WHITE PAPER / **MICHIGAN'S RENEWABLE ENERGY FUTURE**

Key considerations for a renewable future in Michigan

BY Doug Houseman

For Michigan to move to a fully renewable future will require a great deal of planning, law and regulation changes, and the cooperation of the state legislature, universities and large organizations across the state. Fortunately, Michigan stands uniquely prepared to make significant moves toward electrification and grid modernization.

Michigan* is blessed with both natural resources and beautiful natural features; however, this is a mixed blessing as we look for ways to meet future energy requirements. Most consumers do not want to see, hear or think about where their energy comes from — and they don't want energy infrastructure intruding into their favorite natural areas. Striking a balance between conservationist goals and providing reliable, accessible energy is a challenge Michigan faces.

To reduce energy use, Michigan could shut down manufacturing, but that would wreck the state's economy and drive a large segment of the population out of the state. Michigan could shut down tourist attractions to reduce vehicle traffic, offering virtual reality visits instead; but again, that would seriously damage the state's economy. Due to these factors — and for the purpose of this article — let's assume that Michigan's economy in the future will be based primarily on manufacturing, tourism and farming.

Today, Michigan uses fossil fuels to power most of the state's economy; gasoline, propane, coal and other fossil fuels power homes, stores, offices, factories and transportation. While the state has some renewable resources and some nuclear power, most energy generation is still fossil based. The four nuclear reactors in the state will likely retire by 2050; Palisades is confirmed to retire in 2022; the licenses for the two Cook units expire in 2034 and 2037 and probably will not be renewed; and Fermi will probably see extensions of its license to 2050. Additionally, while DTE Energy currently holds a license to build a new nuclear plant, the likelihood that it will — given the costs — is small. That's another four gigawatts of baseload power that will disappear.

Roughly one-third of Michigan's current fossil fuel is utilized for transportation. Another third is used in generating electricity, which is then utilized for many purposes, including a very small but growing share of transportation needs. The final third of Michigan's fossil fuel usage is for heating, feedstock or as material for manufacturing, power and chemicals used on farms, and in other activities.

Technology exists today to convert most personal transportation to electric vehicles. Technology also exists to convert all or most electricity generation to renewable sources. Maximum application and combination of existing and near-future technologies could make electricity up to 80% or 90% of the total energy type consumed in Michigan, freeing up renewable fuels, such as renewable natural gas and biodiesel, to be used as feedstocks or lubricants. Additionally, most plastics are created from fossil sources, but in the future, many could be made from soybeans or other plant products.

Seasonality of power sources and demand

In Michigan, even as the sun shines much less in the winter than in the spring, the state uses much more energy in the winter than in the spring. To allow solar power to replace some fossil fuel sources for electricity and space heating, the extra energy that could be generated from sunlight in the spring would need to be stored somehow until fall or winter for use. It is also possible to build extra solar facilities to produce the energy needed in the coldest and darkest periods of winter, then turn them off when they overproduce during the spring and early summer. However, both of these options would add to the cost and the potential intrusiveness of solar power on our neighborhoods.

The wind blows more steadily than the sun shines during most of the year, but during polar vortex and summer inversion conditions — the two weather events during which heating or cooling are most needed — the wind nearly always decreases or dies completely. Again, significant amounts of energy storage would be needed to allow wind energy to replace fossil fuels as a reliable source of electric power to homes and businesses throughout Michigan.

Almost all of Michigan's rivers are suitable for canoeing and kayaking. This means that they don't offer the hundreds of feet of drop that mountain rivers near either coast do, reducing the ability to use hydroelectric plants or dams to make massive amounts of energy. Many of the rivers in Michigan do offer modest power generation capacity at existing dam locations, but dozens of the existing dams do not have the turbines necessary to produce energy. Newer, more effective hydroelectric generation at existing dams — especially dams that were originally built to produce hydropower and already have grid connections — is a relatively easy step to take to expand Michigan's renewable energy generation portfolio.

