CHP ROADMAP FOR MICHIGAN

EXECUTIVE SUMMARY

Prepared for the Michigan Energy Office on behalf of the Michigan Agency for Energy and the US Department of Energy

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Project Team

The **Michigan Energy Office** (MEO) is within the **Michigan Agency for Energy** (MAE). MAE is a government agency within the Michigan Department of Licensing and Regulatory Affairs. MAE coordinates, analyzes, advises on, and advocates for the state's policies, programs, and proposals related to energy. The MEO is a recognized State Energy Office by the federal Department of Energy. MEO encourages and informs energy policy and technology and program development by facilitating partnerships, administering grant funds, and providing statewide education, outreach opportunities and stakeholder collaboratives.

5 Lakes Energy (5LE) is a Michigan-based policy consulting firm dedicated to advancing policies and programs that promote clean energy, sustainability and the environment. The team has decades of experience in research, modeling and analysis. From public policy design to reviewing policy implementation around the country and world, 5 Lakes Energy has the deep knowledge base necessary to review, analyze, and recommend models for optimizing the deployment of clean energy.

Sustainable Partners LLC (SPART) was formed in 2011 to develop and finance alternative and renewable energy projects and provide related consulting services to major industrial and commercial energy users. SPART excels at building consensus among stakeholders, leading cross-functional teams, and ensuring accountability, while helping clients thoroughly evaluate energy options and implement sustainable projects through advisory services and direct capital investment.

The **Energy Resources Center** (ERC), established in 1973 at the University of Illinois at Chicago, is an interdisciplinary public research center bringing experts from across the fields of electric, mechanical and environmental engineering, in addition to economics, public policy, and bioenergy. The ERC manages the U.S. Department of Energy's Midwest CHP Technical Assistance Partnership (TAP), which provides services to twelve Midwest states, including Michigan.

NextEnergy is one of the nation's leading accelerators of advanced energy and transportation technologies, businesses and industries. NextEnergy drives technology demonstration and commercialization, delivers industry and venture development services, and provides an authoritative voice in the public sector. Founded in 2002 as 501(c)(3) nonprofit organization, NextEnergy has helped attract more than $1.6 billion of new investment, including programs in excess of $160 million in which NextEnergy has directly participated.

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About the Report

The Combined Heat and Power (CHP) Roadmap for Michigan is a collaborative effort to accelerate the adoption of CHP in Michigan through three objectives:

1. Identify and evaluate CHP technologies and applications with a potential for adoption in Michigan;
2. Assess, measure, and determine the cost and value of CHP in Michigan's future energy mix;
3. Listen, educate, and advocate for the inclusion of CHP based upon economic, environmental, and system benefits.

Project partners worked to identify strategies to remove transactional, market, finance and policy barriers to CHP deployment. Project partners also worked to leverage proven methodology to map and engage the Michigan-specific CHP supply chain. This report shares results and recommendations that can be utilized to accelerate the adoption of CHP in Michigan and achieve the resulting economic benefits.

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Executive Summary

1 Summary

Michigan has the opportunity to capture enormous benefits by embracing optimal levels of combined heat and power (CHP) generation in its future energy mix. CHP provides a path to make Michigan businesses more competitive by lowering and stabilizing energy costs, reducing strain on the electric grid, improving on-site reliability and resiliency, and lowering harmful greenhouse gas emissions. Yet many studies have shown that CHP is a vastly underutilized energy resource across the country due to a combination of policy barriers, market impediments, and other factors. Michigan intends to be a leader in advancing CHP deployment and this Roadmap is a significant initial step in that effort.

CHP is *the* most fuel-efficient way to produce and utilize both electric and thermal energy from a single fuel source. CHP adoption across Michigan offers a low-cost approach to new electricity generation and uses highly skilled Michigan labor and technology to develop, implement, and operate projects.

Governor Snyder has made smart energy policy a top priority for Michigan, emphasizing the need to reduce energy waste and increase reliability. A confluence of executive and legislative interest in energy policy, coupled with recognition of the potential of CHP to participate in meeting Michigan's energy needs, means the time is right to accelerate CHP deployment in Michigan.

