Renewable Energy Laboratories published a study in 2009 that analyzed the land-use requirements of wind power plants and suggested large wind power installations (more than 20 MW) had a general density of 30-138 acres per MW.[81] A 2017 Strata research paper arrived at a similar estimate, noting that wind requires just over 70 acres per MW. In comparison, nuclear, natural gas, and coal generation each required just over 12 acres per MW. Solar required 43.5 acres per MW and hydroelectric required over 315 acres per MW.[82]

* If these subsidies and mandates were to be revoked, the competitiveness of wind within the entire energy market could be significantly reduced.

Solar

Harnessing the energy of the sun to produce electricity means that fuel costs are effectively zero compared to other fuel sources that must be extracted, transported, processed and stored. As with wind energy, solar also provides an alternate form of electricity generation and helps to diversify the overall electrical grid without producing pollutants or greenhouse gases at the point of generation.*

Additionally, there has been a great deal of research and development in solar technologies, which has led to a substantial decrease in the price of solar components. Mean levelized cost of energy measures indicate that solar prices were $359 per MWh in 2009, but the unsubsidized price for thin-film utility scale photovoltaic installations was $32 to $42 in 2019.[83]

Some challenges that solar energy faces include a heavy reliance on federal financial support in the form of direct subsidies and targeted tax breaks, as well as state-level financial support, such as net metering payments and renewable portfolio standards, which require utilities to source a certain amount of energy from renewable sources.[84] In Michigan, Public Act 342 of 2016 has mandated that all utilities in the state of Michigan obtain 15% of the electricity they supply to customers from renewable energy sources — like solar — by 2021.[85] Financial support and targeted market carve outs have ensured a higher degree of interest in expanding solar generation capacity.

Despite rapid declines in pricing, recent studies have highlighted additional challenges that exist for solar energy options. As with wind, solar generation cannot produce electricity consistently, not only because the sun sets in the evening, but also because cloud cover, snow, dust, fog and other naturally occurring environmental conditions can limit the amount of generation capacity from solar panels.[86] The full cost of generating electricity from solar power rises substantially when considering costs associated with the need to store this energy in batteries. However, battery technology is not widely available and is still prohibitively expensive. Therefore, solar is typically supported by reliable and dispatchable power, such as that fueled by natural gas, during the more than 74% to 95% of time when solar generation is not producing electricity in Michigan.†[87] Additional costs arise due to the much shorter life cycle, which requires that solar facilities be rebuilt or repowered two or three times, when compared to the longer — 40 to 80 year — life cycles of nuclear, coal, or natural gas facilities. Federal subsidies and state-level market protections and mandates that solar power receives must also be considered when attempting to estimate its total costs.[88]

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* Wind and solar energy do not produce emissions at the point of generation. However, there can be substantial levels of pollutants and emissions produced in the development, construction, and shipping of renewable components to the installation site. Additionally, there are similar emissions associated with the decommissioning and disposal of the components of renewable generation when they pass their useful life cycle. See: Michael Shellenberger, "If Solar Panels Are So Clean, Why Do They Produce So Much Toxic Waste?," Forbes, May 23, 2018; Dustin Mulvaney, "Solar Energy Isn't Always as Green as You Think" (IEEE Spectrum, Nov. 13, 2014), https://perma.cc/N24B-SEL8.

† EIA publishes state level electricity data that indicates solar capacity factor in Michigan varies widely throughout the year. Summer capacity factors in 2018 went over 25%, but winter capacity factors dropped off to as low as 4.9% (https://www.eia.gov/electricity/state/michigan/).

The solar industry is also just beginning to come to grips with the growing threat of environmental harms associated with, first creating solar panels, and second retiring and recycling existing solar panels.[89] A 2017 study by Environmental Progress, a pro-nuclear energy environmental group that aims to reduce energy poverty while protecting the natural environment, critiqued world governments for not having an established plan to deal with the "300 times more toxic waste per unit of energy" created by solar panels than is created by nuclear plants.[90]

Hydroelectric

Using the power of gravity and water to produce energy has several benefits. Conventional hydroelectric generation is a relatively low-emissions form of renewable generation. It does not require the combustion, or use, of fuel to provide electricity — although the Ludington station does use electricity from the grid, which includes fossil- and nuclear-fueled generation, to pump water into the reservoir. Hydroelectric generation has the additional benefit of being dispatchable — it can be turned on or off quickly in response to system demand. This makes hydroelectric more like baseload generation options such as coal, and combined-cycle natural gas*, and separates it from other renewable options like wind and solar, which are non-dispatchable.

Some challenges associated with hydroelectric generation are that it typically requires a dam that blocks river flows, which can impede fish passage. The dams and the reservoirs they create cause substantial changes in riparian ecosystems and can displace a mix of human and wildlife populations.[91] Additionally, although hydroelectric is a renewable energy resource, the creation of large reservoirs can cause the release of substantial amounts of methane gas. This methane is generated by bacteria that digest and decompose organic waste, algae, and vegetation present in the often cold, oxygen-depleted reservoir water. This process can be compounded by nitrogen-rich runoff from agricultural fields, which encourages algal growth in the reservoirs.[92]

* Traditional nuclear technologies are considered less dispatchable as they are designed to run at, or very near, full capacity, with very little variation. However, Gen. 4 reactor designs are expected to allow more flexible operations.

How Electricity is Supplied to Michigan

Michigan's Investor-Owned Public Utilities

The majority of electricity that is produced in Michigan — 702 trillion Btu in 2017 — comes from two investor-owned, regulated public utilities that are both located in the Lower Peninsula: DTE Energy and Consumers Energy.[93] The largest utilities, with the most customers, in the Upper Peninsula are also investor-owned, regulated public utilities called the Upper Peninsula Power Company, or UPPCO and Upper Michigan Energy Resources Corporation, or UMERC.[94]

Investor-owned public utilities are businesses that provide electricity and other utility-related services to customers. They are private companies, but their operations are regulated by state government. For example, the Public Service Commission in Michigan is responsible for approving the rates these public utilities can charge customers for their services.[95]

Investor-owned public utilities are very common across the United States. Edison Electric Institute, the national association representing investor-owned electric utilities, describes their membership as the utilities that "provide electricity for about 220 million Americans, and operate in all 50 states and the District of Columbia." [96]

Partly in exchange for being regulated by the state, investor-owned utilities are guaranteed a minimum return on equity and are provided a determined share of the electricity generation market. This is the case in Michigan: As a result of Michigan's Public Act 286 of 2008, these regulated, investor-owned utilities all serve as effective monopolies in their operating areas.[97] In Michigan, these companies are guaranteed 90% of the weather-adjusted retail electricity sales within their respective operating areas.* This means that no other utility or electricity provider is allowed sell to more than 10% of the retail electricity sold in these defined markets.

DTE Energy

DTE Energy was established in 1996 and is headquartered in Detroit.[98] The company employs over 10,000 people who provide services across the nation and in 450 Michigan communities. Originally founded in 1903, the company was formerly named the Detroit Edison Company.[99]

Over the years, DTE Energy has been separated into various companies for a variety of business purposes and as a result of federal government policy. For example, the Energy Policy Act of 1992 and the Federal Energy Regulatory Commission order 888 in 1996 required partial deregulation of the electricity industry to encourage broader access to electricity transmission infrastructure for electricity generators. This legislative action ensured all electricity generators are allowed access to the grid and are charged the same price any utility would charge to access the grid.[100] FERC described the goal of their order as "to remove impediments to competition in

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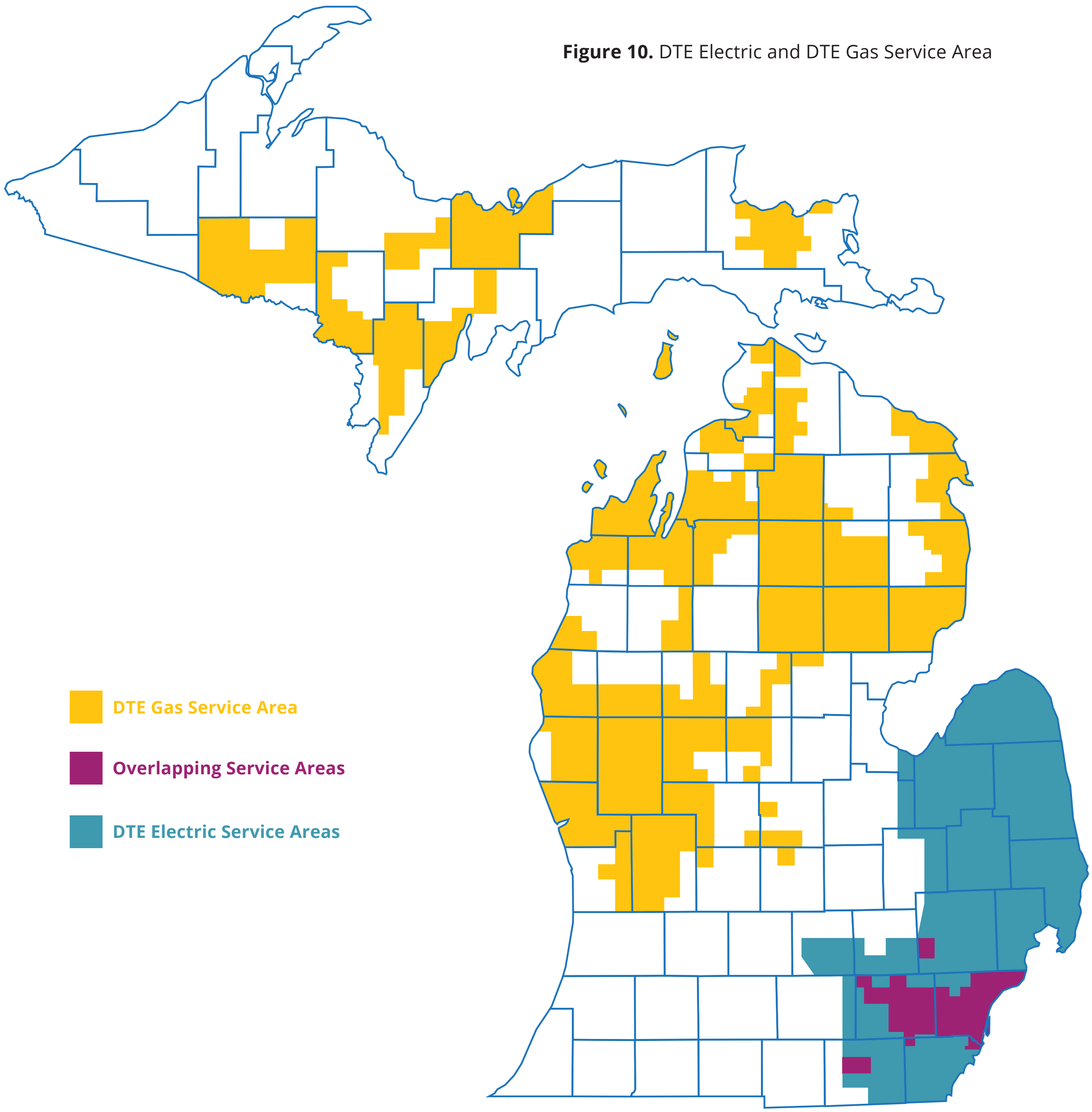
* Electricity customer use is, in part, forecasted by utility generators based on expected average weather patterns throughout the year. Unusual or unexpected weather patterns can cause utilities to use more or less generation capacity than expected. Actual generation use is compared with forecasted use at the end of the year and expected costs are corrected, based on actual temperatures and customer use.

