Assessment of Combined Heat and Power Systems in the Midwest's Top Manufacturing Industries

Joe Ricchiuto, Midwest Energy Efficiency Alliance
Gregory Ehrendreich, Midwest Energy Efficiency Alliance

ABSTRACT

The Midwest is a major industrial center, with individual states having high industrial energy consumption. Eight Midwestern[1] states rank in the top half of all states for industrial electricity use; nine for total energy. Compared to other regions, the Midwest ranks high for electricity use in energy-intense industries: 1st in Primary metals and Food; 2nd in Chemicals, Nonmetallic mineral products and Paper; and 3rd in Petroleum & Coal Products.

Combined heat and power (CHP) is a recognized process to generate electricity and useful thermal energy in manufacturing. CHP saves energy, cuts carbon emissions, and increases energy resilience. As efforts to decarbonize the economy advance, increased CHP investment would have an immediate benefit in reducing grid-based electricity needs through decreased industrial consumption. Increased opportunities to use CHP are ripe in the manufacturing-heavy Midwest, yet there are notable subsectors where CHP deployment fails to meet the opportunity. For example, Primary Metals is a $99B industry with manufacturing in all thirteen Midwest states, but with CHP in only four. As jurisdictions strive to meet decarbonization goals, expanded deployment of CHP can have an impactful role and CHP tax incentives included in the Inflation Reduction Act increase the viability of new adoption in the Midwest.

This paper will explore CHP deployment in six selected Midwest states - Illinois, Indiana, Kentucky, Michigan, Missouri, and Ohio. It will compare CHP generation in high energy-use industries with economic indicators for those industries. The paper will identify opportunities and barriers for new CHP and extrapolate the region's potential generation, capacity and GHG savings.

Background

Combined Heat and Power (CHP) systems generate electricity and useful thermal energy from a single fuel source (USDOE 2023a). One of the significant advantages of CHP systems is their higher fuel efficiency compared to separate heat and grid power systems, which typically have an overall average fuel efficiency of 50-55 percent (EPA 2023b), meaning about half of the energy from the fuel is wasted as discharged heat. This low efficiency can be attributed to the poor average efficiencies of fossil-fuel-fired power plants and the transmission and distribution losses that occur when electricity is transported throughout the grid. In contrast, the five most installed CHP technologies offer efficiencies ranging from 65-80 percent, with some systems approaching 90 percent efficiency (EPA 2023b). The increased efficiency of CHP can play a crucial role in advancing decarbonization in the Midwest, as it reduces greenhouse gas and other air pollutant emissions compared to traditional grid electricity with separate onsite

[1] Defined for our purposes as the thirteen states in MEEA's footprint: IA, IL, IN, KS, KY, MI, MN, MO, ND, NE, OH, SD and WI. (This expands on the Midwest Census Region by the inclusion of KY.)

heating/cooling. Additionally, as the industrial sector shifts towards a low-carbon future, CHP systems can continue to offer their efficiency and emissions benefits by using low- to zero-carbon fuels such as biogas and hydrogen. The reduced fuel consumption and enhanced efficiency of CHP also lead to lower energy and capital expenditures for industrial users. Apart from these benefits, CHP systems have proven to be effective in ensuring continuous electric service and space conditioning during grid disruptions (EPA 2023c). Since CHP can operate independently from the electric grid, it is a dependable, onsite generation source that can provide industrial facilities with electricity and thermal energy 24/7, resulting in a more resilient facility and a more robust Midwest grid.

Despite these advantages, CHP systems are significantly underutilized in some states in the Midwest due to a combination of policy barriers and other factors, such as high upfront costs. This analysis aims to identify gaps in the distribution of CHP systems across major electric use industries in the industry-heavy Midwest states of Illinois, Indiana, Kentucky, Michigan, Missouri, and Ohio. The study will assess the current deployment of CHP systems across specific industrial subsectors and identify areas where they can be more effectively utilized. It will estimate the potential for CHP systems to offset electricity generation needs for these subsectors if some of the policy barriers were alleviated. Identification of these gaps and the deployment potential could aid policymakers and industry stakeholders in developing targets and strategies to increase the adoption of CHP systems in the Midwest.

Methodology

Data Selection. DOE's Combined Heat and Power Installation Database (CHP Database) (USDOE 2023b) contains records of state, industry and technology type for every CHP generator identified in the US. Industries are identified by the *NAICS* field, using the North American Industrial Classification System. NAICS uses a 2-to-6-digit string to identify business subsectors, with more specific detail provided by each additional digit. For example, manufacturing is NAICS codes 31-33; 311 is Food Manufacturing; 3112 is Grain and Oilseed Milling; and 31121 is Flour Milling and Malt Manufacturing. (USCB 2022).