The CHP Roadmap for Michigan differs from previous projects by applying cutting-edge integrated resource modeling tools to determine least-cost deployment of CHP resources. This model – the State Tool for Electricity Emissions Reduction (STEER) – calculates the least-cost resource portfolio to satisfy electricity demand and various reliability and environmental constraints based on projections of demand, fuel prices, technology price and performance, taxes, and other factors. Depending on natural gas prices and the availability of renewable energy resources, STEER recommended an optimal level of additional CHP deployment in Michigan ranging from 722 MW to 1,014 MW by 2030.

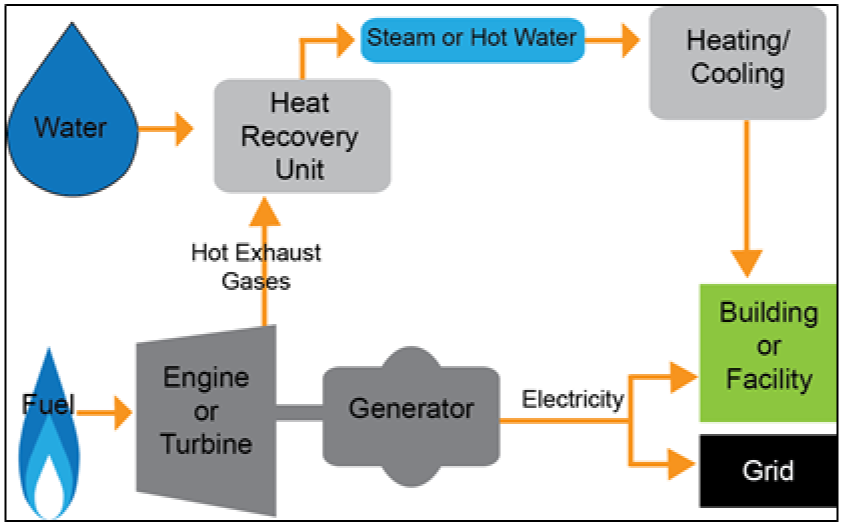
Parallel to this modeling effort, an intensive analysis of Michigan's CHP-related supply and value chains provides insight to support state-level policy analyses and recommendations. Michigan firms have a robust ability to participate throughout the CHP value chain with the majority of economic impact being realized by using the pool of talent based in Michigan companies to design and implement CHP projects.

Finally, the Michigan CHP Roadmap provides a series of prioritized public policy recommendations that will put Michigan on a path to a CHP-friendly future, including recommendations to:

- Offer financing and incentives for CHP in order to reduce the payback period for CHP projects;
- Promote Property Assessed Clean Energy (PACE) financing and on-bill financing for CHP;
- Consider best practices in utility standby rates and PURPA avoided cost/buyback rates;
- Fully value CHP when considering the costs and benefits of distributed energy resources;
- Update interconnection standards to better align with new technologies and best practices;
- Incorporate CHP as a resource in Michigan utility energy waste reduction (EWR) plans;
- Require utility integrated resource plans (IRPs) to consider CHP as both a supply-side and demand-side resource;
- Collaborate closely with expert organizations, such as the Midwest CHP Technical Assistance Program (TAP), to promote CHP assistance.