Lakes Michigan and Superior offer the potential to harvest wave energy, although this technology is still experimental. Wave power generation stations, should they come into existence, would have to overcome significant public resistance to their potential conflict with recreational activities. Similar resistence has been seen against wind turbines, either in the Great Lakes or along their shores. Further complicating

**Numbers used in this report come from a number of U.S. government reports from FERC, EIA and other sources within the U.S. government. Detailed modeling has been done for Michigan by the author to support this report, based on those government sources.*

the use of wave power is the fact that — depending on siting decisions and the exact technology used — wave power might not be available when the area is iced over. This is an important consideration, given the region's experience with the high frequency of extremely cold winter temperatures and winter ice cover on the Great Lakes.

While forests cover much of the state, clear-cutting selected forest areas and replanting on a sustainable, rotating basis would not provide more than a fraction of the total amount of energy required by the state. This amount of wood — if consumed by each household — would exceed the production of all the sustainably harvested forests in Michigan by a factor of five. Though wood cannot meet all of Michigan's energy needs, it would be possible to collect and use some of the 300 million cubic feet of wood that dies each year in Michigan forests for either direct heating or pelletizing for heating or steam generation.

Wind

The most productive opportunity for wind power is also the most resisted by the public: installing a series of large 10- to 15-megawatt turbines on 500-to-800-foot-tall towers offshore in the Great Lakes. Models and simulations based on actual wind strength measurements show up to a 50% capacity factor. That means that offshore turbines would produce electricity for up to 50% of the time if they were customized to work with the offshore winds in their location. With three or four rows of these turbines running along the shore of Lake Michigan from Michigan City, Indiana, to the tip of the Lower Peninsula, the turbines could produce 6 gigawatts of energy and over 21 terawatt-hours of electricity per year, or about 8% of what would be required to completely electrify Michigan.

With good design and planning, the number of turbines that could be placed offshore may be able to be doubled, increasing the annual energy production to as much as 35 terawatt-hours. These large turbines offer a chance for Michigan to add a significant number of jobs in both building the towers and blades within the state and shipping them from the shore to the installation site. With the fall off in Michigan's boat production, existing Western Michigan workforces could be repurposed to manufacture wind turbine blades, as the basic skills used to create boat hulls out of composites are like those used to make a wind turbine blade. With blade lengths of 200 feet or more, building them on the lakefront makes sense from a transportation standpoint.

If the initial build-out was done over a 10-year period, enough experience could be compiled to begin manufacturing for international locations, and the St. Lawrence Seaway offers a transportation gateway for shipping the structures to almost any location in the world. Installation vessels could be built in the Upper Peninsula at an existing shipyard, bridging the military contracts that normally occupy them. Towers would have to be built in pieces, but if done along the lakeshore they could be created in larger pieces than if they were built elsewhere, reducing cost and assembly time on-site.

This, of course, could only be done if an agreement was reached with offshore wind opposition groups within the state and elsewhere, but it would be worth the attempt for the amount of low-cost, environmentally friendly power these turbines would produce and the high paying steady jobs projects would create.

Smaller wind turbines — 300-400 feet tall — could be installed in Michigan's Thumb region and on land along the shore in both the Lower and Upper peninsulas. Offshore turbine work and installation vessels would make delivery for near-shore work less disruptive than transportation on the highway system for long distances. While these turbines would produce less power each year, they would be designed to take advantage of a slightly different wind profile, providing diversity of location and helping to create a steadier supply of power. This type of smaller turbine would have the potential to generate 4 to 15 gigawatts of power depending on zoning, the use of federal land, and whether the necessary infrastructure would be in place.