The Manufacturing Energy Consumption Survey (MECS) (EIA 2018) is aggregated at the regional level (i.e., Midwest Census Region). We used MECS to identify the top ten energy consuming manufacturing subsectors in the region, as shown in Table 1. These subsectors are used as our filters for further analysis.[2]

Table 1: Top 10 energy use manufacturing subsectors in the Midwest Census Region

NAICS Code	Manufacturing Subsector	Total consumption (trillion Btu)
331	Primary Metals	922
325	Chemicals	804
324	Petroleum and Coal Products	518
311	Food	485
322	Paper	274
327	Nonmetallic Mineral Products	237

[2] This subsector-level analysis was inspired by a 2021 analysis by the EIA, which showed six manufacturing subsectors accounting for 90% of national manufacturing sector energy consumption (Lorenz and Aloulou 2021).

336	Transportation Equipment	182
332	Fabricated Metal Products	124
326	Plastics and Rubber Products	110
333	Machinery	73

Source: EIA 2018.

Since MECS does not have direct state level consumption data,[3] the next-best option is to use a proxy for energy use – economic activity. The links between economic activity and energy use are well established and obvious. The production of goods and services requires energy. EIA analysis shows a correlation between growth rates of GDP and electricity use as high as 89% (Arora and Liekovsky 2014).

The Census Bureau's Annual Survey of Manufacturers (ASM)[4] provides data by manufacturing subsector that can be aggregated at the state level. To do an analysis at the state level and by 3-digit NAICS code, we used the ASM field *Sales, value of shipments, or revenue* (hereafter, *Sales*) as an indicator of the size of the manufacturing subsector in each state and a proxy for that subsector's energy consumption. At the 3-digit NAICS level, we get the most consistent data from *Sales* that is useful for our purposes. If we disaggregate *Sales* to the 4-digit NAICS code, a substantial portion of the records are marked "D" for "Withheld to avoid disclosing data for individual companies; data are included in higher level totals." (USCB 2021)

Though MEEA covers a 13-state region, we selected six states to simplify this demonstration analysis. These states include the top energy consuming states in the Midwest as well as several states with lower total industrial energy consumption, as shown in Table 2.

Table 2: Industrial energy consumption in the Midwest states selected for this analysis

State	Total Industrial Consumption (Trillion Btu)	Nat'l Rank (of 51)	MW Rank (of 13)
Indiana	1,187	5	1
Illinois	1,131	6	2
Ohio	1,107	7	3
Michigan	620	12	5
Kentucky	565	14	7
Missouri	305	31	12

Source: EIA 2020.

Data Preparation. We used Tableau Prep Builder to do a basic ETL (extract, transform, load) process on our data sets. First, records from the CHP Database were filtered to MEEA's states. The *NAICS* field was then aggregated to the 3-digit level by truncating the field to only the leftmost 3 digits in the string, regardless of how many digits were supplied in the individual record, and was filtered to the codes noted in Table 1. Similarly, the ASM data set was filtered to MEEA states and aggregated at the 3-digit NAICS level before downloading and was then filtered to the same top 10 codes.

[3] The current iterations of EIA's Residential (RECS) and Commercial (CBECS) surveys have included state-level statistics for the first time, so it is likely that the next MECS will follow that trend.

[4] The ASM has been discontinued as of 2021, unfortunately, and it isn't clear as of time of writing what data will replace it at the Census Bureau.

For this analysis, we used *NAICS*, along with *State* and *Capacity (kW)* from the CHP Database. From ASM, we used the fields *2017 NAICS Code*, *State*, and *Sales*. The aggregated *NAICS* and *2017 NAICS Code* along with *State* from both data sets were used to union the data. We then added back in the field *Meaning of NAICS Code* from ASM to provide additional descriptive information. A simplified diagram of the data prep flow is shown in Figure 1.

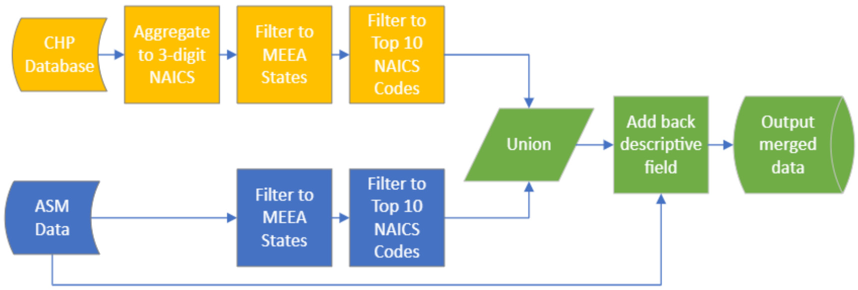

Figure 1: Simplified representation of data preparation methodology

Results

The merged *CHP Capacity* and *Sales* data for the selected Midwest states and NAICS codes is shown in Table 3. The states we studied have a range of $107-279 billion in sales across the top 10 manufacturing subsectors, and a range of 25-2,954 MW of CHP installed capacity.