2 Background

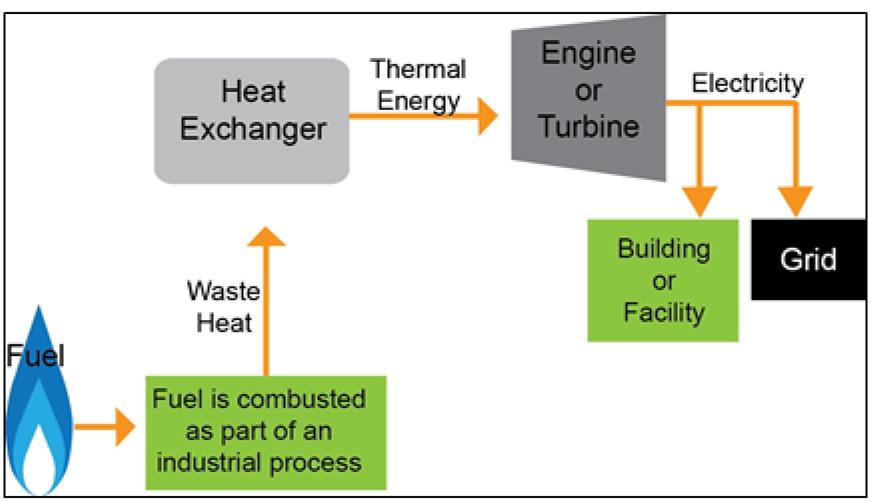
CHP is the simultaneous generation of electricity and useful thermal energy from a single source of fuel, located at or near the point of energy use. Electricity is primarily used on site as a substitute for utility-provided power, with any excess generation potentially sold onto the grid. The thermal energy can be used to support process applications or human comfort through the production of steam, hot water, hot air, refrigeration, or chilled water.



CHP Topping Cycle

Installed CHP systems typically achieve total energy efficiencies of 65% to 80%, compared to a weighted average of only about 45% to 60% for conventional separate heat (via boilers/furnaces) and power generation (via central utility plants). By avoiding electric line losses and utilizing much of the thermal energy normally wasted in power generation, CHP significantly reduces the total primary fuel needed to supply energy services, reducing greenhouse gas emissions and saving fuel and money. CHP systems can range in size from 5 kilowatts (kW; the demand of a typical single-family home) to several hundred Megawatts (MW; the demand of a very large industrial plant). The more efficiently the thermal energy can be utilized, the more money the end-user saves on energy consumption and costs.

CHP technology can be deployed quickly, with few geographic limitations, and can utilize a variety of fuels, both fossil and renewable. CHP may not be widely recognized outside industrial, commercial, institutional, and utility circles, but it has quietly been providing highly efficient electricity and process heat throughout the United States for decades to vital industries, large employers, urban centers, critical infrastructure like hospitals and wastewater treatment plants, and university campuses.



CHP Bottoming Cycle: Waste Heat to Power (WHP)

3 Methodology

The methodology employed throughout the Roadmap was developed with the objective of replicability in other states. To achieve this objective, project partners relied on:

- U.S. Department of Energy (DOE) state-by-state CHP technical potential projections,
- U.S. Environmental Protection Agency (EPA) data on CHP economics and performance across a range of technologies and generating capacities, and
- U.S. Energy Information Administration (EIA) data for Michigan's existing power plant portfolio

According to DOE, Michigan has nearly 5 GW of CHP technical potential at more than 10,000 sites across 17 industrial and 24 commercial sectors. This potential, on a capacity basis, is roughly evenly split between industrial candidates in the transportation equipment, chemicals, primary metals, paper and food sectors; and commercial candidates in the commercial office building, higher education, hospital, retail location, and multifamily housing sectors.

The EPA provides cost and performance data for the five CHP technologies which comprise 99% of existing installations: reciprocating engines, steam turbines, combustion turbines, microturbines and fuel cells. Data from DOE, EPA and EIA serve as a major proportion of the input required for the STEER model to dynamically identify which CHP configurations are economically viable across a wide variety of scenarios. This analysis narrows the scope of Michigan's technical potential to only include those projects that are economically viable given Michigan's overall power generation portfolio.

Mapping of the Michigan CHP supply and value chain utilized methodology previously developed to support creation of the Michigan "Clean Energy Roadmap." Boundaries for supply and value chain mapping were determined through market research and market analysis based on likely economic impact to the state of Michigan arising from deployment of CHP projects. Market segments where Michigan companies are currently participating in the CHP supply or value chain were given principal consideration for surveys and interviews. A directory of Michigan supply and value chain firms has been created and will be distributed to foster collaboration and promote CHP deployment.

In customizing and prioritizing proposed solutions for Michigan, project partners considered the estimated proportion of potential projects affected, perception of barrier magnitude by stakeholders, and the ease/practicality of achieving change in the short term. Focus was placed on those barriers that are most significant to restricting deployment of CHP across Michigan and to which attainable solutions exist. These include 1) a lack of access to low-cost capital; 2) prohibitive utility rates; 3) failure to fully embrace CHP in energy waste reduction and integrated resource planning; and (4) a lack of awareness or familiarity with CHP. For the most part, solutions take the form of legislative change or regulatory relief, modification of utility rate structures, and financial incentives.