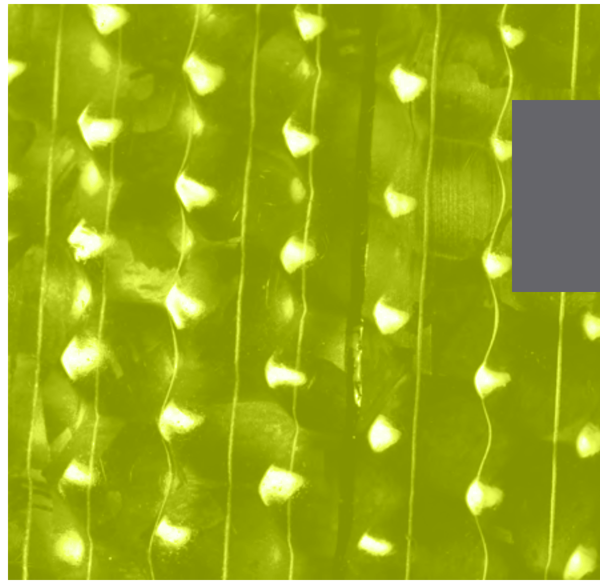
Solar

Many people assume that solar is the most effective choice for renewable energy. Panels generally do not move and can be installed on rooftops or close to the ground, where they can be hidden from most passersby and, therefore, be mostly invisible. Unfortunately, there is nowhere near enough rooftop area in Michigan to support the amount of solar power necessary to meet the expected demand.

Typical solar sites in Michigan require approximately 5 acres per megawatt of capacity and produce approximately 1,250 megawatt-hours per year, or about 250 megawatt-hours per acre per year. Michigan consumes approximately 110 terawatt-hours per year. As the country moves more and more of its transportation to electric vehicles, the total number of terawatt-hours needed to serve Michigan's population will increase the need for electricity from 250% to 300% based on current total energy use in the state.

If efforts to improve energy efficiency in Michigan succeed, doubling the current electric power generation capacity would be enough. In this scenario, for Michigan to become 100% solar would require 1,400 square miles of solar panels — 700 square miles to provide just 50% of the needed electricity. This is roughly 1% of the total land area of the state. With forest taking up more than half of Michigan's land area and cities, inland lakes and other areas not feasible for low-cost solar installation covering another 10% of the state, the reality is that solar generation would need to take approximately 2.5% of the available open land in the state to meet needs. Perhaps many farmers would likely welcome the income available from turning some of their least productive fields into solar power "farms."

The most effective locations for solar in the state, based on maps from the National Renewable Energy Laboratory, are along the Ohio border. The good news is much of the state's population is in reasonable proximity of this area, and the transmission lines from Ohio transit this area. The bad news is there is not enough transmission or distribution infrastructure in this area to move the power, as well as the fact that the region has some of the best agriculture land in the state, putting fresh produce in competition with solar power. Some of this area is also used by airlines for routes in and out of the state and airline pilots have complained of glare from solar panels when there are large arrays. These issues will need to be worked out, and the siting of solar will be based on land and infrastructure availability, zoning restrictions and other factors rather than pure technical production potential.



Solar, like wind, has a major part to play in a sustainable future. Michigan already has solar photovoltaic production facilities and there are jobs associated with them. Solar installation jobs are mostly low pay, manual labor jobs; they offer entry-level positions to able-bodied individuals for the period during which solar is being installed in a small region, and then they end. It is the factory jobs, the skilled electrician jobs, and the distribution control and monitoring equipment operator jobs that Michigan needs to focus their future on, rather than manual labor installation positions. Additionally, Michigan's universities would do well to determine how to automate as much of the installation-based manual labor as possible to reduce costs and improve the overall quality of installed solar.

When it comes to rooftop-distributed solar, Michigan could create a socially just program that puts some solar panels on the roof of every residence. Based on existing load of an average house, 2 kilowatts of solar on each single-family home's roof would provide the best technical answer and meet most of the daylight load for an average household in Michigan. This amount would minimize export back to the grid and the need to increase infrastructure size to support solar generation. Apartments, condominiums and houses should all be included in this kind of a program, though there isn't enough roof area on many multiunit buildings to provide all the power they would need. Thus, solar generation should be provided as part of the electric service on each dwelling unit. Unfortunately, the regulatory mechanism remains to be decided on how to do this fairly for all residents of the state, regardless of income or ownership.