Table 3: Results summary: Merged *CHP Capacity* and *Sales* data for selected states and manufacturing subsectors

	IL		**IN**		**KY**		**MI**		**MO**		**OH**	
NAICS code	Sales ($B)	CHP Cap. (MW)	Sales ($B)	CHP Cap. (MW)	Sales ($B)	CHP Cap. (MW)	Sales ($B)	CHP Cap. (MW)	Sales ($B)	CHP Cap. (MW)	Sales ($B)	CHP Cap. (MW)
311 Food	$52.00	494	$27.86	92	$14.54	1	$19.87	29	$26.53	0	$35.61	1
322 Paper	$6.83	7	$5.83	0	$5.81	0	$5.47	261	$5.41	0	$9.25	131
324 Petroleum & Coal Products	$31.87	214	$17.87	661	N/A*	0	$5.29	0	$1.22	0	$21.84	105
325 Chemicals	$41.45	31	$29.16	15	$11.66	27	$18.35	1,848	$14.56	25	$34.94	79
326 Plastics and Rubber Products.	$16.14	0	$12.26	87	$6.60	5	$13.91	0	$4.18	0	$22.16	12
327 Nonmetallic Mineral Products	$4.99	14	$5.15	0	$2.89	0	$6.15	47	$3.39	0	$8.17	0
331 Primary Metals	$14.06	79	$36.63	1,572	$13.17	0	$9.70	1	$2.76	0	$24.45	121
332 Fabricated Metal Products	$23.45	1	$18.30	0	$6.05	0	$19.41	2	$8.19	0	$33.28	5
333 Machinery	$24.80	82	$13.48	4	$6.16	0	$23.94	0	$11.02	0	$23.55	1
336 Transp. Equipment	$25.50	0	$92.70	27	$48.76	0	$108.62	766	$30.48	0	$66.21	0
Total	**$241.10**	**922**	**$259.24**	**2,457**	**$115.64***	**33**	**$230.71**	**2,954**	**$107.74**	**25**	**$279.46**	**454**

*Kentucky NAICS 324 is the only state & industry where the value of Sales was still noted as withheld in the ASM data at the level of aggregation we used for the analysis. For our later analysis of *CHP Capacity/Sales* at the subsector level we can safely assume that this is a non-zero value, which will give a valid result (of zero) for that computation. We did not, however, assign any value when computing the state total shown in this table.

To help compare the level of CHP deployment in the states, we normalized to MW of *CHP Capacity* per $1 billion in *Sales*. We know that the policies across the states are not the same, so this metric can help us identify states where the policies are not conducive to the full economic deployment of CHP that manufacturing could be achieving.

As shown in Figure 2, Missouri and Kentucky have both the lowest economic value of the top ten manufacturing subsectors and the lowest deployment of CHP across those industries. Neither state is an industrial powerhouse for the region, and neither of them have had a need to develop strong industrial energy policy to support CHP deployment. Ohio stands out as the state with the highest total *Sales* across the subsectors, but comparatively low *CHP Capacity* deployed. This is a case where weak industrial energy policy has not kept up with industrial growth and where there is not a strong economic case for CHP in the absence of policy drivers. Illinois is the Midwest's second highest industrial energy consumption state, as shown previously, but it occupies the middle for both *Sales* and *CHP Capacity*. It is a state in which there are likely both policy drivers and barriers. Michigan and Indiana, then, are the states in our selection that are raising the average, with high capacity of deployed CHP along with high level of economic activity in the industrial subsectors. The combination of favorable industrial energy policies and economics in the highest performing states are likely strong contributors to these levels.

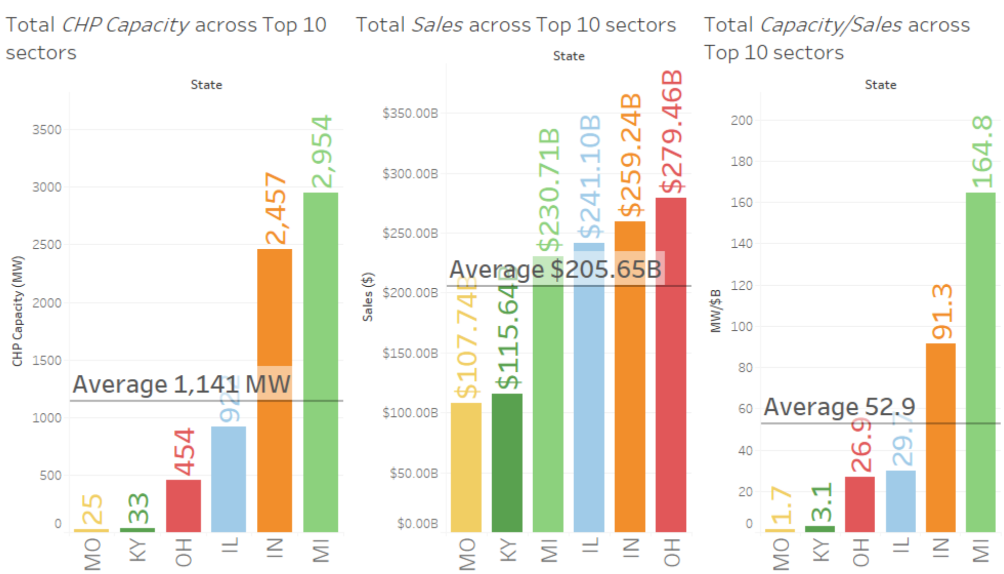

Figure 2: *Sales* and *CHP Capacity* totals by state and averages across the states

