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Fresh Energy

Advancing Industrial Electrification in Minnesota

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EXECUTIVE SUMMARY

Manufacturing is a vital economic engine in Minnesota, employing over 300,000 people and contributing 11% of the state's annual GDP.[1] Modernizing Minnesota's manufacturing sector with clean heat technologies offers a path to reduced emissions, progress toward the state's 2050 net-zero goal, and global competitiveness for years to come.[2]

In this report, we lay out a roadmap for decarbonizing low- and medium-temperature (LMT) process heat in Minnesota's manufacturing sector. Using engineering models, we identify where and how industrial electrification can deliver climate, economic, and public-health benefits to Minnesota and its residents. We also recommend near-term actions that policymakers can take to accelerate deployment of clean heat technologies. This analysis can inform emerging state efforts to define industrial decarbonization pathways across agencies and subsectors.

Minnesota's Clean Heat Opportunity

- **Minnesota presents a major industrial electrification opportunity**. The industrial sector as a whole is responsible for 18% of statewide greenhouse gas (GHG) emissions.[3] Excluding refineries, over 90% of the emissions from large industrial manufacturing facilities come from the chemicals, food & beverage, and pulp & paper sectors, all of which rely heavily on fossil fuel combustion for process heat.[4]

- **Industrial electrification can cut GHG emissions in Minnesota's manufacturing sector**. Strategic electrification of LMT process heat with technologies available today can reduce emissions of existing processes at 33 major manufacturing facilities by up to 66% (~62 MMT CO_2e) between now and 2050, assuming 95% grid decarbonization on the same timeframe.[5]

- **Soybeans, beet sugar, and ethanol manufacturing can be first-movers**. These three subsectors make up 87% of low- and medium-temperature process heat emissions at the 33 facilities we analyzed in Minnesota and have the most favorable economics for electrification (with emissions savings below $100/metric ton CO_2e).

- **Smart rate design can speed up electrification**. In Minnesota, industrial electricity rates are roughly 4 times more expensive than natural gas on a per-MMBtu basis.[6] To close this gap, state officials should work with the Minnesota Public Utilities Commission (MPUC) to establish special industrial electricity rates for facilities that electrify. Setting strict qualification criteria and encouraging off-peak consumption through time-of-use and/or access to wholesale market pricing can help ensure that electrification does not strain the grid or raise rates for other rate classes.

1 National Association of Manufacturers. Minnesota. Accessed April 2026.

2 Minnesota Pollution Control Agency. Greenhouse gas emissions in Minnesota 2022-2025. January 2025.

3 Ibid.

4 U.S. Environmental Protection Agency. GHGRP FLIGHT. 2023.

5 Our emissions estimates use NLR's Cambium 23 "Mid-case with 95% grid decarbonization by 2050" scenario in years 2026-2050 and eGRID grid intensity factors for 2025, the baseline year. This could be relatively conservative: Minnesota's clean electricity standard requiring 100% clean electricity by 2040 means that the grid could get cleaner even faster than the scenario we model, delivering overall emissions reductions on a faster timeline than we estimate.

6 U.S. EIA. Electric Sales, Revenue, and Average Price (Table 8). October 2025.; U.S. EIA. Natural Gas Monthly Report (Table 22). November 2025.

- **Existing federally-funded grant programming can form the basis of an ongoing industrial decarbonization strategy**. Supported by funding authorized by the Inflation Reduction Act, Minnesota is leading the way on climate-smart food by supporting electrification of food processing facilities. Policymakers should convene manufacturers, utilities, clean tech providers, and researchers to evaluate outcomes from the first round of awarded projects. The governor and state officials should work with the legislature to establish a durable financing mechanism that extends support for industrial electrification.
- **Load growth from industrial electrification is manageable**. We estimate that full electrification of LMT process heat in 33 of the state's largest manufacturing facilities would add around 6.5 TWh of additional annual load, when using the most efficient technologies. In practice, this load will be phased in gradually as facilities electrify. This can be managed with proactive grid planning, demand flexibility, and behind-the-meter solutions.
- **Smart policy can encourage innovation and cut GHG emissions and air pollution**. For example, a cap-and-invest program covering the industrial sector can bring down emissions and generate revenue to re-invest in electrification. Clean equipment standards can lower exposure to toxic air pollutants for local communities.