Pumped storage

Pumped storage is an area in which Michigan used to really shine and could do so again. There are a number of mines — mostly abandoned — found throughout the state, some open pit and some hard rock tunnels. They can provide a way to store massive amounts of energy. In one Michigan limestone mine, there is the ability to install more than 20 gigawatts of generators and store more than 10 terawatt-hours of electricity. This is an existing mine that could be repurposed. Additionally, the lake bottom in the lake nearest to the site is also limestone of the same variety, moving water between the storage facility and the lake would not contaminate the water.

More than 100 mines that exist in the state are capable of providing multiple gigawatt-hours storage capacity or more for storage at costs that are a fraction of those of batteries. This would allow the state to make use of facilities that are without value today, returning value to the tax rolls for the state. Other states have either water or mines, but few have both and few have as many hard rock mines that don't pollute the water on each cycle. In several Upper Peninsula mines, the mine is large enough and deep enough that the entire pumped storage cycle could happen within the mine, creating a closed-cycle system.

Michigan Technological University has pioneered research on using mines for pumped storage and is doing an inventory of available properties that contain potentially useful facilities. Changes to state laws and regulations would be needed to move this idea forward to take advantage of Michigan's natural sustainability advantages. Building and maintaining not only the storage facilities, but the supporting transmission network that would be required, would provide high-skill jobs for at least the 20 to 50 years required to transition to renewable power.

This would give Michigan a position similar to that which it holds today in natural gas, in which storage facilities allow for the purchase of the natural gas when the demand and price is low and the sale of gas when the prices are higher. For decades, natural gas prices for residents of Michigan have been lower than wholesale national prices because of this nearby storage capability. Mines converted to pumped-water storage could provide Michigan with a similar position when it comes to electricity.

Pumped hydro — where the structure already exists — has five to 20 times the life span and a tenth of the cost of battery storage. These characteristics give Michigan a huge advantage in a renewable future and would offer the manufacturing industry energy prices that would out compete any other state — provided the right laws and regulations were put in place. Today, Michigan has the highest electricity costs in the Midwest; tomorrow, it could have the lowest. It is up to the people of Michigan to determine how pumped storage will work in their state.

In Ludington, Michigan, an existing pumped storage facility went through years of opposition based on theories that were proven wrong when it began operations. The Ludington facility has operated for decades with minimal environmental impact. The pumped water battery at Ludington is pumping Lake Michigan water into a reservoir during periods of low electricity demand and then withdrawing the banked power by running the water over hydroelectric generator turbines when power demand is high. In the future, we may find that water is our most important resource for making our future energy use green, and Michigan stands in a unique position to influence a national transition to a sustainable energy model.

Batteries

The more electric and hybrid-electric vehicles sold, the more batteries are being utilized for transportation. Michigan now has two lithium-ion battery plants in operation, and another two battery pack assembly plants are planned by Michigan automakers. These manufacturing jobs offer a way to provide for electric transportation while at the same time offering small-scale batteries for backup power throughout Michigan.

Batteries will continue to be important to the electric grid and to key critical facilities, such as hospitals. As such, more will have to be installed when fossil fuels are phased out for electricity and heating.

Batteries in vehicles may also serve in a critical role to the grid: providing electric power to the buildings they are parked next to during storms or periods of peak demand. However, arriving at the point where electric vehicle batteries can both draw power from the grid and give it back will be an important step in the integration of transportation and the grid. Drivers will have to set limits on how much power the battery can offer the grid and may be required to set a price at which they would be willing to offer the power. It will need to be understood that the grid will not draw more energy from the battery then the limit set by the driver, leaving the driver with enough power to get home. Again, Michigan state laws and regulations would help make this possible to provide auto manufacturers with a market in which to test equipment and software.

Renewable gas generation

Michigan's landfills not only contain waste created by Michigan residents but also from residents of surrounding states. Much of the energy created by the decay of that trash is lost today because of the cost and complexity of collecting landfill gas to convert it to useful fuel.