Looking across the industry subsectors, we can clearly see a couple of key things. First, Chemical manufacturing (325) is the most common subsector for CHP deployment, but the amount of CHP compared to the value of the industry is vastly higher in Michigan. This suggests that within that subsector, there is probably a lot of room for growth of CHP capacity in the other states. Conversely, the low distribution across states and the low overall capacity where it is installed suggest that there is not strong potential for expansion in fabricated metal (332) or machinery (333).

Table 4: MW of <u>*CHP Capacity*</u> per $1B of <u>*Sales*</u> by subsector

NAICS code	Meaning of NAICS Code	IL	IN	KY	MI	MO	OH
311	Food manufacturing	9.50	3.31	0.07	1.46	0.00	0.02
322	Paper manufacturing	0.95	0.00	0.00	47.68	0.00	14.20
324	Petroleum and coal products manufacturing	6.71	36.97	0.00	0.00	0.00	4.81
325	Chemical manufacturing	0.75	0.53	2.29	100.70	1.72	2.26
326	Plastics and rubber products manufacturing	0.00	7.06	0.76	0.00	0.00	0.52
327	Nonmetallic mineral product manufacturing	2.82	0.00	0.00	7.68	0.00	0.00
331	Primary metal manufacturing	5.60	42.91	0.00	0.10	0.00	4.93
332	Fabricated metal product manufacturing	0.06	0.00	0.00	0.09	0.00	0.14
333	Machinery manufacturing	3.30	0.26	0.00	0.00	0.00	0.03
336	Transportation equipment manufacturing	0.00	0.29	0.00	7.05	0.00	0.00

The data between the extremes show some interesting things as well. Paper manufacturing (322) occupies a relatively flat range of $5.50B-9.25B across the states (Table 3), but only three states have taken advantage of CHP opportunities in this subsector. The relatively high value of CHP Capacity/Sales in MI and OH for that subsector suggests that the opportunity for expanding CHP in that industry is substantial. The nonmetallic mineral products subsector (327) shows similar characteristics. Primary metals (331) Sales are 50% higher in IN than OH, but almost nine times as much CHP per dollar. That would suggest Ohio as a key expansion target for CHP in that subsector to achieve the most economic savings.

Projections

Expanding CHP within states. As we have noted and will discuss further, Midwest states have adopted a variety of policies that promote or hinder CHP. Without trying to prescribe specific policy changes for each state, we assume in our expanded CHP scenario that (1) policy drivers have been enhanced and barriers reduced and (2) for each industry with CHP levels below the regional average in a given state, new CHP installations can close the gap. The number of subsectors where CHP is below average is shown in Figure 3.

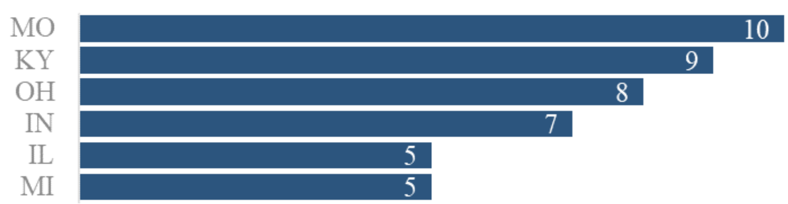

Figure 3: Number of industries below average CHP MW for that industry in studied states

For each state and industry, if the CHP deployed is less than the average MW for that industry, we multiplied the state's *Sales* value by the average value across states for *CHP Capacity*/*Sales* (in MW per $) to estimate the MW of CHP that would be required to move the state up to the average and close the gap. Those results are shown in Table 5.