1. WHY ELECTRIFY MINNESOTA MANUFACTURING?

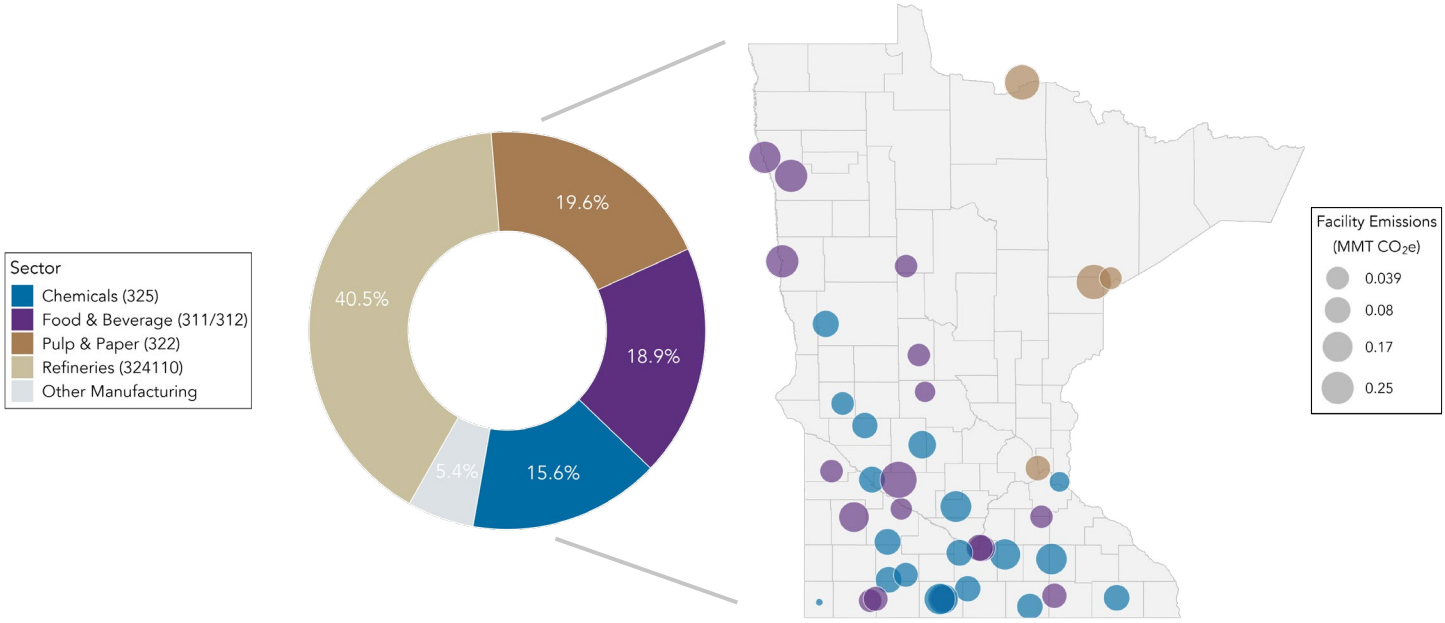


Figure 1: Large Facility Manufacturing Emissions in Minnesota.

Source: GHGRP (2023). Donut shows the full GHGRP emissions profile of Minnesota manufacturing facilities, including process emissions. The map shows emissions from stationary combustion only in the three sectors we focus on. Sectors defined according to the North American Industry Classification System (NAICS). Emissions measured in million metric tons (MMT).