Finally, deployment of the Roadmap involves the ongoing effort to educate CHP stakeholders, and especially end-users, on the merits of CHP. Project partners engaged with over 300 individuals through outreach and education efforts related to the development of the Roadmap. Project partners are working with the Michigan Agency for Energy to expand outreach and assistance over the next several years as a critical step toward achieving the goal of accelerating the deployment of CHP in Michigan.

4 State Tool for Electricity Emissions Reduction (STEER)

The STEER model was used to assess, measure, and determine the cost and value of CHP as one of multiple resources in Michigan's future energy mix. In our primary application of STEER, we considered the net value of CHP to the economy by considering the cost of installing and operating various CHP systems, the value of the heat produced by CHP measured as the cost of supplying heat in the least-cost way other than CHP, and the value of electricity produced by the CHP system measured as the marginal cost of producing electricity absent the CHP system.

Because we determined that standby rates are one of the principal barriers to CHP adoption and may be amenable to policy adjustments, we also used STEER to evaluate the effect of standby rates on the economic potential for CHP in Michigan. Further, because resilience of CHP site host operations is an important benefit of CHP that is not reflected in standard electric power system evaluations, we also used STEER to evaluate the additional economic potential for CHP in Michigan if site hosts would not otherwise choose to build CHP but sufficiently valued resilience to enable them to build CHP. Consideration of resilience value increases the potential deployment of CHP in sectors where loss of power is most consequential and can significantly increase CHP potential beyond the levels that would be supported only by power sector value. Based on our analysis of Michigan potential, resilience value could increase CHP potential by around 60%. Standby rates, on the other hand, substantially reduce the profitability of CHP ownership and thereby reduce potential CHP deployment by 50% or more.

STEER modeling indicates that steam turbines, gas combustion turbines, and reciprocating engines appear profitable above some size threshold size in each scenario. Conversely, microturbines and fuel cells do not appear economically viable.

Scenarios with higher natural gas prices and higher cost of renewable resources in the future both tend to lower the minimum size threshold for the more viable CHP technologies, thereby expanding the number of potential installation sites in Michigan.

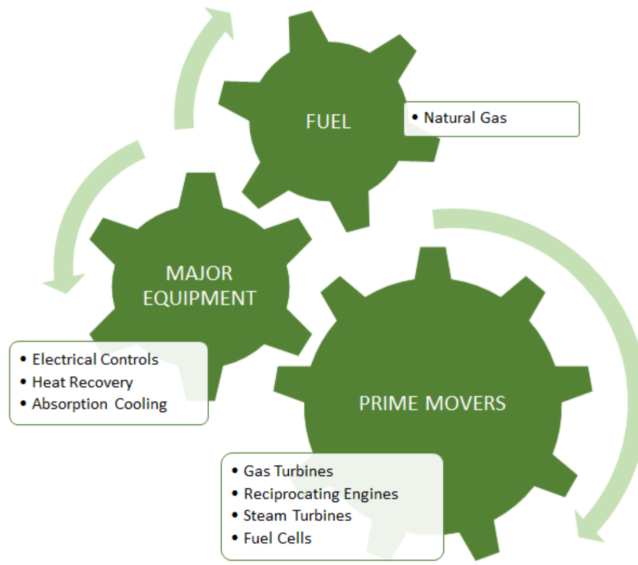
About half the sites where steam turbines are economically feasible are colleges and universities, confirming that this sector should be an important part of end-user outreach and education. We also note that this result does not necessarily mean that combustion turbines and reciprocating engines would not be suitable for many of these applications.

In our reference scenario, economic potential for CHP in Michigan is about 1,014 MW electric generation capacity with direct investment of about $865.6 million, annual direct O&M activity of about $67.6 million, annual economic profit of about $109.5 million, annual fuel cost savings of $94.7 million, and annual air emissions reductions of 662 tons CO_2 per year, 379 tons NO_x per year, and 39 tons SO_x per year.