Figure 10. DTE Electric and DTE Gas Service Area



DTE's Energy Generation Assets, Owned and in Service as of Dec. 31, 2018

Power Plant Name	Plant total capacity or utility's share of total capacity (MW)	Number of operating units	Type of fuel	County	Year in Service
Nuclear					
Fermi	1,141	1 nuclear	Nuclear (Fermi 2)	Monroe	1988
Fossil-fueled					
Belle River	1034/256/14	2	Coal	St. Clair	1984–1985
Greenwood	785	1	Natural gas steam turbine	St. Clair	1979
Monroe	3,066	4 coal	Coal	Monroe	1971–1974
River Rouge	272	1	Coal	Wayne	1958
St. Clair	1,216	6	Coal/Petroleum Liquids	St. Clair	1953–1970
Trenton Channel	495	1	Coal/Fuel Oil	Wayne	1968
Other gas/oil peaking units	2,033	Various	Natural gas, oil — peaking units	Various	1966–2003
Renewables					
Ludington	1,054*	6	Hydroelectric Pumped Storage	Mason	1973
Brookfield Wind Park	75	44	Onshore wind turbine	Huron	2014
Echo Wind Park	112	70	Onshore wind turbine	Huron	2014
Gratiot Project	102	64	Onshore wind turbine	Gratiot	2011
McKinley Wind Project	14.4	9	Onshore wind turbine	Huron/Sanilac	2012
Minden Wind Project	32	20	Onshore wind turbine	Huron/Sanilac	2012
Pine River	147.5	59	Onshore wind turbine	Gratiot/Isabella	2019
Pinnebog Wind Park	51	30	Onshore wind turbine	Huron	2016
Sigel Wind Park Project	64	40	Onshore wind turbine	Huron/Sanilac	2012
Utility-Owned SolarCurrents	14	Multiple	Solar PV	Various	2010-2016
Utility Scale Solar	50	Multiple	Solar PV	Various	2017

Source: U.S. Energy Information Administration, U.S. Wind Turbine Database, Form EIA-860 and DTE Energy 2019 Form 10-K. The Pine River Wind Project was brought online after the publication of the February 7, 2019 DTE 10-K Annual Report.

* 1,054 MW represents DTE's 49% interest. The Ludington facility has a total nameplate capacity of 2,151 MW.

the wholesale bulk power marketplace and to bring more efficient, lower cost power to the Nation's electricity consumers."[101]

As a result, International Transmission Company, originally a subsidiary of DTE Energy, was separated from DTE in 1999 and then purchased by ITC Holdings Corporation in 2003.[102] ITC now owns and operates high-voltage electricity transmission lines in Michigan's Lower Peninsula.[103] DTE has retained its other generation and distribution assets.

DTE Energy is also the parent company for several subsidiary companies. These include:

- DTE Electric, electricity services to the state of Michigan;
- DTE Gas Company and DTE Gas Storage, purchasing, transmitting, storing, and selling natural gas to 1.2 million customers in Michigan;
- DTE Gas Laboratory Services, natural gas sampling, analytics, and other services;
- DTE Energy Supply, commercial and industrial natural gas sales and services;
- DTE Power & Industrial, industrial energy services, renewable energy, and environmental controls to industrial customers in 16 states;
- DTE Biomass Energy, capturing landfill methane for renewable energy;
- DTE Energy Trading, energy management and sourcing services, including marketing and sales of fuels, and fuel transport and storage;
- Midwest Energy Resources Company, coal transportation services;
- Citizens Gas Fuel Company, a natural gas utility in Lenawee County.

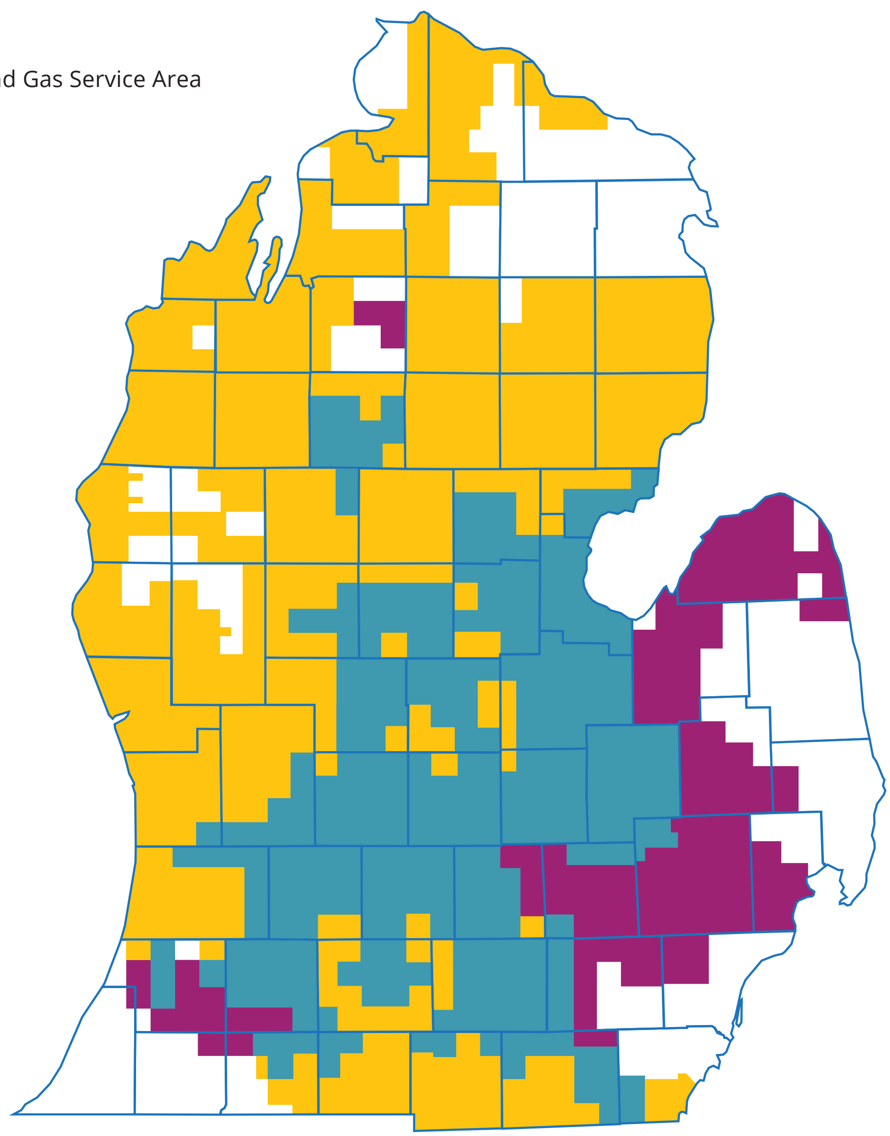
DTE Electric is the largest subsidiary operating under the DTE Energy umbrella. It generates and provides electricity to 2.2 million customers across southeast Michigan. The company owns and operates 11,084 megawatts of electricity generation capacity, using a mix of coal, nuclear, natural gas, hydroelectric pumped storage, and renewable generation options, such as wind, solar, hydro, biomass and geothermal.[104] Its largest generation asset is the Fermi 2 nuclear plant, located just south of the Detroit metro area, which provides 30% of Michigan's nuclear capacity.

Consumers Energy

Based in Jackson, Consumers Energy, often just referred to as "Consumers," was formed in 1886. Consumers is a principle subsidiary of CMS Energy and employs over 15,000 employees and contractors. Consumers serves a customer base of 6.7 million in Michigan with its 5,885 megawatts of generation capacity. The company produces its electricity with a mix of fossil fuels, nuclear, hydroelectric and renewables such as wind and solar.[105]

Figure 11. Consumers Energy Electric and Gas Service Area

Source: CMS Energy 2017 Annual Report



Consumers' Energy Generation Assets, Owned and in Service as of Dec. 31, 2018

Power Plant Name	Plant total capacity or utility's share of total capacity (MW)	Number of operating units	Type of fuel	County	Year in Service
Nuclear					
Palisades	812	1	Nuclear	Van Buren	1972
Fossil-fueled					
J.H. Campbell 1 & 2 — West Olive	608	2	Coal	Ottawa	1962–1967
J.H. Campbell 3	782	1	Coal		1980
J.H. Campbell A	12	1	Petroleum liquids		1968
D.E. Karn 1 & 2	515	2 Units/4 boilers	Coal	Bay	1959–1961
D.E. Karn 3 & 4	1203	2	Oil/Gas steam		1975–1977
Jackson	543	9	Natural gas combined cycle	Jackson	2002
Zeeland	526	3	Natural gas combined cycle	Ottawa	2002
Zeeland	315	2	Natural gas simple cycle	Ottawa	2001
Other gas/oil combustion turbine	—*	8	Gas/Oil simple cycle turbine	Various locations	1966–1971
Renewables					
Ludington	1097†	6	Hydroelectric pumped storage	Mason	1973
Other conventional hydroelectric	77	35	Hydroelectric	Various locations	1906–1949
Cross Winds Energy Park	22	81	Onshore wind turbine	Tuscola	2014, 2018
Lake Winds Energy Park	14	56	Onshore wind turbine	Mason	2012
Solar Gardens — Allendale/ Kalamazoo	2	15,100 panels	Solar	Allendale	2016

Source: U.S. Energy Information Administration, Form EIA-860 and CMS Energy 2018 Annual Report.

* Consumers Energy has closed numerous gas/oil turbines across the state since 2013. Those remaining represent a negligible input to their total generation capacity and output.

† 1,097 MW represents CMS Energy's 51% interest. The Ludington facility has a total nameplate capacity of 2,151 MW.