The industrial sector is a major source of GHG emissions in Minnesota, accounting for 18% of statewide emissions in 2022. The state's Climate Action Framework set greenhouse gas reduction targets of 50% below 2005 levels by 2030 and net zero by 2050.[7] Recent planning and regulatory proposals are likely to strengthen these goals. Industrial electrification policy is one of the most actionable near-term pathways to meet these commitments.[8]

Looking at emissions from Minnesota's most polluting manufacturing facilities, about 16% come from the chemicals sector, 20% from the pulp & paper sector, and 19% from the food & beverage sectors (see Figure

7 MPCA. Greenhouse gas emissions in Minnesota 2005-2022 Legislative Report. 2025.

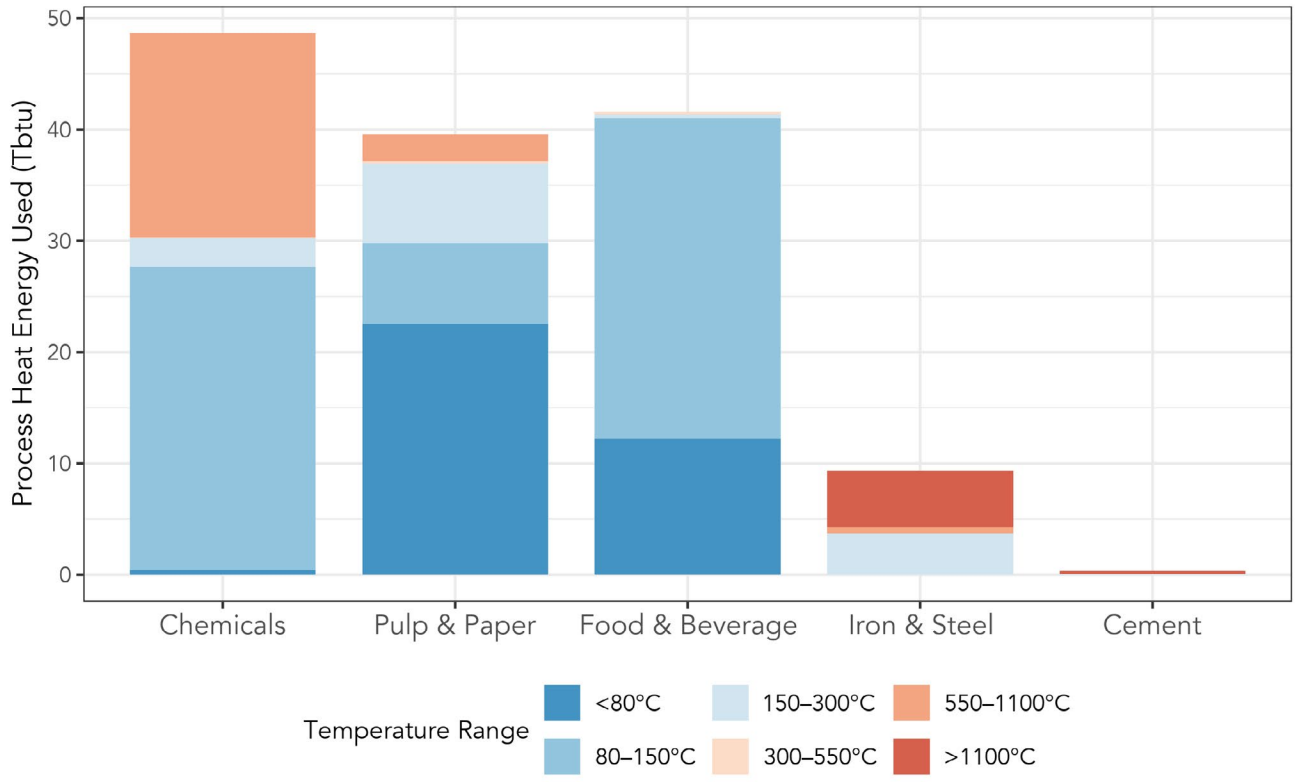
8 Fresh Energy, Great Plains Institute, NRRI, 5 Lakes Energy. Net Zero Industry in Minnesota. March 2026.

1).[9] This amounts to 6.45 MMT of GHG emissions in Minnesota annually, equivalent to 1.5 million gas-powered vehicles driven for one year.[10]

Much of the emissions in these sectors come from combusting fossil fuels for low-and medium-temperature (LMT) process heat (<300°C, Figure 2). LMT process heat generally takes the form of hot air, hot water, and especially steam. Steam is a key input for many industrial processes, as it is easy to distribute and capable of delivering precise heat for everything from cooking food products, to driving chemical reactions or sterilizing equipment. In Minnesota's manufacturing sector, LMT process heat is used for activities like desolventizing soybeans, grain mashing for ethanol, and juice extraction for sugar beets.