In various scenarios, assuming various fuel and technology costs, the economic potential for new installed CHP in Michigan varies from 722 MW to 2,360 MW.

5 Michigan Supply and Value Chain

Demand for CHP projects in both the private and public sector is primarily driven by an economic comparison of the costs and benefits of CHP versus the costs and benefits of current operations. This status quo typically entails electric generation at a utility-owned power plant and thermal energy generation on-site by end-user-owned boilers or furnaces.

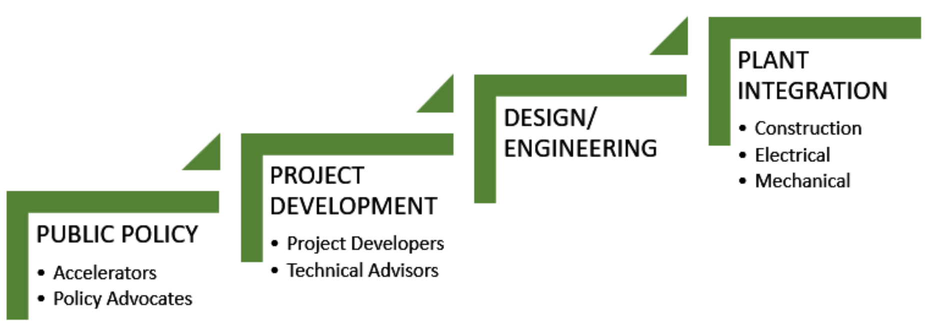


The **CHP supply chain** consists of the physical equipment and fuel required for the CHP system to operate. The major sectors of the CHP supply chain include CHP end-user applications, prime mover manufacturers and distributors, major equipment manufacturers and distributors, and fuel suppliers and brokers.

While Michigan manufacturers cannot realistically tap into prime mover manufacturing, there are a handful of Michigan companies that manufacture some of the major ancillary equipment that may be found in CHP projects but are not part of the prime mover systems. And manufacturers of both prime movers and other equipment execute sales, engineering, and service functions through Micihgan-based distributors.

Fuel supply and price can be controlled via 5 to 10 year contracts in most industrial and commercial locations, with costs currently near histroric lows. This ability to control commodity costs significantly mitigates investment risk. In some regions of the state, particularly rural areas and the Upper Peninsula, the infrastructure for handling large volumes of natural gas is inadequate or nonexistent. Biomass-based fuel sources may be utilized but require significant additional effort on the part of the project developer. In the Upper Peninsula, unless a potential CHP project is located in one of the few major cities or along the east-west natural gas transmission corridor, fuel supply may be an impossible hurdle to overcome.

Michigan firms have a robust ability to participate throughout the **CHP value chain**, which consists of the intellectual capital and skilled trades required to develop, design, engineer, finance, install, and integrate CHP systems. The major sectors of the value chain include policy advocates and accelerators, project developers and technical advisors, design/engineering firms, and plant integration contractors.



The majority of the economic impact of CHP will be realized by using this pool of talent based in Michigan companies to design and implement projects.

6 Barriers to CHP in Michigan

CHP has the potential to be a significant, reliable, cost-effective, and environmentally protective contributor to Michigan's energy mix. However, those interested in installing CHP projects face a number of obstacles. In order to fulfill the promise of energy waste reduction (EWR) in Michigan through optimal deployment of CHP, these barriers should be examined and understood in general, and in light of the unique circumstances facing Michigan energy users.

While CHP can save a system owner money in the long run, there are a few economic barriers that could prevent a CHP project from moving forward in the first place. The relatively high upfront cost of installing a CHP system can be a barrier in itself. Additionally, a lack of sufficient access to financing options can prevent otherwise cost-effective installations. CHP developers must navigate a complex landscape of project financing alternatives and provide detailed project information in order to attract investors. Inadequate information can cause project delays, leading investors to offer less favorable financial terms, or even decline a CHP investment opportunity all together.