Other Investor-owned Electricity Utilities

Alpena Power Company: Founded in 1881 to provide the city of Alpena with electricity, APC serves approximately 16,300 residential, commercial, and industrial customers. APC generates and purchases electricity from a mix of energy resources, including coal, natural gas, oil, hydroelectric, wind, solar, and nuclear for the electricity it sells to customers.[106]

Indiana-Michigan Power Company: A subsidiary of American Electric Power, Indiana Michigan Power is based in Fort Wayne and operates in the southwest corner of Michigan and in northern Indiana. Indiana Michigan Power provides electricity to almost 128,000 residential, commercial and industrial customers in Michigan, generating and purchasing electricity from a mix of generation technologies, including nuclear, coal, hydroelectric, wind and solar.[107]

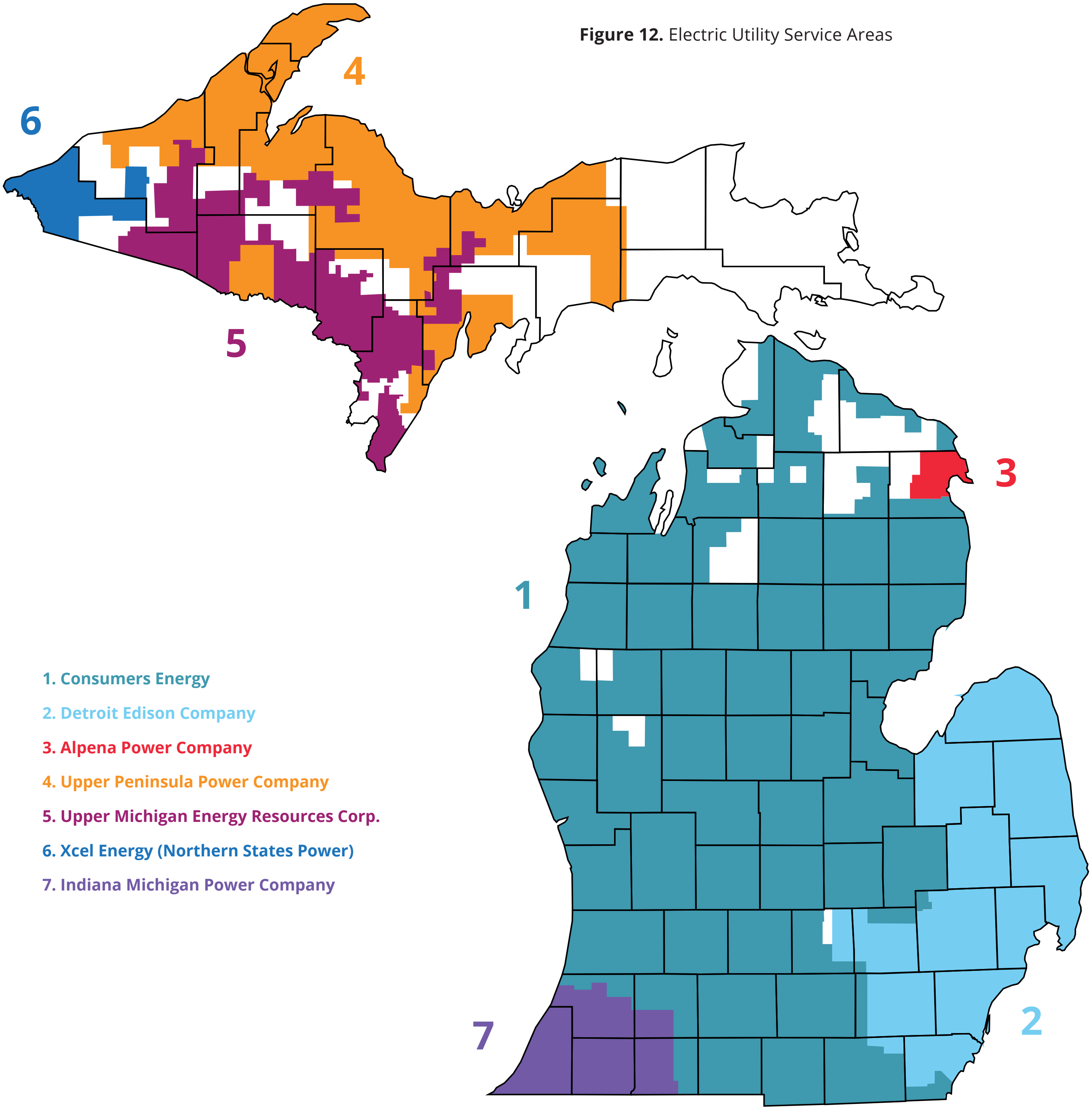
Northern States Power Company: A subsidiary of Xcel Energy, Northern States Power Company is based in Eau Claire, Wisc., and operates in the western portion of Michigan's Upper Peninsula and northwestern Wisconsin. NSP provides electric power to approximately 259,000 customers generating and purchasing electricity from a mix of generation technologies, including nuclear, coal, natural gas, and renewable generation technologies.[108]

Upper Michigan Energy Resources Corporation: A subsidiary of WEC Energy Group, UMERC has offices in Iron Mountain and Menominee and supplies electricity to former WEPCo and WPSC customers in the southwestern portion of Michigan's Upper Peninsula.[109] UMERC provides electricity to more than 42,000 customers, generating and purchasing electricity from a mix of generation technologies, including nuclear, coal, natural gas, oil, and renewable — hydroelectric, biomass, wind and solar — technologies.[110]

Upper Peninsula Power Company: UPPCO was founded in 1947, when three Upper Peninsula utilities merged. UPPCO provides electricity to approximately 52,000 retail customers in the north and central Upper Peninsula, generating and purchasing electricity from a mix of generation technologies, including hydroelectric and natural gas generation technologies.[111]

Wisconsin Public Service: A subsidiary of Wisconsin Electric Power Company, Wisconsin Public Service Corporation, provided electric service to a small number of communities in the Upper Peninsula that are adjacent to its Wisconsin service area. In Michigan, WPSC generated and purchased electricity from a mix of generation technologies, including coal, natural gas, and hydroelectric, solar, wind and biogas technologies.[112] As of January 1, 2017 WEPCo/WPSC customers are serviced by UMERC.[113]

Figure 12. Electric Utility Service Areas



Municipal Electricity Utilities

The Michigan Municipal Electric Association, the trade association representing municipal utilities in Michigan, notes that their 40 member cities meet approximately 8% of the total electricity demand in the state.[114]

Communities that provide electricity to their residents often own their own generation services or will partner with a larger utility. They typically sell electricity to their residents in the same way they offer water and sewage services.[115] Municipal electric utilities are publicly owned and regulated by the communities they serve. The Michigan Public Service Commission does not have regulatory authority over their services and/or rates.[116]

The municipal electric utilities in Michigan that serve more than 10,000 customers are,

Bay City: Bay City Electric Light and Power provides electric power to over 21,000 customers in Bay City, Bangor Township, Frankenlust, Hampton, Monitor, and Portsmouth.[117] BCELP obtains its electric power through a combination of wholesale purchases, partial ownership of the Belle River and Campbell coal plants, and peaking power provided by dual fuel diesel generators at the Water Street and Henry Street plants.[118]

Grand Haven: Grand Haven Board of Light & Power serves about 14,000 customers in Grand Haven, Ferrysburg, and sections of nearby townships. The majority of their power is generated from the J.B. Sims Generating Station on Harbor Island accompanied by a diesel engine. They purchase 10-15% of their energy from the MPPA.[119]

Holland: The Holland Board of Public Works owns three generation facilities, as well as the partially idled coal and natural gas plant, the James De Young Power Plant. Its operating plants include the natural gas-fueled Holland Energy Park, fuel-oil and natural gas-fueled 48th Street Station and the oil-powered 6th Street Station. It also own shares in the J.H. Campbell Complex and Belle River plants that are run by Consumers Energy and DTE and, when needed, will obtain power from the open market. HBPW serves 27,000 customers in Holland, Filmore, Laketown and Park townships.[120]

Lansing: Lansing Board of Water and Light owns and operates the natural gas-fueled REO Town Cogeneration Plant and the coal-powered Eckert and Erickson Stations. It receives a portion of the generated electricity from the coal-fueled Belle River Plant as a member of the MPPA, and it also purchases and sells energy from the Midcontinent Independent System Operator open energy market. LBWL is the state's largest municipal electric utility, providing energy to 100,000 customers.[121]

Marquette: The Marquette Board of Light and Power serves almost 17,000 consumers in Marquette, Negaunee, Ishpeming, West Branch, Richmond, Chocolay, Skandia, Sands and Forsyth. They generate power from a coal-fired generator, two hydro plants, and the Marquette Energy Center, dual-fueled by natural gas and fuel oil.[122]

Traverse City: Traverse City Light & Power serves over 12,000 customers in Traverse City and parts of East bay, Elmwood, Garfield, Paradise, and Peninsula Townships. The utility provides electricity and services to its customers through a mix of generation sources, including wholesale purchases of coal, natural gas, and renewable sources.[123]

Wyandotte: Wyandotte Municipal Services owns and operates a mix of coal, natural gas, and petroleum liquids generation capacity with which it provides electricity to its over 12,000 customers.[124]

The remaining municipal electric utilities in Michigan serve fewer than 10,000 customers.

Municipal Electric Utilities In Michigan Serving Fewer Than 10,000 Customers

Name	Locations Served	Customers Served	Generates Power With/Purchases Power From
Village of Baraga	Baraga	900	Purchases wholesale power from Wisconsin Public Power, Inc.
City of Charlevoix Electric System	Charlevoix, Eveline, Hayes, Marion Townships	4,500	Partial owner of Belle River & Campbell coal plants Partial owner of gas turbines in Kalkaska and Ohio Purchase power as part of the Michigan Public Power Agency
Croswell Light and Power	Croswell	900	Purchases bulk power from CMS Energy, sourced from coal and oil
City of Crystal Falls	Crystal Falls	1,600	Owns and operates Paint River 1 MW hydroelectric plant Purchases wholesale power from Wisc. Public Power
Dagget Electric Department	Dagget	—	Purchases wholesale power from Wisc. Public Service
City of Dowagiac	Dowagiac	2,594	Purchases wholesale power from American Electric Power
Escanaba	Escanaba and adjoining townships	7,200	Up until 2019, purchased power from Great Lakes Utilities 2019-2024, purchases power from NextEra Energy Resources
Gladstone	Gladstone	2,857	Purchases wholesale power from Wisc. Public Power
Harbor Springs Electric	Harbor Springs, Little Traverse Township, West Traverse Township	3,700	Purchases wholesale electricity as member of Mich. Public Power Agency 20% of electricity comes from ownership interest in generation plants in Kalkaska, Holland and Freemont, Ohio 12% from landfill gas 42% from long-term contract from multiple generators 26% from short-term contracts
Hart Hydroelectric Plant	Hart	1,000	Purchases wholesale electricity as member of Mich. Public Power Agency Hart hydroelectric plant as a backup
L'Anse Electric Utility	L'Anse	1,204	Purchases wholesale electricity from Wisc. Public Power
Lowell Light & Power	Lowell	—	Purchases wholesale electricity as member of Mich. Public Power Agency Ownership interest in coal plants J.H. Campbell 3 and Belle River Plant Purchases power from American Municipal Power Ohio Joint owner and operator of natural gas-fueled Kalkaska Combustion Turbine