Table 5: Additional CHP capacity (MW) in states and industries under expansion scenario

NAICS	Meaning of NAICS Code	IL	IN	KY	MI	MO	OH	**Total**
311	Food manufacturing		97	51	69	93	125	**435**
322	Paper manufacturing	71	20	20		19		**130**
324	Petroleum and coal products manufacturing				66	15	274	**356**
325	Chemical manufacturing	559	393	157		196	471	**1,778**
326	Plastics and rubber products manufacturing	22		9	19	6	30	**86**
327	Nonmetallic mineral product manufacturing		10	6		7	16	**39**
331	Primary metal manufacturing	247		232	171	49	430	**1,128**
332	Fabricated metal product manufacturing		1.3	0.4		0.6		**2.4**
333	Machinery manufacturing		11	5	20	9	20	**65**
336	Transportation equipment manufacturing	54	1,163	612		382	831	**3,042**
Total		**953**	**1,697**	**1,092**	**345**	**777**	**2,197**	**7,061**

Overall, CHP capacity would more than double under our expansion scenario. The largest increase in CHP capacity under this scenario would be in the Transportation equipment subsector (336). Michigan sets a high bar in that industry, and bringing other states up to the current average would more than triple the amount of CHP in that subsector (Figure 4). Chemicals (325) and Primary metals (331) would see lower percentage growth but together would add almost as much capacity as Transportation equipment. Those three sectors account for 85% of the additional CHP capacity envisioned under the scenario. Smaller industries have lower overall capacity possible, so even though there is significant growth possible for some of them, there is not as much to be gained, and they should be less of a focus.

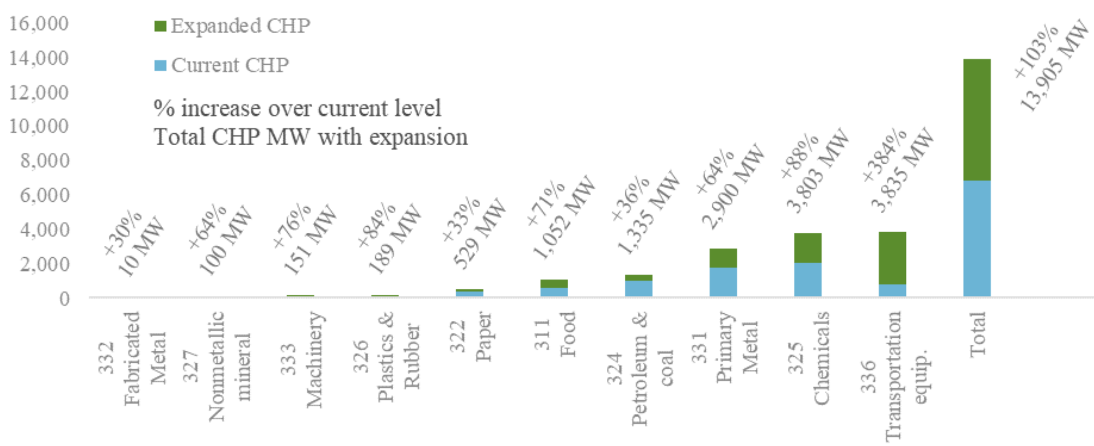

Figure 4: CHP Deployment in Midwest states under expanded CHP scenario

Greenhouse Gas Savings. The Midwest region as defined by the EPA AVERT tool does not overlap perfectly with the states we examined – it leaves out Ohio and adds several southern states. But AVERT is still a useful tool for examining the possible CO2 impacts of the expansion of CHP in Midwestern manufacturing. We used AVERT Web Edition (EPA 2023a) to estimate the impact of the addition of our expanded CHP scenario on grid emissions in the Midwest. Ahn et al. (2021) found a 58% capacity factor for industrial CHP, meaning that 42% of the time the capacity is going unused, which we used to estimate the marginal reduction in grid-based electricity use from the CHP deployment. We then approximated the emission reduction using AVERT's uniform energy efficiency emission factors, "which represent a constant customer load reduction similar to the effect of CHP units running continuously." (EPA 2022)

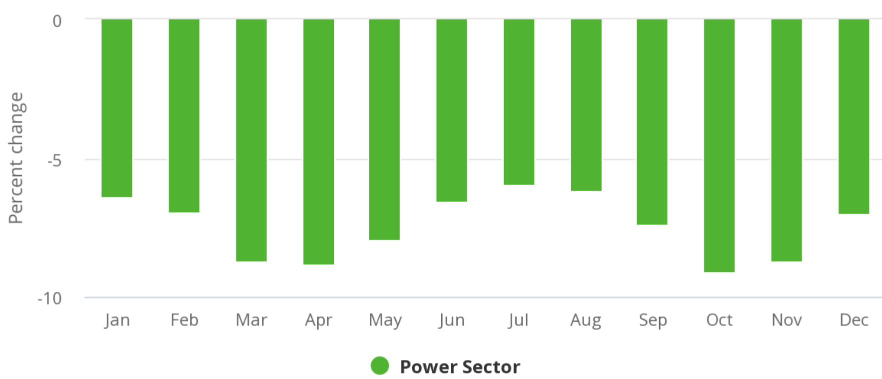

Figure 5: Change in grid-based CO2 emissions in the Midwest Region from new CHP deployment scenario (AVERT) (EPA 2023a)

Figure 5 shows the results of the AVERT modeling. This represents only the reduction of emissions from the grid and does not account for additional CO2 that new CHP projects would be producing. To account for the CO2 emissions from new CHP installations, we assumed that these new installations would be gas turbines of various sizes. We used a weighted average of typical gas CHP system CO2 emissions (USDOE 2016) to calculate the amount of CO2 production from the new installations and subtracted that from the AVERT results to give a net CO2 reduction value. Under this scenario, the new CHP installations would save the Midwest region 18 million tons of carbon dioxide annually, an annual reduction of 4.4% of grid-based CO2 emissions for the region.