Regulatory barriers can dramatically affect a CHP project's bottom line and projected payback period. An overarching barrier that affects the valuation of CHP throughout regulatory and policy discussions stems from the failure to account for the full value of CHP, including qualities such as resilience. Ignoring grid-wide and societal benefits affects how CHP is portrayed in standby rates, avoided cost rates, energy waste reduction standards and integrated resource planning. Standby rates, or charges a utility customer pays for the utility to provide backup service in case of a scheduled or unscheduled CHP system outage, can be so high as to completely undermine the economic viability of a proposed CHP system. Beyond standby rates, avoided cost or buyback rates under the Public Utility Regulatory Policies Act of 1978 (PURPA) may be insufficient to make a CHP project worthwhile. Interconnection processes can be lengthy, cumbersome and costly. Where states have embraced energy waste reduction (EWR) goals or standards, a failure to incorporate CHP, or to properly calculate energy savings from participating CHP systems, will lead to less than ideal deployment numbers. Finally, even as regulators and utilities embrace a longer-term resource planning approach, integrated resource planning (IRP) models often fail to recognize the value of CHP as both a supply side and demand side resource, resulting in CHP being overlooked in utility long-range resource plans.

Each of these barriers – which are often dependent on geography, project size and technology, utility constraints, and the prevailing regulatory climate – adds to the risk and cost associated with a potential CHP project. And since CHP is not regarded as part of most end-users' core business focus, it is often subject to higher investment hurdle rates than competing internal options.

Given the substantial capital investment involved in developing a CHP project, and in light of the benefits offered by more robust deployment of CHP, it is vitally important that these risks and costs be mitigated through thoughtful policies and incentives to avoid preventing CHP projects that would otherwise make good sense for Michigan businesses and the state's future energy mix.

Michigan businesses interested in CHP have access to the U.S. DOE's Midwest CHP Technical Assistance Partnership (TAP), managed by the Energy Resources Center and based in Chicago, Illinois. The Midwest CHP TAP promotes greater adoption of clean and efficient energy generation and use through CHP, district energy, and waste heat recovery. The Midwest CHP TAP provides a number of resources to potential CHP end-users including free or low-cost technical advisory services.

7 Roadmap for CHP Deployment

There is strong interest and capability for Michigan to move closer to optimal levels of CHP deployment. Currently, Michigan is home to over 3,300 MW of installed CHP capacity, and STEER indicates that ideal levels of CHP in Michigan include between 722 MW to 2,360 MW of new installed capacity. In order to pursue a greater role for CHP in Michigan's future energy mix, these recommendations reflect lessons learned from stakeholder surveys, interviews, Midwest CHP TAP experience and expertise, and best practices from other states.

1. **Offer financial incentives for CHP.** Payback period is critical to the development of a CHP project. Efforts to reduce the payback period of CHP by either defraying some of the initial upfront cost through a grant or offering a production incentive would be beneficial in addressing this barrier.
2. **Promote Property Assessed Clean Energy (PACE) financing and On-Bill Financing (OBF) for CHP.** PACE financing eliminates the high upfront cost and spreads the repayment over a long enough term that the annual savings generated from the CHP project exceed the PACE payments starting in the very first year. With OBF, the customer's costs of energy waste reduction retrofits or equipment are amortized and added to savings resulting from the measures on the customer's utility bill.
3. **Consider best practices in utility standby rates and PURPA avoided cost/buyback rates.** Standby rates are difficult are to interpret and navigate and negatively impact a CHP project's bottom line. The need for a revised approach to standby rates in Michigan stands as a prime example of a barrier to CHP that can be readily reduced or eliminated.
4. **Fully value CHP when considering the costs and benefits of distributed energy resources.** Michigan's current distributed generation program is targeted at small installations and does not include CHP. Future consideration of the costs and benefits of distributed energy resources should include CHP and attempt to capture its full value, including the value of resilience.
5. **Update interconnection standards to better align with new technologies and best practices.** Michigan's new energy law (passed in December 2016, PA341 and PA342) gives the MPSC authority to revisit and update the interconnection technical standards. Other states in the Midwest have recently revised their interconnection standards for small electrical generations to follow best practices and reflect the proposed standards in FERC Orders 792 and 792-A.
6. **Incorporate CHP as a resource in Michigan utility energy waste reduction (EWR) plans.** When allowed as an eligible measure, CHP can improve a utility's ability to meet energy reduction goals and further increase CHP deployment.
7. **Require utility IRP's to consider CHP as both a supply-side and demand-side resource.** This would help ensure that these complicated projects are allotted equivalent analyses as other resources.
8. **Enable commercial/industrial property owners to utilize shared CHP assets under flexible terms.** Current legislative policy allows contiguous, but distinct, industrial end-users to share the electrical power from a single CHP installation, while prohibiting contiguous, but distinct, commercial end-users from sharing electrical power from a single CHP installation.
9. **Collaborate closely with expert organizations (e.g. Midwest CHP TAP) to promote CHP assistance.** These resources can be enormously helpful for those interested in developing CHP projects.