Name	Locations Served	Customers Served	Generates Power With/Purchases Power From
Michigan South Central Power Agency	Clinton, Coldwater, Hillsdale, Marshall, Union	—	Purchases power from coal-fueled Prairie State Energy Campus in Illinois, natural-gas-fueled AMP Fremont Energy Center in Ohio and hydroelectric power from Menominee, Marshall and Union City, as well as Oconto Falls, Wisc. Partnerships with American Municipal Power
Neguanee Dept. of Public Works	Neguanee	2,214	Purchases wholesale electricity from Wisc. Public Power
Newberry Water & Light Board	Newberry	—	Purchases wholesale electricity from Wisc. Public Power Owns and operates internal combustion generators using petroleum liquids
City of Niles	Niles	7,500	Purchases wholesale electricity from American Electric Power
City of Norway Electric Dept.	Norway	2,087	Two-thirds of electricity from Sturgeon Falls Hydroelectric project One-third from wholesale electricity purchases from Wisc. Public Power
Paw Paw	Paw Paw	—	Purchases wholesale electricity from Indiana Michigan Power and Michigan Public Power Agency
City of Petoskey Electric Division	Petoskey	5,606	Purchases wholesale electricity as member of Mich. Public Power Agency Owns portions of generation plants near Kalkaska, West Olive, Saint Claire and Fremont, Ohio
Portland Township	Portland & Portland Township	—	Owns and operates diesel and hydroelectric generation plants
City of St. Louis Electric	St. Louis	1,900	Purchases wholesale electricity as member of Mich. Public Power Agency Owns and operates mix of petroleum liquids and hydroelectric facilities
Sebawaing Light & Water	Sebawaing	—	Purchases wholesale electricity purchases as part of MISO Zone 7 Owns and operates petroleum liquids internal combustion generation
South Haven Electric Dept.	South Haven	7,400	Purchases wholesale electricity from Indiana Michigan Power
City of Stephenson	Stephenson	—	Purchases wholesale electricity from Wisc. Public Service
City of Sturgis	Sturgis, portions of St. Joseph County	7,200	Purchases wholesale electricity from Indiana Michigan Power Owns and operates a mix of hydroelectric and diesel internal combustion
Village of Union City	Union City	—	Owns and operates river hydroelectric plant
City of Wakefield	Wakefield	1,020	Purchases wholesale electricity from American Electric Power
Zeeland Board of Public Works	Zeeland, and portions of Zeeland and Holland Townships	6,225	Purchases wholesale electricity as a member of Mich. Public Power Agency Owns and operates 36,000 kW of natural gas generation capacity Owns shares in coal-fueled Belle River Plant, natural gas-fueled AMP Freemont Energy Center, and wind generation in Gratiot County

The information in the table was obtained from correspondence with officials from these municipalities, from information found on their websites and from data from the U.S. Energy Information Administration. The cities of Chelsea and Eaton Rapids also have municipal electric utilities, but we were unable to obtain information on their customer base or generation assets.

Alternative Electricity Suppliers

Michigan's Public Act 286 of 2008 guarantees 90% of retail electricity sales to Michigan's regulated utilities — within their respective operating areas. The remaining 10% is open to competitive markets, where "alternative electric suppliers" are allowed to operate.[125] The MPSC defines an alternative electric supplier as "a licensed third party company who sells electricity at unregulated rates to customers located in Michigan."[126] In Michigan, industrial and commercial users, and public schools make up the choice market.[127]

To sell electricity in Michigan's choice market, suppliers must be licensed and meet minimum standards set by the MPSC. The following companies are licensed as Alternative Electric Suppliers in the state of Michigan.

Alternative Electric Suppliers Licensed in Michigan

Name	Approval to operate in Mich.	Headquarters	Notes
AEP Energy, Inc.	February 2006	Ann Arbor	Formerly BlueStar Energy Services Purchased by AEP Energy in 2012, which provides electricity to more than 400,000 customers in 6 states and D.C.
Calpine Energy Solutions, LLC	April 2002	Southfield	Formerly Sempra Energy Solutions, a subsidiary of Sempra Energy Acquired by Calpine Corp in 2016 and renamed Operates in deregulated electricity markets across U.S.
CMS ERM Michigan, LLC	August 2000	Jackson	Began operations in 2003 Owned and operated by CMS Enterprises, which also owns and operates Michigan-based independent generation facilities
Constellation NewEnergy, Inc.	January 2002	Ann Arbor	Exelon acquired the Constellation Energy Group in March 2012
Dillon Power, LLC	January 2015	St. Clair Shores	A subsidiary of Dillon Energy Services Provides energy management services and supply, electric brokerage, consulting services, and energy efficient products.
Direct Energy Business, LLC	November 2002	Lansing	Formerly Strategic Energy, LLC, a subsidiary of Great Plains Energy, Inc. Direct Energy acquired Strategic Energy and merged it with Direct Energy Business in June 2008.
Direct Energy Services, LLC	December 2005	Lansing	A wholly owned subsidiary of Centrica plc. Operates as a residential electric retailer in all 50 states, Washington, D.C., and four Canadian provinces.

Name	Approval to operate in Mich.	Headquarters	Notes
EDF Energy Services, LLC	February 2016	Plymouth	A wholly owned subsidiary of EDF Trading North America Operates in multiple U.S. states and two Canadian provinces
Eligo Energy MI, LLC	June 2015	Southfield	A wholly owned subsidiary of Eligo Energy, LLC
Michigan Gas & Electric	April 2012	Harbor Springs	A subsidiary of Crius Energy
FirstEnergy Solutions Corp.	January 2002	Bingham Farms	A subsidiary of FirstEnergy Corp.
MidAmerican Energy Services, LLC	April 2016	Novi	A wholly owned subsidiary of Berkshire Hathaway Energy Co.
Spartan Renewable Energy, Inc.	September 2007	Cadillac	Formed to develop renewable energy projects Member of the Wolverine Power Supply Cooperative
Texas Retail Energy, LLC	December 2012	Lansing	A wholly owned subsidiary of Wal-Mart Stores, Inc. Only provides retail electricity to facilities owned by its parent company, Wal-Mart.
U.P. Power Marketing, LLC	October 2007	White Pine	A subsidiary of Traxys Power Group Initially provided electricity only to the White Pine Copper Refinery, but now services other industrial and commercial entities. Prairie Plant Systems, a biotech and biopharmaceuticals company, acquired UPPM in August 2014.
Wolverine Power Marketing Cooperative, Inc.	November 2000	Cadillac	A rural electric co-op supplying electricity to member organizations across Michigan.[128]

Source: Appendix: Additional Table Citations contains the citations for the information used in this table. MPSC publishes a list of licensed AES, available here: https://perma.cc/VZG9-Q7QK.

Note: Some firms are licensed as an AES in the state of Michigan, but do not currently operate in, or sell electricity in the state. Only firms that are currently providing Michigan customers with electricity were included in this list.

Electricity Cooperatives

In the early 20th century, when electricity service was initially spreading across the nation, electric utilities could not afford to build transmission lines and generation facilities to provide electric service to rural areas. The low density of population in rural areas, compared to urban environments, made the economics of generating and distributing electricity there difficult. Electric cooperatives were, therefore, formed to provide that service. Electric cooperatives are locally owned and operated, not-for-profit utilities that generate and/or purchase wholesale electricity, which they deliver to their customers in the more sparsely populated rural areas of the state.[129] In Michigan, electric co-ops serve approximately 750,000 residential, commercial and industrial customers overall. [130]

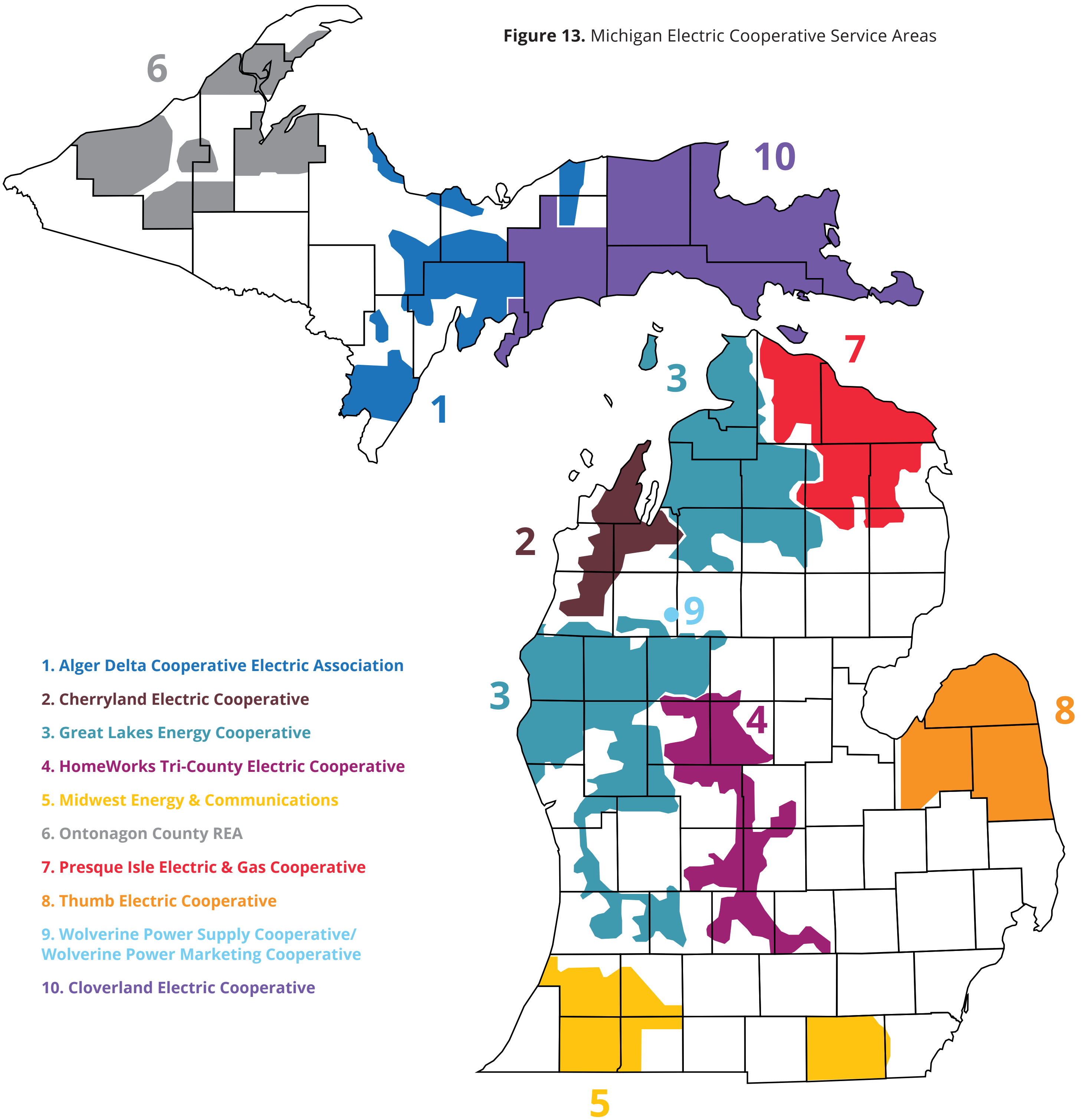
Cooperatives Distributing Electricity in Michigan

Co-op	Founded	Approx. # of Members	Service area
Alger Delta Cooperative Electric Association	1937	10,000	Upper Peninsula
Bayfield Electric Cooperative, Inc.	1945	8,800	Gogebic County
Cherryland Electric Cooperative	1939	35,000	Grand Traverse region
Great Lakes Energy Cooperative	1937	125,000	26 counties
Homeworks Tri-County Electric Cooperative	1937	22,000	13 counties
Midwest Energy and Communications	1937	35,000	Southern Michigan
Ontonagon County REA	1937	5,000	Western Upper Peninsula
Presque Isle Electric & Gas Co-op	1937	35,500	Nine counties in NE Lower Peninsula
Cloverland Electric Cooperative	1938	42,000	Eastern Upper Peninsula
Thumb Electric Cooperative	1938	12,000	Thumb region
Wolverine Power Supply Cooperative*	1983	268,000	More than 40 counties

Source: See Appendix: Additional Table Citations

* Wolverine Power Supply Cooperative supplies wholesale electricity to seven owner-members. Five of those members are cooperatives listed above: Cherryland, Great Lakes, Homeworks, Midwest and Presque Isle. Their other two owner-members are Spartan Renewable Energy and Wolverine Power Marketing Cooperative.