This calculation could be refined by using the desktop version of AVERT to better calculate emissions for only the states that we are studying. The mix of CHP types could also be adjusted to account for other types of projects that may come online – for example, renewable or hydrogen-based CHP. Nevertheless, the calculation here is still useful for level setting to understand the scale of the impacts.

Better use of the existing installed CHP capacity would be a route to enhanced electricity and carbon savings without the expense of additional new installations. This would require aligning grid and market policies to support full capacity deployment. And, of course, the CHP expansion we envision here could not actually happen unless policy and economic conditions are suitable. We will close this paper with a discussion of some of those factors.

Discussion

Policy Implications for CHP Adoption in the Midwest

The six states reviewed in this paper have a variety of policies that advance or hinder CHP adoption. An example is **interconnection standards**, which govern how CHP systems and other distributed energy resources (DERs) can connect to the grid. Interconnection with the grid is essential for facilities that use CHP, so that a facility has backup power in case of insufficient generation or outages. In the Midwest, requirements and procedures for CHP to interconnect to the grid are inconsistent. This can drive up costs for potential CHP users and discourage new installations. When interconnection standards do not establish clear timelines and fees or vary between different utilities in the same state, this can confuse customers and deter them from developing projects (USDOE 2020). Interconnection standards that effectively promote CHP deployment generally outline clear requirements and include provisions that address larger systems, apply to both fossil and renewable fuels, include capacity tiers, include net metering policies, and offer standardized application forms and contracts. DOE analyzed all 50 U.S. states to determine which states have interconnection standards that encourage CHP deployment (USDOE 2020). Out of the states reviewed for this paper, Illinois, Indiana, Michigan, and Ohio encourage CHP through their interconnection standards, while Kentucky and Missouri do not. That said, apart from Missouri, none of these states have interconnection standards with provisions for net metering. Simplifying and standardizing interconnection standards would enable better grid and market connectivity of existing systems that are currently islanded, helping to make better use of existing CHP capacity. (Ahn et al. 2021)

Net metering compensates the owners of DERs for electricity they feed back into the grid. Although all the states in this analysis have net metering for industrial users, the specific policies may still hinder the overall adoption of CHP systems.

For example, Illinois, Kentucky, Missouri, and Ohio allow net metering for CHP systems only if they run on renewable fuel sources such as biogas. These states also restrict the capacity of certain systems that can be net-metered, ranging from 30 kW to 5 MW (ACEEE 2022a; ACEEE 2022c; KPSC 2008; PUCO 2023).

Michigan replaced its statewide net metering policy with a distributed generation program in 2016. Existing customers are allowed to continue under net metering for 10 years following the date of enrollment, so some utilities still allow net metering for CHP that runs on renewable fuel sources. In contrast to net metering, which only compensates customers based on the net amount of electricity distributed back to the grid, the new program uses an inflow/outflow billing mechanism that separately prices the incoming and outgoing electricity flows based on instantaneous measurements. Utilities in the program may permit CHP systems that run on renewable fuel sources (MPSC 2018).

Indiana permits net metering but does not recognize CHP as an eligible technology (ACEEE 2022b). Although Indiana does not allow net metering for CHP, the utility NIPSCO offers feed-in-tariffs (FIT), an alternative to net metering through which customers can sell back electricity generated by renewable CHP systems at a fixed, contracted rate. FIT is different from net metering in that it compensates customers for electricity produced at a fixed price, rather than at actual retail value. It also requires an additional meter to be installed to measure generation separately from consumption (NIPSCO 2023).

Although most of these policies promote the use of CHP systems that run on renewable fuel sources, the restrictions on size and fuel type may inadvertently discourage common CHP systems such as reciprocating engines and turbines that combust natural gas. Expanding net metering policies to allow for larger CHP systems with natural gas as a fuel source could aid the Midwest in decarbonization efforts and improve grid resilience while the region transitions to carbon neutrality.