Because of the research capacities of the state's university system, Michigan could become a world leader in developing systems that produce and distribute both renewable landfill gas and biogas from farming waste. Michigan State University already has commercial biogas facilities up and running and is executing multiple research projects with the experience and knowledge to improve those systems. Having Michigan State and other universities expand their work to commercialize landfill gas production and collection should be encouraged. An additional benefit of these efforts would be to reduce the release of methane, a potent greenhouse gas, to the atmosphere from farms and landfills.

Trash and biogas will play a small but highly important role in a sustainable future. The weather does not always provide enough renewable energy, but it can also provide far more load than the system can handle. Using storage the state already has and saving this gas through the existing pipeline system for a rainy day means there would be ready access to additional stored energy in areas of the state that don't have other energy resources. This would provide voltage and frequency support for a generation system supplied predominantly by intermittent solar and wind power, offering stability and reliability.

Vehicle electrification

Whether it is a private car for taking the children to school and soccer practice or a heavy truck delivering bananas or a tractor to a field to plant corn or harvest navy beans, transportation will eventually go entirely electric. It may happen using the current battery technology pioneered by Tesla and others or perhaps we'll move to liquid batteries that can be quickly refilled and charged at a service station, requiring that you pump out and refill a vehicle battery with fresh, charged electrolytes, leaving the used fluids behind to be recharged at the service station.

In any case, infrastructure will need to be developed to both provide and distribute electricity to cars to charge them, including a charging infrastructure throughout Michigan to support convenient tourist travel. Solving these challenges will be critically important to letting Ford, GM, FCA and other Michigan companies sell or lease its electric vehicles to the residents of Michigan by allowing automotive companies to test their products in the state, keeping critical, high-skill jobs in Michigan.

Installing electric chargers before electric vehicles become a major portion of transportation would allow people to feel like they could always find a charger, just like they do today with gas stations. Truck stops and depots will also need charging infrastructure. The California Department of Weights and Measures has set standards for vehicle chargers that exceed any previously existing standard. Should Michigan follow California's lead, or should some other laws and regulations take hold? This is a decision that needs proper public policy debate.

Consumer and manufactured goods cargo traffic transits Michigan primarily on an east/west axis. Taking these large trucks off the road and putting their cargo containers on trains would reduce goods such cargo energy use by 90% or more. Finding the most effective way to do this will not be easy. Car trains could be developed to ferry individually owned vehicles using energy-efficient trains instead of the individual vehicle's power source. Doing something similar for the entire U.S. along the I-75 north-south corridor would be useful both for heavy trucks and for vacationers going to the Upper Peninsula. Yes, this would mean fewer tourist stops in the smaller places along I-75, but it would lower energy usage and make the route faster.

Buildings

Michigan has many inefficient buildings, lacking sufficient insulation and using appliances, lights and other equipment that could be much more energy efficient. Trading out propane, fuel oil and natural gas furnaces for high-efficiency heat pumps would increase employment among HVAC techs, excavators and plumbers for a decade or two across the state.

Developing a heat pump that can produce heat in subzero temperatures is a job for the researchers in Michigan's state university system. Right now, most heat pumps begin to be less efficient at freezing and stop being useful around zero degrees Farenheit. Building better systems is something that could go a long way to helping Michigan keep manufacturing jobs and create more jobs over a much longer time period than installing solar or wind power systems.

Every building in Michigan should be assessed and rated on its current energy efficiency. The building code requirements for insulation, lighting and HVAC system efficiency need to be brought up to the same standards that Canada now uses and then be increased slowly. Requirements for overall building efficiency should also increase. Most major remodeling projects should trigger requirements for higher efficiency in order to meet the new codes. Dow, combined with the work of state Michigan's research universities, should create development of better insulation materials than those on the market today. Improved products specifically designed for retrofit of existing housing and commercial buildings are also needed.

For low- and fixed-income residents, the state needs to develop a loan program that costs very little and is paid back on the sale of a home. These residents live in some of the worst-insulated dwellings, with appliances that have the lowest efficiency. A serious program on energy efficiency would not leave those people behind. Again, public policy debate and changing laws would move the state forward. The program would need a strong inspection regime and competitive bids. Bidders who don't deliver the specifications wouldn't get paid and wouldn't get to continue in the program. Those that do should be able to get more business through the program and access to low-interest loans for people who do not qualify for the low- or fixed-income program. Rental properties, condominiums and other types of dwelling units should be included in the program.