Figure 13. Michigan Electric Cooperative Service Areas



How Electricity is Delivered to Michigan Homes and Businesses

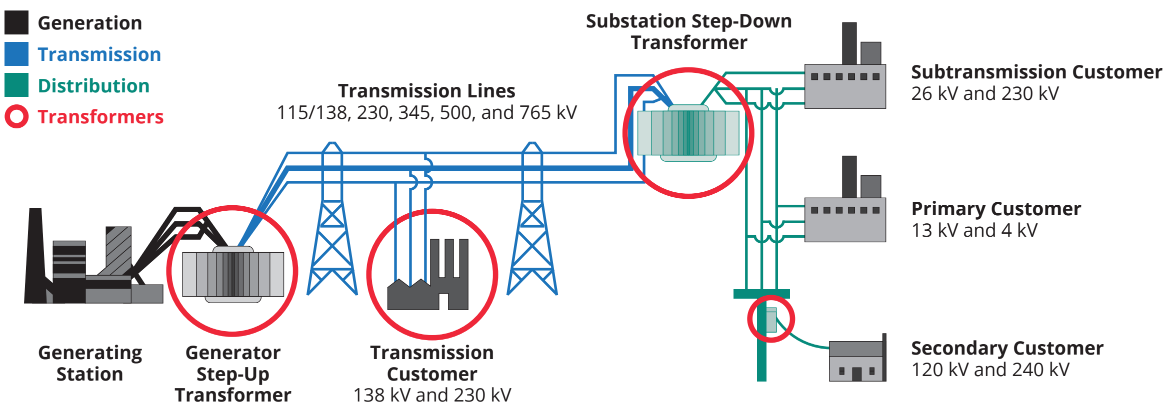
Most current generation facilities produce electricity at 25,000 volts, or 25 kilovolts.[131] Having producers generate a standard level like this helps keep the electric system stable and predictable. After that stable supply of electricity is produced at generation facilities across the state, it must be moved from those facilities to distribution points throughout the system of transmission and distribution facilities and wires commonly referred to as "the grid."

As generation facilities are not typically located immediately beside the customers for whom they produce electricity, electricity must be fed into high voltage transmission lines that transport it, at least part of the way, from the generator to the customer.

One of the challenges of moving electricity over long distances like this is that electric current traveling through transmission lines causes the lines to heat up, resulting in a phenomenon known as "line loss." The primary way to fight line loss is to use higher voltages.[132] Therefore, the electricity is "stepped up" by transformers to much higher voltages — 115kV, 138kV, 230kV, 345kV, 500kV or 765kV. These higher voltages allow the electricity to be transmitted over long distances far more efficiently, but residential and commercial consumers cannot safely use electricity at these high voltages.[133] So before it reaches the final distribution points, such as homes and businesses, substations and transformers "step-down" the voltage depending on the requirements of the end user. Subtransmission systems and customers receive electricity at 26kV and 69kV; primary, or industrial customers receive 13kV and 4kV; and secondary customers, or businesses and residential homes receive 120 volt and 240 volt.[*134]

Figure 14. Generation, Transmission, and Distribution

Source: U.S. Federal Energy Regulatory Commission and U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

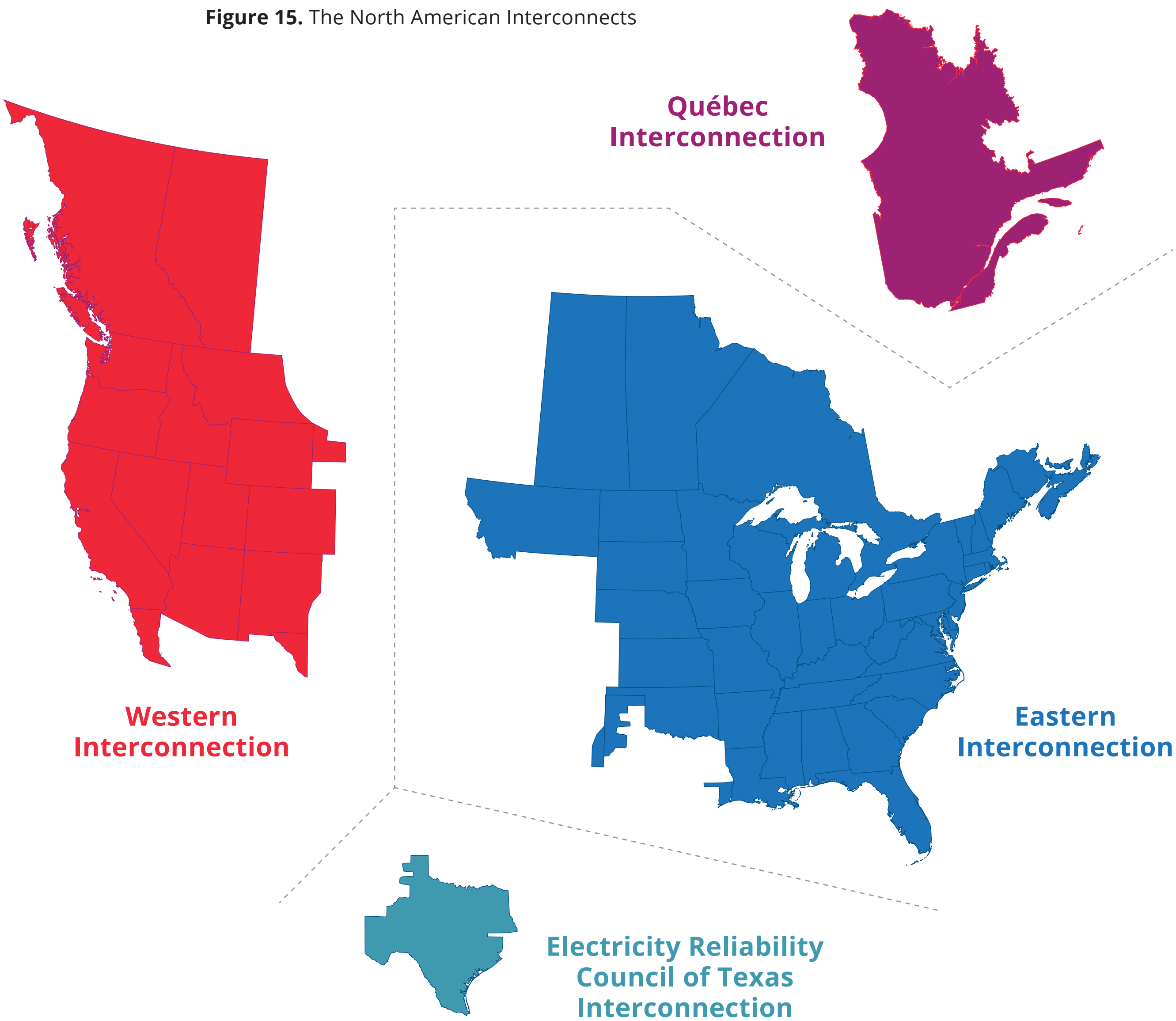


* Subtransmission systems are used to supply distribution substations within the grid. Edvard Csanyi, "Basics Of Subtransmission Systems" (Electrical Engineering Portal, Dec. 17, 2010), https://perma.cc/M5UB-ZK8G.

Regional Interconnections

Across North America, there are four primary sections of the electrical grid — areas where transmission and distribution lines are combined to service homes and businesses. These four areas are separate grids that make up the entire North American grid and are called "interconnections." They are grouped together like this to capitalize on economies of scale, while still making it possible to efficiently transmit electricity within reasonable distances. The Energy Information Administration explains that interconnections ensure the reliability, or resiliency, of the grid by allowing electricity to flow from generators to end users via several routes. Redundancies created across these interconnected regions make for a more stable and reliable grid that can withstand fluctuations or outages in power supply.[135]

Figure 15. The North American Interconnects

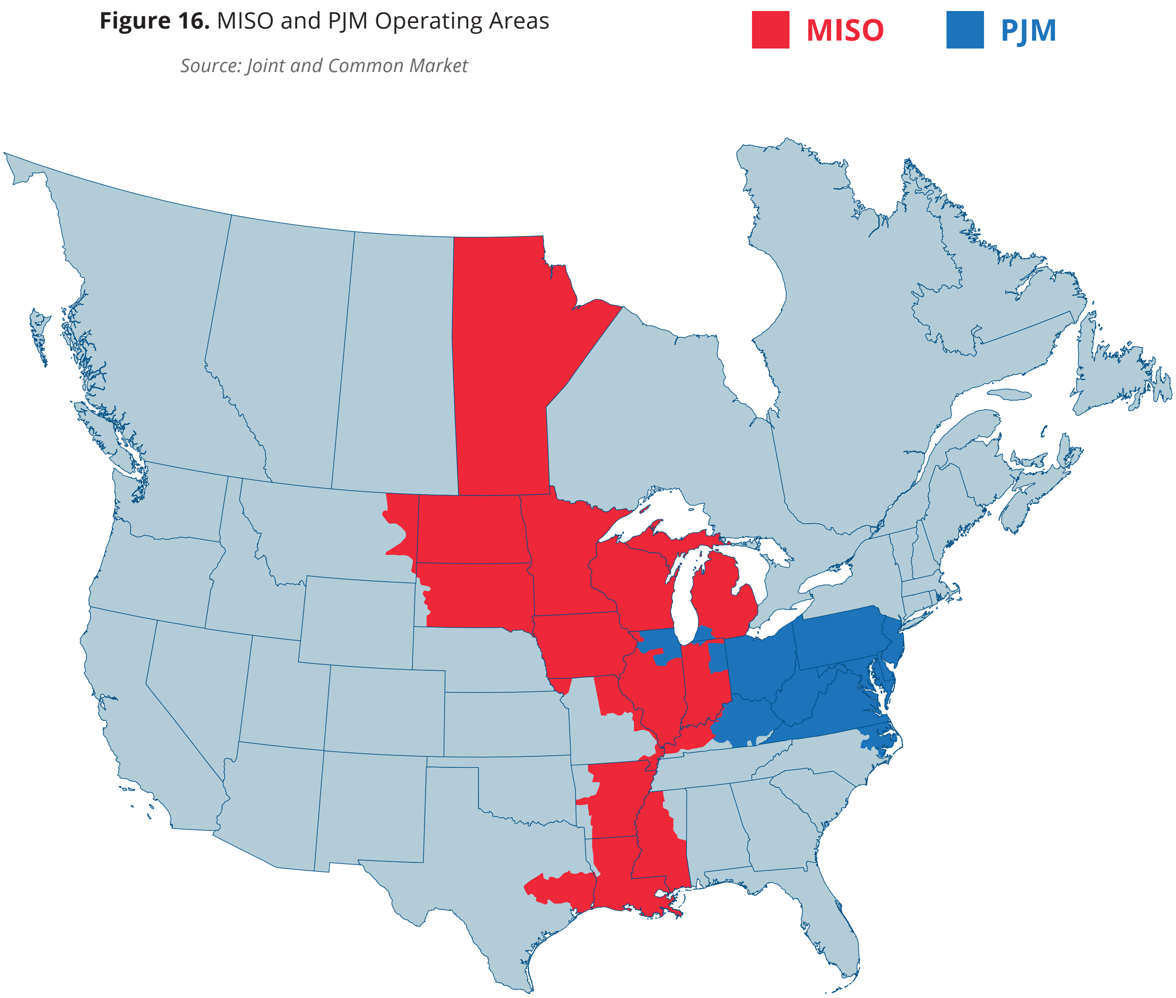


Michigan is in the Eastern Interconnection along with several states in the eastern United States and seven of the eight most eastern Canadian provinces.* Utilities in an interconnect are electrically linked together in normal operating conditions to provide electricity to the states and provinces within their area. This means that an electrical generator in Michigan could conceivably generate electricity that is used by a customer in Indiana.[136]