LMT process heat is one of the best near-term opportunities to decarbonize the industrial sector, as there are commercially available technologies that use electricity to produce this heat. The transportation, buildings, and power sectors are being transformed by technologies including heat pumps, electric vehicles, solar PV, and batteries. As we show below, the industrial sector is not far behind, with the emergence of technologies such as air-source high-temperature heat pumps (HTHPs) and thermal energy storage. These systems are cleaner, more efficient, and enable companies to gather more data on their production processes than fossil-fuel fired equipment.

Figure 2: Minnesota Process Heat Demand by Manufacturing Sector and Temperature Range



Source: McMillan (2019)[11]

9 The petroleum refining sector (NAICS 324) also contributes about 41% of large facility emissions and a significant amount of medium temperature heat demand, but we exclude it from our analysis because energy efficiency, carbon capture, and transportation sector decarbonization are generally considered more viable paths to net-zero for this sector. See U.S. DOE. Industrial Decarbonization Roadmap. September 2022.

10 U.S. Environmental Protection Agency. GHGRP FLIGHT. 2023.; U.S. Environmental Protection Agency. Greenhouse Gas Equivalencies Calculator. 2024.

11 McMillan, C. Manufacturing Thermal Energy Use in 2014. NREL Data Catalog. 2019.

Beyond emissions reductions, modernizing Minnesota's manufacturing sector can generate long-term economic benefits and help ensure that goods made in Minnesota remain competitive in global markets. In 2024, Minnesota reported $3.9 billion in exports to European Union (EU) member states.[12] These exports are now subject to the EU's emissions trading laws, with the full implementation of the EU carbon border adjustment mechanism in January 2026.[13] Lowering the carbon intensity of Minnesota's manufacturing will make these exports more competitive. Sourcing technology solutions from American manufacturers will also help support the growth of resilient, domestic clean energy supply chains and high-quality jobs for American workers.

In our earlier, national report, *The Clean Heat Climate Opportunity*, we simulated the direct electrification of LMT heat across 798 large manufacturing facilities across the country, spanning 32 manufacturing subsectors. **Here, we downscale this analysis to Minnesota, covering 11 manufacturing subsectors and 33 large manufacturing facilities.**

Table 1: In-Scope Subsectors Represented in Minnesota[14]

Chemicals (325)	Pulp & Paper (322)	Food & Beverage (311-312)
• Ethyl Alcohol Manufacturing (325193)	• Paper Mills (322120) • Paperboard Mills (322130)	• Animal (except Poultry) Slaughtering (311611) • Beet Sugar Manufacturing (311313) • Breakfast Cereal Manufacturing (311230) • Cheese Manufacturing (311513) • Frozen Fruit, Juice, and Vegetable Manufacturing (311411) • Rendering and Meat Byproduct Processing (311613) • Soybean and Other Oilseed Processing (311224) • Wet Corn Milling and Starch Manufacturing (311221)

12 Minnesota Department of Employment and Economic Development. Export and Trade Statistics. 2024.

13 European Commission, Directorate-General for Taxation and Customs Union. "CBAM successfully entered into force on 1 January 2026." January 2026.

14 We use 6-digit NAICS codes to identify facilities for inclusion in our study. This system classifies industrial establishments according to the type of goods they manufacture. See https://www.naics.com/ for more information.

2. ASSESSING INDUSTRIAL ELECTRIFICATION IN MINNESOTA

2.1 Modeling Industries with Process Archetypes

Industrial emissions are often labeled "hard-to-abate,"[15] but this obscures important variation within the sector. For LMT process heat specifically, many clean technologies are already commercialized and ready to deploy.