Commercial and public buildings need to be included too, and those buildings should be subject to similarly strict standards.

Appliances and media devices

Michigan has several appliance brands that have research and development in the state, providing great jobs. Combine this with the research programs at state universities and a goal of moving the bar for energy star appliances, and more great jobs become available in the state. With the opportunity for low-cost sustainable electricity, manufacturing jobs may flow back into the state as well. Rather than follow California with creating a one-state or few-state standard, Michigan could support this with tax incentives. The tax incentives would need to be a moving target, always higher in the next few years to keep people wanting more efficient appliances. Europe has utilized this moving target model for appliances for more than 15 years, leading to more and more energy-efficient appliances and media devices, like TVs.

Demand response

Today, Michigan's idea of demand response is turning off the air conditioner on a hot day. This is a widely panned program — not just in Michigan, but everywhere. There is discussion of sending prices directly to all energy-using devices and allowing them, based on what the owner desires, to decide if they will turn off or not. Known as "prices to devices" and "transactive energy," this kind of a program may provide more reliable demand response in the future and allow air conditioners to run while the pool pumps and hot water heaters turn off. Michigan state legislature would need to determine how this would be executed, but devices in the home and business with the smarts to turn on and off based on a pricing signal are rare today, and if there is not a clear value to buying them, most homeowners will not.

Cybersecurity threats will always be an issue with a modernized grid and an electrified world. Both the long-term value and the security of the devices are items that Michigan state legislators must think about and work with the stakeholders to come up with desirable solutions. Again, the state universities need to be engaged to connect with the residents of the state and develop a clear picture of what they would be happy with and how much incentive it would take to make the move. This, combined with research from the Institute for Social Research at the University of Michigan, would give stakeholders a more substantial voice.

In this area, too, the requirements for a low- or fixed-income household and small businesses would need to be considered in designing the test programs. Once the test programs had run, then long-term policy could be built for the whole state. Again, Michigan can lead if it chooses to.

Planning the transition

The transition to a sustainable energy system will have to happen gradually; people can only afford to pay so much for energy, no matter the form they purchase it in. Utilities are limited by regulations to a limited capacity for investment and installation work in a given period. Even if third parties were offered the chance to help, the engineering and integration work required would limit the amount of work that could be done each year.

There are a limited number of people who understand what to do to safely make the changes needed in the existing infrastructure. It takes a significant amount of time to train new people. Given these limits, completing a full transition in a 30-to-50-year time period is probably reasonable for Michigan. This amount of time would allow people to make replacement purchases for sustainable items as their appliances, cars and other devices wear out or become obsolete, rather than forcing them to junk items that still have useful life. By choosing a natural replacement cycle, the transition would allow individuals to replace items as they have the money and the need.

In electric transportation, for instance, the circuits that exist today were sized and built for household use, not for transportation use. To provide the amount of electricity needed to charge electric vehicles means moving more than twice as much electricity through a system than it was designed to handle.

Because of the way regulation works in Michigan, utilities have not been allowed to over-build the system. In many cases, the electric grid is already overloaded on a hot or cold day. Because of this, more than 90% of the distribution grid would need to be rebuilt to provide power for electric transportation. In some cases, vehicle electrification demands a voltage increase by a factor of 10 and increasing the wire size by a factor of 5. For some distribution circuits an increase of 50 times in electricity demand will be triggered by vehicle electrification, even without the increases expected from electric heat. These circuits serve commercial and industrial areas that now draw only lighting and appliance energy from the electric grid and do almost everything else with natural gas. They currently depend on gas stations elsewhere to provide the energy for transportation, but they house a large number of commercial vehicles. On rural circuits electric tractors and farm equipment will increase demand far more than typical urban residential circuits and in many cases these rural circuits have the least capacity to deliver electricity today.