Portfolio standards are policies implemented by states to promote the use of renewable sources of energy. In Illinois, Michigan, Missouri, and Ohio, renewable portfolio standards (RPS) require utilities to produce a percentage of their electricity from renewable sources, which can include CHP systems that use renewable fuels. Ohio's RPS requires that at least 8.5% of electricity sold by investor-owned utilities come from renewables by 2026 (Ohio Rev. Code §4928.64). In Illinois, the RPS requires that at least 25% of electricity sold by investor-owned utilities come from renewables by 2025 (IEC 2021). Michigan's policy required investor-and public-owned utilities to generate 15% of their electricity from renewables by 2021, with an additional goal of 35% by 2025 (Scripps et al. 2022). Missouri's policy required investor-owned utilities to use eligible renewable technologies to generate 15% of the electricity sold by 2021 (NRDC 2013). In Indiana, a voluntary standard provides incentives to utilities to increase energy production from renewables, aiming to achieve 10% clean energy by 2025. Indiana's program allows up to 30% of the goal to be met with CHP and other systems (DSIRE 2022). Although these policies do promote the adoption of CHP, they do not place particular emphasis on the most widely used CHP systems that utilize natural gas as their primary fuel source. Kentucky has not implemented an RPS. This means that utilities in Kentucky are not currently required or incentivized to generate any of their electricity from renewable sources, including CHP systems that use renewable fuels.

While CHP can operate without relying on the grid, interconnection to the grid ensures backup power during scheduled or unscheduled outages. To cover the infrastructure costs associated with service, reassure CHP customers that power will be available when required, and safeguard revenue, utilities often implement burdensome rate structures. These include disproportionate standby rates and harsh penalties for any system outages (CHPA 2018). The higher fees charged to customers who generate their own electricity can substantially increase the payback period for new CHP projects, making them less viable. These rate structures can also dissuade customers from investing in CHP because of the uncertainty of the long-term costs versus the potential savings. Tariffs that are poorly designed often feature reservation fees and demand charges that are fixed and billed based on contracted standby capacity, rather than actual usage. Such fixed charges do not consider the lower costs that self-generation customers impose on utility infrastructure, nor the benefits they provide to the grid. Consequently, there is an ongoing debate around the appropriateness of these rate structures and the extent to which they should be applied.

Available Incentives and Funding to Advance Adoption of CHP in the Midwest

CHP systems require significant initial investments and changes to existing infrastructure, which can deter industrial users from adopting the technologies. A common basic indicator of the economic potential of CHP is known as the "spark spread," the difference between average annual electricity and natural gas prices in dollars per million BTU ($/MMBTU). Spark spreads tend to be fairly volatile, largely due to fluctuations in wholesale electric power prices, which vary widely with changes in demand for electricity and the available electric supply. A spark spread of greater than $12/MMBTU has a higher potential for favorable CHP payback. (Cuttica and Haefke 2009) The spark spread for Midwest states is shown in Figure 6. With the exception of Ohio, the spark spread in all of the states studied (and the rest of MEEA's states, not shown) is favorable for CHP deployment. Of course, any potential installation should use their own precise rates rather than statewide averages.

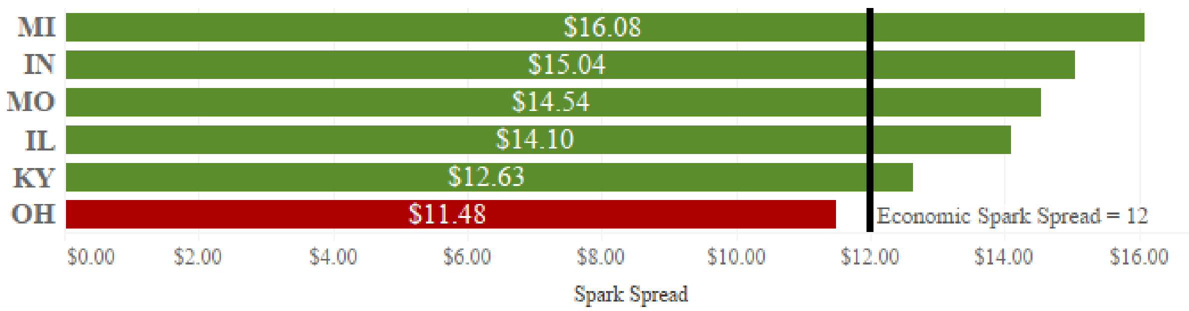

Figure 6: Spark spread ($/MMBTU) in states included in this study (2021). Source: EIA 2022, EIA 2023.

Fortunately, besides just the price economics, industrial users in the Midwest who are interested in installing a CHP system can also take advantage of various financial incentives provided by federal, state, and utility programs. These incentives can help offset the initial costs associated with implementing CHP technology and make it a more attractive and feasible option for industrial users.

Under the Inflation Reduction Act (IRA), the Sec. 48 investment tax credit (ITC) is available for qualifying CHP systems. To be eligible for the ITC, CHP projects must meet the following criteria: commence construction before January 1, 2025, have a maximum capacity of 50 MW or less, and have an efficiency of 60% or more. If these criteria are met, new CHP systems can receive a tax credit of up to 50% (CHPA 2022). The base credit for these projects is 6%, which can increase to 30% by satisfying prevailing wage and apprenticeship requirements. IRA also offers additional bonus credits of up to 10% each for fulfilling domestic content and energy community location requirements. Moreover, new CHP projects that commence construction after December 31, 2024, are eligible for renewable energy tax credits under the new technology-neutral Sec. 45Y production tax credit or Sec. 48E ITC, provided that the project produces zero greenhouse gas emissions (CHPA 2022). The funding available under IRA can cover as much as 50% of the costs of a new CHP project in the industries reviewed in this analysis (CHPA 2022), significantly increasing the financial feasibility of these projects for Midwest industrial users.