Within the state of Michigan, two operations monitor high-voltage transmissions and ensure Michigan residents have access to an open, nondiscriminatory, high-voltage transmission system, as required under Federal Energy Regulatory

Figure 16. MISO and PJM Operating Areas

Source: Joint and Common Market



* Not including Quebec, which has its own interconnection.

Commission Order 888.[137] This means that any legally operated generator has a right to access high voltage transmission lines to transmit their electricity to the open market. The organizations that provide this service are the Independent System Operator and the Regional Transmission Organization.

The specific roles of ISOs and RTOs are similar, and it can be difficult to see a difference between the two. Both operate under the auspices of FERC, which regulates the transmission of electricity, natural gas and oil across state lines.[138] FERC describes its role: "assist[ing] consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means."[139] Both ISOs and RTOs exist to control and manage the electrical grid in their respective areas of operation. RTOs are described as having a "greater responsibility for the transmission network" than ISOs.[140]

The majority of Michigan falls within the Midcontinent Independent System Operator, or MISO territory. A small portion of southwestern Michigan is within the operating area of a RTO called PJM. PJM was originally called the Pennsylvania-New Jersey-Maryland Interconnection. Due to their proximity, MISO and PJM have agreed to operate their full markets as a "joint and common," or a single wholesale market, to serve customers in their operating areas and to effectively help the two areas to operate more like a single market.[141]

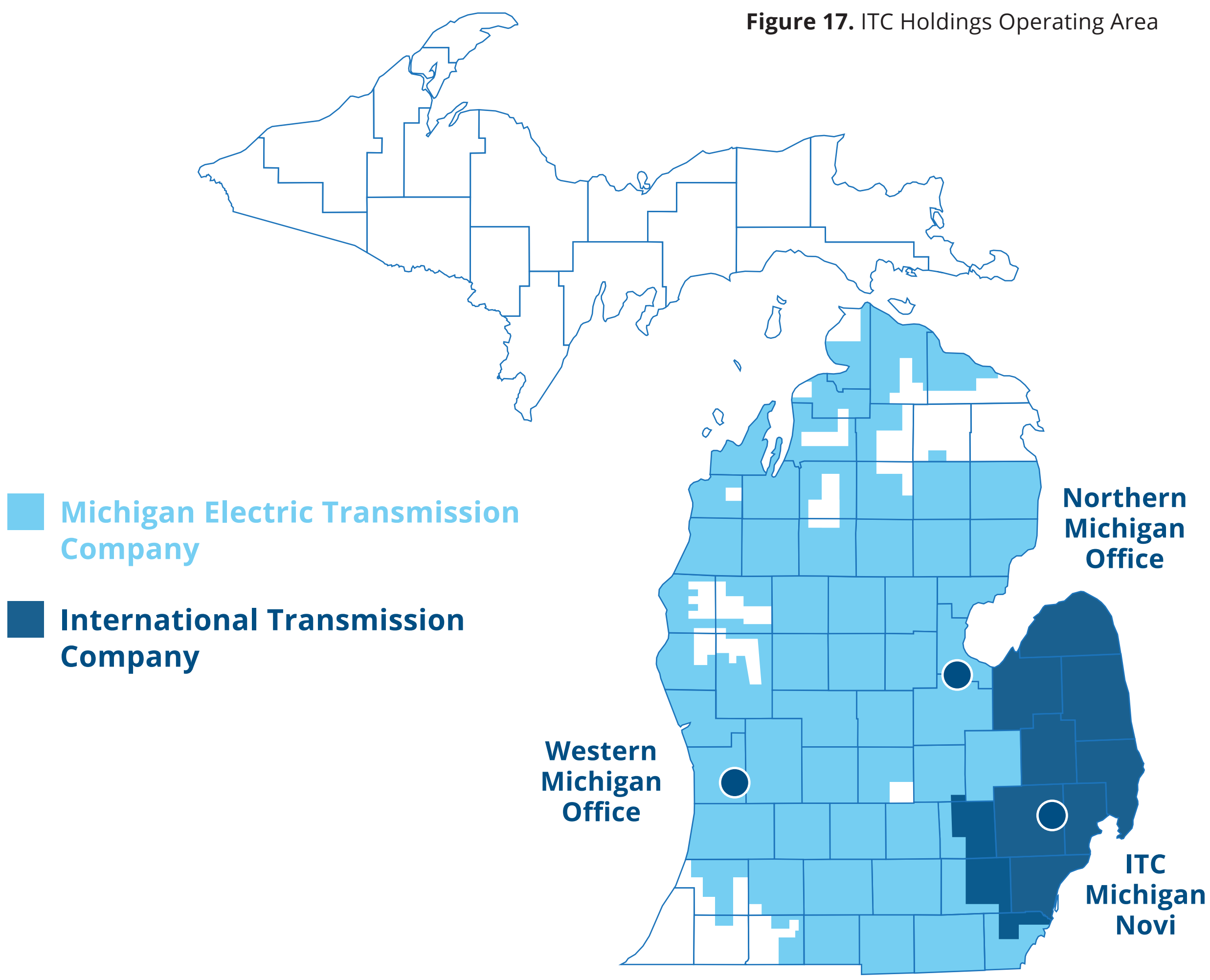
Transmission Services

The primary provider of transmission services in Michigan is ITC Holdings Corp., a Novi-based company.[142] ITC Holdings is made up of two wholly owned subsidiaries — Michigan Electric Transmission Company and International Transmission Company. Together they are often called ITC Michigan.

METC and ITC Transmission together serve the majority of Michigan's lower peninsula population of almost 10 million people with approximately 8,700 miles of high-voltage transmission lines.[143] While ITC has constructed additional transmission resources, the backbone of their system is made up of infrastructure that was originally owned by Consumers Energy and DTE.[144] ITC describes their customers as: electric co-ops, municipal utilities, regulated utilities, independent power producers and nonutility generators, and interconnections for merchant generators.[145]

The primary provider of transmission services in Michigan's Upper Peninsula is American Transmission Company.[146] The company's published

Figure 17. ITC Holdings Operating Area



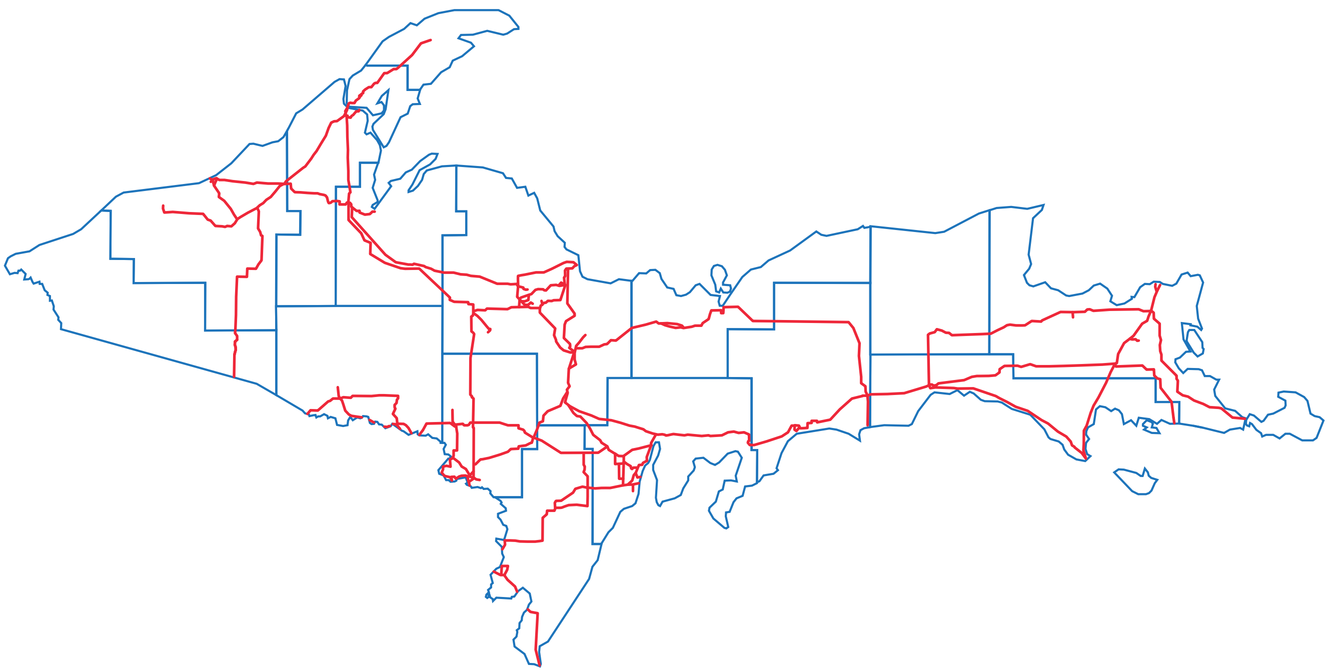
information does not include specific information on their Michigan operations. But they note they provide transmission services to more than five million residents in 72 counties across four states.[147]

Both ITC and ATC are compensated for their transmission services by charging their utility customers to access their lines. The rates they charge are regulated by FERC.[148]

The MPSC also lists six other organizations that operate transmission infrastructure within or adjacent to Michigan. The following table lists and describes these transmission providers.