In a perfect world, the regulations and planning would change soon to start making these investments today. If this isn't done, utilities will have to touch, retouch and touch again the power systems as the load grows. The allowed rate of distribution equipment replacement in Michigan for non-storm damage reasons is running at just about 1% per year. Current regulations mean that it will be at least 2120 before the whole grid will be equipped to handle the needs of a sustainable future. Accommodations will have to be made to handle things like off-site charging or limiting vehicles per company or household.

Ford's Michigan Assembly Plant, in Wayne, is a great example of a facility where load could increase by a factor of 20-50 overnight — simply by adjusting to build Ford's upcoming electric pickup truck.. Once assembled, those new trucks would need their batteries charged to be able to be delivered safely to dealers across the country.

Transmission systems across the state will lose some of their capability to move power as coal and other large plants are

shut down. Today, those plants inject the reactive power and voltage support needed to keep the transmission capability operating at its capacity ratings — remove those plants and the transmission system must be redesigned or derated to move less power. Recycling the generation equipment at those central plants — no fuel would be used, just the existing generation machinery — would remedy this reduction in capability significantly.

But can the investment in operating this type of system — a synchronous condenser — fit into the current split ownership regulations in Michigan, where generation, transmission and distribution have different owners and different rate cases and are treated differently by the regulators and state laws? How this is resolved is a work in progress. But all the stakeholders have different objectives, so finding common ground will take time.

One of the most technically challenging parts of electric transmission is to tightly link Michigan's two peninsulas together. While the two regions should be able to operate independently, they should also at least be able to operate in tandem. If Enbridge is permitted to build its proposed tunnel under the Straits of Mackinac, the tunnel should be sized to accommodate high-voltage (500-kV or higher) transmission. Reducing the cost of both electricity and propane to the people of the Upper Peninsula — and taking advantage of mine sites and generation that the Upper Peninsula offers the rest of the state — would increase earning potential for many residents.

Investment in Michigan's future

Because Ford, GM, FCA and other automotive companies are located in Michigan, any investment in the electric grid and sustainable energy is also an investment in jobs and the state's future. Every large company in the state should be encouraged to work on making its products better, more efficient and powered by electricity. Investment in research and development is an investment in the people of the state of Michigan and, when supported by the universities, an investment in education for future needs.

Utility companies should be encouraged to invest in transmission and distribution infrastructure, and possibly even renewable generation and storage. These companies are the ones who will end up operating and maintaining these assets, so maybe they should own them. Co-ops, municipal utilities and even investor-owned utilities should have incentives to build for the future and not to nickel-and-dime the upgrades.

A Michigan choice

Michigan can either sit on the sidelines and let others develop the technology and manufacturing facilities or it can choose to make a move to become the state where much of this work is done. It can choose to ignore the mismatch between renewables and traditional demand or take strategic advantage of the position Michigan is in and build pumped storage projects, helping manufacturing keep costs down and absorbing a lot more renewable generation. Michigan can build a sustainable ecosystem or borrow someone else's in 10 or 15 years. Michigan has strategic advantages; the question is are the lawmakers and the regulators willing to use them and to work with stakeholders to put them to work?

This will not require a huge amount of government funding from the state. Instead, a law change here and a regulation change there, piece by piece, would help the state move forward. Lowering barriers and encourage development while working with stakeholders to make projects easier to do will encourage forward thinking. Small changes in how current money is handed out to universities and the development of a common curriculum for community colleges in many of these areas will speed the number of students who are ready to dig in and help.

But the state legislature in Michigan must make a conscious decision to be on the leading edge and encourage movement, lest the state sit back and let others do the work. Jobs, communities, companies and the state's future ride on what they decide to do.

Biography

Doug Houseman is a principal consultant who specializes in the power industry and grid modernization at 1898 & Co., part of Burns & McDonnell. He is an industry veteran who is a member of the GridWise Architecture Council and chair of the IEEE PES Intelligent Grid and Emerging Technologies Coordinating Committee. In 2019, Doug was selected as a Top 25 Newsmaker by *Engineering News-Record*.

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14517-MRE-0220