Industrial users can also secure state-level funding or tax credits to incentivize the implementation of CHP. For instance, Ohio has a tax exemption on certain CHP projects to ensure they are not subject to tangible personal property taxes, provided that an application is submitted and approved. (Ohio Rev. Code §5727.75). In Kentucky, the *Incentives for Energy-related Business Act* (KRS § 154.27) offers tax credits for CHP systems using renewable fuel sources. Additionally, the *Kentucky Industrial Revitalization Act* (KRS §154.26) provides tax incentives for businesses that invest in the renovation of industrial sites, which can include the installation or rehabilitation of CHP systems.

Existing legislation in Illinois, Kentucky, Michigan, Missouri, and Ohio supports Property Assessed Clean Energy (PACE) financing (PACENation 2019). PACE allows industrial customers to fund energy efficiency projects, including CHP, without requiring a substantial upfront investment. Repayment occurs via a voluntary assessment added to property tax bills, and the financing is tied to the property rather than to an individual. Industrial customers can pay for their CHP system over a longer term than traditional financing, typically 20-30 years. This approach incentivizes property owners to invest in CHP even if they do not anticipate staying at the property for the useful lifetime of the system. PACE allows CHP investments to be cash-flow positive, as savings typically exceed the required payments (PACENation 2019). While Indiana has previously provided funding for industrial CHP projects, there are only limited state-level tax incentives or funding available at present. Indiana Senate Bill 411 (S.B. 411), introduced in January 2023, would have allowed towns, cities, and counties to adopt PACE programs, but it did not advance during the regular legislative session.

Utility-level incentives can also make CHP projects more appealing to industrial customers. In several Midwest states, utilities offer custom incentive programs that can include compensation for CHP projects. A good example of this is in Illinois, where both ComEd and Ameren Illinois, the state's largest utilities, offer such incentives (Ameren Illinois 2023; ComEd 2023). It is essential that industrial users considering installing a CHP system conduct thorough research into utility, state, and federal incentives and funding to enhance the financial viability of their projects. Stacking these funding and incentive opportunities can dramatically reduce the cost of a project and increase the feasibility of CHP.

To make better use of existing installed CHP capacity, CHP must be allowed to be aggregated, such as under FERC Order 2222, and to participate in capacity markets. Currently, CHP systems that participate in ancillary services markets are not allowed to participate in real-time energy markets. Changing this would allow CHP systems to better meet demand changes between real-time dispatch intervals and enhance the use of CHP systems as fast-ramping, dispatchable resources. Creating more flexibility in contract lengths and contracted capacity between the owners of CHP systems and grid operators would also help to better align CHP capacity with the demand needs of the primary facility as well as with the time frames of anticipated grid needs, while minimizing risks from fuel price volatility. (Ahn et al. 2021)

Future Analysis

Having identified workable data and a framework for analyzing which states and industries could be prioritized for expanding CHP deployment, there are several lines of inquiry for future work.

It was useful to limit the number of data points in this initial study to simplify analysis of our results and evaluate our analytical approach. Limiting the study to ten codes across six states nevertheless provided an interesting matrix of results and was sufficient to show that we are on track. Expanding this analysis to all of MEEA's states will give us a more complete regional picture. We can then delve deeper into the specific policy drivers or barriers that exist in the high-performing and low-performing states. Similarly, removing the state filter entirely to look at the national level may help to identify states outside of our region that are performing at a similar level to the states in our region, or help identify clusters that may have similar enabling policies to review.

The next expansion would be to examine additional subsectors – for Midwest states there are five additional 3-digit NAICS codes represented in the CHP Database beyond those we looked at in this analysis, and at the national level, it includes deployments in six more codes not represented in the Midwest. Putting it all together, it moves us from 60 elements in our matrix of results to 195 (13 states x 15 NAICS codes) for the Midwest or up to 1,029 possible elements if we look at all 49 states with records in the CHP Database crossed with economic data on all 21 NAICS codes in the 31-33 range with CHP deployment.

A final area of analysis might investigate different or additional economic indicators to use. Additional insight would be gained if data could be located that provided state-level economic data by NAICS code for sectors beyond 31-33 (Manufacturing). For example, there are a substantial number of records in the CHP Database for Midwest states in NAICS 11 (Agriculture), 22 (Utilities), 53 (Real Estate), 56 (Waste Management), 61 (Education), 62 (Health Care), and 92 (Public Administration). Similar gap analysis of any of those sectors where comparable data could be located would also help guide CHP advocacy efforts in the region.

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