Company	Location of Service
AEP/American Electric Power	Southwest portion of Michigan, within the PJM region
Wolverine Power Supply Cooperative	Various regions within Michigan’s lower peninsula
Xcel Energy	Western portions of Michigan’s upper peninsula
MISO/Midwest Independent System Operator	MISO is responsible for monitoring transmission within the state of Michigan
PJM Interconnection	PJM is responsible for monitoring transmission within the state of Michigan (in the southwest corner)
Ontario’s Independent Electricity System Operator	IESO operates in the Canadian province of Ontario. It’s actions impact imports and exports of electric power to and from Michigan

Figure 18. American Transmission Company Operating Area

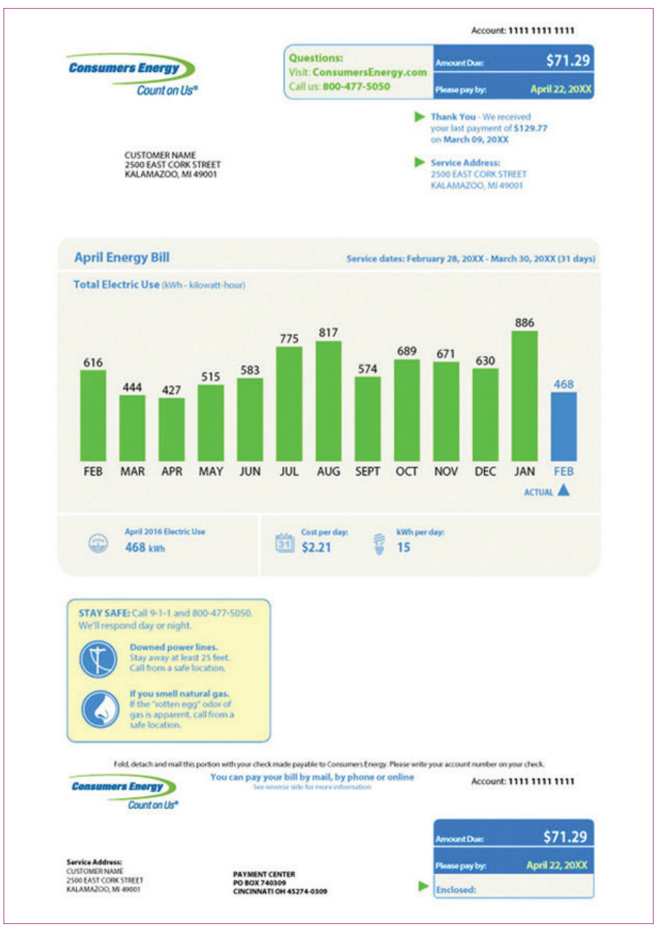


Your Utility Bill Explained

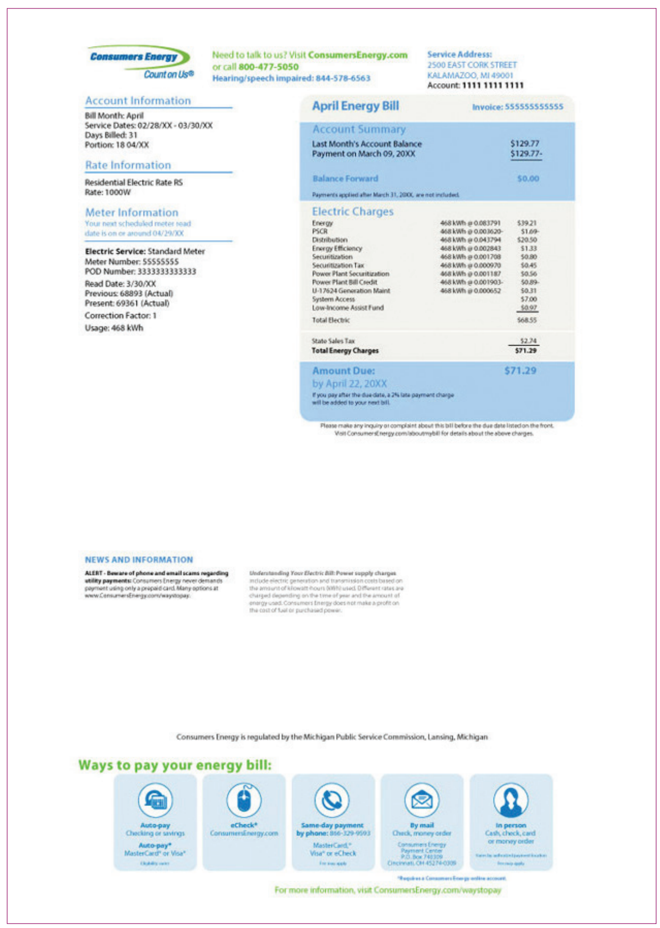
Each month Michigan residents and businesses receive a bill from their local utility apprising them of the costs of the electricity that they have used for the previous month. But utility bills do not just charge for electricity. There are several other charges and fees on each month's bill. Here is a sample Michigan electric bill to explain some of the normal charges and expenses Michigan residents pay each month. This section describes some of the main charges seen on a typical Michigan electric bill.[149]

Beginning or Ending Read/Actual Meter Read: A meter reading that exactly measures the electricity used during a billing period and is based on an actual reading of the meter, not an estimate. Customers that retain the traditional analog meter, or a noncommunicating version of the advanced meter will need to have their meter read by a utility employee. This will involve a visit to the service property to allow the meter reader to physically view the meter to collect electricity usage data. Those customers who have a smart meter installed

Front



Back



will have their meter read remotely, as advanced metering infrastructure is able to communicate with the utility via radio frequencies, the internet and data transmission networks.[150]

Beginning or Ending Read/Estimated Meter Read: A meter reading that estimates electricity used during a billing period.

Billing Period/Billing Month/Billing Cycle/ Days Billed: The days of electricity use recorded on a standard electric bill.

Choice Implementation Surcharge: Public Act 141 of 2000 allows utilities to recover the costs of customers who purchase electricity from an alternative electric supplier. These charges must be approved by the MPSC and are paid by existing customers.[151]

Distribution/Distribution Charge/Delivery Charge/Retail Transmission Services: Charges approved by the MPSC, that are based on the number of kWh used by customers and that cover the costs for infrastructure — substations, transformers, etc. — to deliver electricity from transmission infrastructure to the end user (a home or business).[152]

Energy/Energy Charge: The charge paid to the utility or alternative electricity supplier for electricity — in kilowatt hours — they have purchased or generated, and that the end customer has used in the billing period. The rate for this electricity is initially suggested by the utility, based on expected generation costs and is then authorized, by the Michigan Public Service Corporation and used to repay the utility for the costs associated with purchasing fuel and generating electricity.[153] Separate, or higher rates may be set for time of use and/or time of season. These higher rates are typically charged during periods of increased demand — during the summer and during the day. Time of day rates are generally easier for utilities to track with the advent of the advanced metering infrastructure, or "smart meters."[154]

- **On-peak hours:** Weekdays from 3 p.m. to 7 p.m. Electricity costs are higher in on-peak hours.[155]
- **Off-peak hours:** Weekdays from 11 p.m. to 7 a.m. and all day on weekends and designated holidays. These hours correspond to times when electricity demand and electricity prices are lowest.
- **Mid-peak hours:** Weekdays from 7 a.m. to 3 p.m. and 7 p.m. to 11 p.m. Electricity prices are similar to utility standard rates.
- **Critical peak events:** Critical Peak Pricing events occur during periods of extreme demand. During a CPP event, prices rise to 95¢ per kWh. Utilities must notify customers in advance of implementing a CPP and are limited to a maximum of 56 hours of CPP in a calendar year.
  - After Jan. 1, 2020, Consumers Energy is transitioning to a Residential Summer On-Peak Basic Rate, which accounts for changing seasonal demand. The new RSP rate delineates "On-" and "Off-peak" rates. On-peak rates are charged from June 1 to Sept. 30 between 2 p.m. and 7 p.m. on weekdays. Off-peak rates are charged between 7 p.m. and 2 p.m. on weekdays and through the weekend. As with the previous rate format, on-peak rates are higher than off-peak. From Oct. 1 to May 31 electricity

rates are the same regardless of time of day, or day of the week.[156]

- As utilities work to implement demand response and energy efficiency programs, their pricing structures, times, and details of incentive programs are likely to change. Therefore, reporting a simple, statewide pricing structure will become increasingly difficult.

- **Energy for First 600 kWh:** From June through September, lower rates are set for the first 600 kWh of a customer's monthly electricity use.
- **Energy over 600 kWh:** From June through September, higher rates are set for a customer's monthly electricity use over 600 kWh.

Energy Efficiency/Energy Optimization: MPSC-approved monthly charges for business customers and per kWh charge for residential customers. These charges pay for utility energy efficiency programs put in place under the authority of Public Act 295 of 2008.[157] Energy efficiency and optimization programs — that encourage the use of newer more efficient technologies to provide similar services using less electricity — can provide rebates and incentives, as well as efficiency education. The Energy Efficiency charges cover the cost of these incentives and rebates.

Enhanced Security Surcharge: A charge ordered by the Nuclear Regulatory Commission to cover increased anti-terrorism security measures, such as vehicle barriers and security staff, at American nuclear generation plants.[158]

Implementation Surcharge: Older bills may show this charge that allowed utilities to impose charges when self-implementing a rate increase and before that increase had been approved by the MPSC. When Public Act 341 of 2016 was passed, utilities in Michigan were no longer allowed to self-implement rate increases. Therefore, this surcharge is unlikely to be seen on current or future bills.

Kilowatt: A unit of power equal to 1,000 watts

Kilowatt Hour: A unit of energy equivalent to the energy needed to keep one 100-watt incandescent light bulb lit for 10 hours.

Low-Income Energy Assistance Fund/Michigan Energy Assistance Program: Public Act 615 of 2012 created the Michigan Energy Assistance Program to provide energy assistance to low-income households in Michigan.[159] Public Act 95 of 2013 created the Low-Income Energy Assistance Fund that adds a monthly surcharge to each bill, which is capped at $1.[160] Public Act 87 of 2019 extended this $50 million fund to Sept. 30, 2023, providing financial aid, or energy assistance for Michigan's low-income residents in the heating season, in the form of payments to utilities for overdue bills.[161] Utilities may choose not to collect this charge, but cannot disconnect electric service for any residential customer because of nonpayment between the dates of Nov. 1 to April 15.[162]

Nuclear Decommissioning Surcharge: A charge associated with the closure and removal of a nuclear generation plant. As described in the nuclear energy section of this paper, there are four nuclear reactors operating in Michigan. This surcharge collects funds to cover the costs of decommissioning those plants at the end of their life.

Power Plant Securitization Charge/Securitization Bond and Bond Tax Charge: MPSC-approved, per kWh charges applied to customer bills that were

established by Public Act 142 of 2000.[163] These charges helped to cover the cost of refinancing higher cost debt accumulated when constructing new power plants, or decommissioning and stranded costs associated with the early closure of plants as a result of changing regulatory requirements.[164]

Power Supply (Energy) Charges/Generation Services: Charges paid by customers to the utility for electric generation — turning fuel into electricity — and transmission that are based on the amount of electricity used by a customer.[165]

Power Supply Cost Recovery Charge Factor: These charges are added to cover the cost — no markup or profit is added — of electricity that is purchased by a utility from an outside source. Each year, the utility must submit and obtain approval for their annual power supply cost recovery charge factor plan from the MPSC.