8 Moving Michigan Forward

Michigan is poised to move forward toward optimal levels of CHP development. According to the U.S. DOE, Michigan has nearly 5 GW of CHP technical potential at more than 10,000 sites across 17 industrial and 24 commercial sectors. STEER model results indicate that ideal levels of new CHP in Michigan, as a least-cost resource option, range between 722 MW to 2,360 MW.

This increase in CHP deployment will enhance Michigan's efforts to lead on energy waste reduction among other states. Currently, Michigan ranks 7th in the nation for potential annual CO_2 reductions from industrial energy efficiency and CHP and waste heat to power (WHP). In the 2017 American Council for an Energy Efficient Economy (ACEEE)Energy Efficiency Scorecard, Michigan was ranked 14th (tied with Arizona, Delaware, Iowa, New Jersey, New Mexico, Ohio, Texas, and Wisconsin) in the CHP category, slightly lower than its overall energy efficiency rank of 11th.

Demonstrating leadership in CHP development will serve to both reinforce and grow Michigan's demonstrated commitment to energy waste reduction. According to the Michigan Public Service Commission, regarding energy waste reduction overall, "For 2015, Michigan utility providers successfully complied with the energy savings targets laid out in PA 295. Providers met a combined average of 121 percent of their electric energy savings targets and 117 percent of their natural gas energy savings targets – one percent of retail sales for electric providers, and 0.75 percent of retail sales for gas providers. Energy Optimization programs across the state accounted for electric savings totaling over 1.1 million MWh (megawatt hours) and natural gas savings totaling over 4.58 million Mcf (thousand cubic feet) for program year 2015." CHP could be key to continuing to meet strong energy savings targets in the future. A single CHP system can offer the efficiency savings of many smaller energy efficiency projects. Given that some utilities are reporting a lower availability of cheap ("low hanging") energy efficiency savings opportunities in the commercial and industrial sector, CHP can offer deep savings at a very low cost, enhancing the overall cost-effectiveness of energy efficiency portfolios.

Execution of the Michigan CHP Roadmap will likely have significant impacts on the levels of CHP deployed in Michigan. For example, by addressing the CHP barrier of standby rates, STEER results using the EIA Reference Case indicate that Michigan could see an increase of 345 MW of CHP capacity built.

Additionally, CHP incentive programs in other states have seen dramatic results in additional CHP capacity coming online. The NYSERDA CHP incentive program has had an enormous market impact in New York. Between 2013 and 2016, the NYSERDA program has provided incentives to over 150 sites with a cumulative total capacity of over 70 MW. Similarly, in Illinois, the impact of the public sector CHP incentive was immediately felt, with the incentive program receiving 17 applications providing 31 MW of capacity. Through implementation of the Michigan CHP Roadmap, well-crafted CHP incentive programs could have similar positive effects on CHP development in Michigan.

Building on its strong commitment to energy waste reduction, Michigan is well-positioned to take advantage of the opportunities offered by increased CHP development in the state. By implementing the Michigan CHP Roadmap, the state can expand its energy waste reduction vision to include the many benefits of CHP, helping businesses to achieve their cost-savings and energy reliability goals. With key revisions to programs and policy, CHP has the potential to be a significant, reliable, cost-effective, and environmentally protective contributor to Michigan's energy mix.