Rate: The MPSC-approved charge per unit of energy consumed by a customer

Regulatory Asset Recovery Surcharge: A charge to replace utility investments made during a rate cap and rate freeze brought in by P.A. 141 of 2000. Regulatory assets are costs a utility can postpone and count as an asset on its balance sheet. Examples of regulatory assets include energy-efficiency programs.[166]

Renewable Energy Plan Surcharge: MPSC-approved per meter charges to recover the costs of utility renewable energy programs, such as the construction of solar and wind power. This charge is associated with renewable generation built to achieve the minimum required renewable generation — renewable portfolio standard requirements associated with Public Act 295 of 2008.

System Access/Customer Charge/Monthly Service Charge/Availability Charge: Charges approved by the MPSC and separate from energy charges, covering the use of an electric meter and billing.[167]

5 Regulation and Electricity Choice

This chapter explains some of the key regulatory issues that impact Michigan consumers. These issues are by no means the only regulatory topics of interest, but they are likely to have the largest impact on the reliability and affordability of electricity, the two chief concerns of nearly all utility customers.

Regulation of Public Utilities

As noted in the opening of this paper, Michigan's market is generally divided into three distinct phases: generation, transmission and distribution.[168] A mix of companies, including DTE, Consumers Energy, UPPCO, UMERC, and a portion of alternative energy suppliers — both in state and out — are responsible for the generation and distribution of electricity. ITC and ATC are primarily responsible for the transmission in Michigan.

Prior to 2000, Michigan had a vertically integrated electricity system, meaning the electricity used by Michigan's residents was provided by monopoly utilities working within a fully regulated system. Utilities operated as "natural monopolies," generating electricity, and operating both the transmission and distribution sectors.[169]

In another Mackinac Center report titled, "Proposals to Further Regulate Michigan's Electricity Market," authors Diane Katz and Ted Bolema explained the concept of a natural monopoly in electricity markets:

> Historically, the provision of electricity in Michigan was considered to be a "natural monopoly." The theory of natural monopoly, now largely questioned, presumes that building competing electricity infrastructure would be too costly for a second electricity supplier to afford. The customer base and price of electricity supposedly are insufficient to recover the capital investment required to construct competing facilities. Consequently, the state bestowed regional monopoly status on select utilities and imposed price controls and other regulations to temper their monopoly market power.[170]

Attitudes toward the natural monopoly concept have been questioned and are viewed by many as being less than an ideal way of providing reliable and affordable electricity to the public. The natural outgrowth of those changing mindsets came in FERC's Order 888, which broke up these natural monopolies across the nation and moved transmission of electricity into a separate segment.[171]

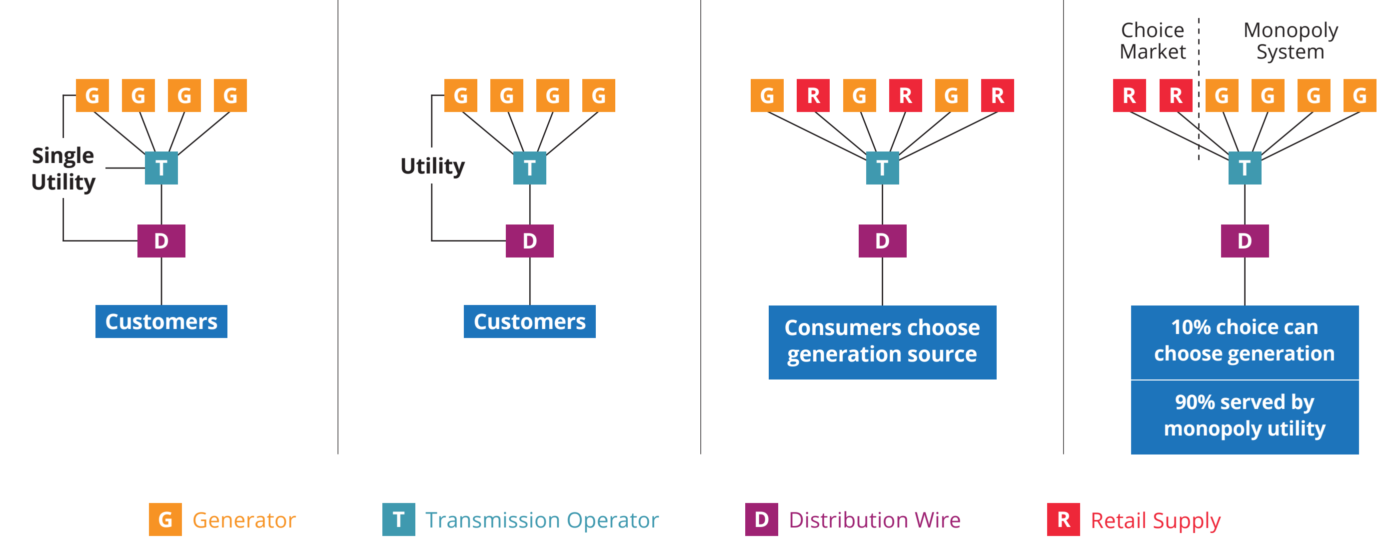
Today, Michigan's monopoly utilities — DTE and Consumers Energy — no longer own and operate the majority of high voltage transmission lines. But they do continue to operate the generation and distribution sectors for 90% of Michigan's retail electricity markets. The remaining 10% is supplied by alternative electricity suppliers, operating in a more free-market system that allows them to either generate the electricity that their customers require, or to purchase electricity from regional markets. Transmission continues to be provided by single, "natural monopoly" transmission providers, with ITC and ATC building and maintaining much of the state's high voltage transmission system.

Regulation of Electricity Rates

In 1999, Michigan's electricity rates were higher than the national average and electricity rates in adjacent

Figure 19. Michigan's Hybrid Electric System

Vertically integrated monopoly Pre-1996 FERC Order 888	Investor-owned utilities control generation and distribution — Pre - P.A. 141 of 2000	Post P.A. 141 of 2000 Open competition (2000-2008)	Post P.A. 286 of 2000 90% Regulated/10% Choice Current System
• Vertically integrated monopoly - Monopoly utilities owns and operate transmission, distribution and variety of generation. • Rates approved by MPSC • No customer choice	• Monopoly structure • Utilities own and operate distribution and variety of generation • Separate monopoly owns transmission • Rates approved by MPSC • No customer choice	• Choice/retail sales and utilities compete for customers - Utility and merchant generation • Utilities own distribution/sell access to merchant/choice retailers • Separate monopoly owns transmission • Rates set by market competition • Customers choose generation option	• Hybrid: blends monopoly and choice • Choice system limited by law to 10% of retail sales • Choice providers compete for 10% choice market • Choice rates set by market • Monopoly rates approved by MPSC • Separate monopoly owns transmission



Great Lakes states. In response to customer demand, state legislators passed Public Act 141, which authorized an electricity choice program. Michigan opened up its electricity system to allow retail electricity sales and recognized the right of residents to buy from the energy providers of their choice. This situation is analogous to the deregulation of the telephone system, when customers were able to choose providers other than old "Ma Bell." [172]

P.A. 141 of 2000 provided every electricity customer with a choice of an electricity supplier.[173] But in 2008, the Michigan Legislature effectively reversed itself on electricity choice by passing Public Act 286 of 2008, removing market options and reinstituting monopoly provision of electricity to the majority of Michigan residents. The language of Public Act 286 guaranteed DTE and Consumers Energy, and other monopoly providers in Michigan's Upper Peninsula — currently UPPCO and UMERC — the legal right to provide electricity to 90% of the retail electricity market within their respective operating areas. The energy choice market is now capped at 10%.[174]

Those interested in accessing the electricity choice market must obtain service in the state from one of the monopoly utilities and then apply to be added to the electricity choice wait list. The Michigan Public Service Commission's 2019 "Status of Electric Competition in Michigan" report indicated that, in

December 2019, 5,817 customers were enrolled in the choice program, but another 6,447 were on the wait-list.[175]

That report also noted that the choice program is currently fully subscribed and that, if the cap did not exist, choice participation would be approximately 27% in Consumers Energy's operating area, 17% in DTE's operating area, 16% in the Upper Peninsula Power Company's area, and 20% in Upper Michigan Energy Resources Corporation's operating area.[176]

When paying for their rates, "full-service" customers of DTE or Consumers, who have not entered the choice market, will receive a monthly bill from that utility containing customer charges, distribution charges, other fees and taxes, as well as charges for their electricity supply.

Electric rates for full-service utility customers are set by the Michigan Public Service Commission, a state government body that, among other things, was created to "establish fair and reasonable rates for regulated services…for Michigan's utility customers." They approve the rates that monopoly utilities propose to charge their customers. Alternative energy suppliers do not have their rates regulated, as their rates are constrained by operating in a competitive market.

2016 Legislative Reforms

The two electricity bills, passed in December 2016 and effective in April 2017, aimed to ensure electrical system stability in Michigan by mandating all generators — across Michigan's hybrid electricity market — maintain sufficient electricity generation capacity for four years into the future. Those utilities that do not maintain sufficient capacity resources can be subjected to fines, penalties, or made to pay refunds to their customers.[177]

The language of public acts 341 and 342 attempts to address the reality that monopoly utilities are legally the supplier of last resort, meaning that they could be required to provide electricity for choice market customers that leave the choice system, and, therefore must maintain sufficient generation capacity to meet the needs of the choice market, as well as their customers.[178]

Section 6w of Public Act 341 mandates the MPSC to ensure utilities meet a capacity demonstration requirement. That is, electricity providers must confirm that they have sufficient resources to meet their customer's needs.[179]

If alternative electricity suppliers fall short on their advance planning, PA 341 empowers the MPSC to hold public hearings to determine an appropriate capacity charge to pay for access to generation assets operated by the major utilities.

The MPSC ruled on June 25, 2017, that electricity providers in the choice market would also be required to source their electricity from in-state sources, or meet a local clearing requirement. This new expectation is expected to come fully into force in 2022. Currently, this requirement is being based in what the MPSC is terming "incremental capacity methodology," meaning electric utilities or providers in the Lower Peninsula "must demonstrate a minimum level of local resources equivalent to 1.5% of its peak demand for planning year 2022/2023 and 3.0% of its peak demand for planning year 2023/2024."[180]

Conclusion

We hope that this document provides readers with a better understanding of how Michigan's electricity system works, that it gives readers a clear idea of how electricity is generated, transmitted, and used in our state. With this understanding, we hope to help Michigan residents become better consumers, customers, and more informed voters.

We want to remind our readers that we must understand the importance of electricity to our modern lifestyle. It's easy to forget how much we rely on electricity; how it is now an essential part of our lives. We have become so accustomed to it that we take it for granted. But, reliable and affordable electricity is essential for our lives and well-being. It helps us to live comfortable and healthy lives.

As we described in the opening section of this report, knowing how Michigan's electricity system operates is the first step in fully appreciating the benefits we derive from it and the first step in helping make it even better.

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