2.1.1 Clean Process Heat Technologies

Electrode boilers, air-source HTHPs, waste heat recovery heat pumps (WHRHPs), electric resistance ovens, and electric resistance dryers can be used to modernize industrial facilities, improve efficiency, and cut emissions. In particular, electrode boilers and air-source HTHPs[16] can meet the primary steam demands of large-scale industrial facilities and have already been deployed in U.S. manufacturing[17]:

- **Electrode boilers** use electric current passed directly through water to generate steam, offering high efficiency and minimal maintenance compared to combustion-based alternatives.
- **Air-source HTHPs** use electricity to power a mechanical vapor compression (MVC) cycle that harvests and "upgrades" heat, allowing them to produce even more heat energy than electrical energy consumed. Their efficiency, measured by the "coefficient of performance" (COP), depends on output temperature and ambient conditions. While COPs vary by location, we estimate that a range of around 1.2 to 2.0 may be feasible across Minnesota industrial plants, based on the average external temperatures of Minnesota counties and the process temperatures of plants located in these counties.[18] In sectors where we identify opportunities for WHRHPs, COPs range from 2.5 to 5.3.

15 International Energy Agency. Energy Technology Perspectives 2020. February 2021.

16 Surface water (ponds, lakes, etc.) and shallow ground-source heat can also serve as the heat source for a high-temperature heat pump and are proven for hot water applications. However, these systems require additional investments in fluid access and conveyance that may not be practical at all sites.

17 Hoffmeister, A. et al. Industrial Electrification Across the United States. ACEEE. July 2025.

18 COP refers to the ratio of *heat output* to *energy input* of a heat pump. A more efficient heat pump has greater heat output per kWh of electricity, which means less electricity consumed (and lower costs) for a given amount of heat demand. For a full explanation of our method for estimating COPs, see The Clean Heat Climate Opportunity.

Next-Generation Clean Technology Spotlight

Geothermal systems tap underground thermal energy for steam generation. Thermal batteries can store up to ~300 MWh of thermal energy for hours to months, allowing for time-of-use savings for electric heat generation. While we do not model these technologies in this set of results, they are also potential clean heat solutions that should be considered for policy support.

Geothermal Systems for Direct Industrial Process Heat

Geothermal systems circulate fluid underground and draw energy from the subsurface, providing a clean, firm source of heat. Today, these systems are mainly used for space heating (via ground-source heat pumps) or to generate electricity. But, they are also capable of supplying hot water or steam to industrial facilities, especially in places with favorable subsurface characteristics. This allows industrial facilities to use clean heat *without* adding load to the grid or paying high electricity prices. Our earlier report, *Unlocking Next-Generation Geothermal Heat for Industry*, dives into how geothermal can be harnessed for industrial process heat.[19]

Minnesota has several networked shallow geothermal systems that draw on subsurface energy to provide low-emissions heating and cooling to groups of buildings (commonly known as "district heating" and "thermal energy networks", or TENs). This includes systems in Downtown Rochester, Carleton College, and the University of Minnesota St. Paul. Meanwhile, the 2024 Minnesota omnibus bill (HF 5257) included funding for a TEN site suitability study, a TEN workgroup, and a geothermal heating project at Sabathani Community Center.

These efforts could be extended to industrial facilities. Industrial sites often include multiple buildings that require HVAC, making them a good fit for a TEN. Waste heat from existing fossil-fuel-based industrial processes could also be fed into the TEN system to provide heat to other buildings, a practice which is common in places like Denmark.[20]

While TENs and other shallow geothermal systems operate at lower temperatures than those required to make steam, there are also many industrial processes that operate at these lower temperatures, such as milk pasteurization and lumber drying. These processes could feasibly be supplied by a shallow geothermal system, which can operate more efficiently than an air-source system in cold weather.

For higher temperature processes, a shallow geothermal system could be combined with an HTHP, which would step up the lower temperature heat to generate steam. This greatly improves the efficiency of the HTHP. For example, at one of its manufacturing sites in Budapest, Hungary, Procter & Gamble combined a lower-temperature geothermal resource with an HTHP to replace its steam-generating boiler.[21]

19 Mariano, N. et al. Unlocking Next-Generation Geothermal Heat for Industry. *The 2035 Initiative.* July 2025.

20 Hoffmeister, A. et al. Electrification of U.S. Industry: Applying Lessons from Denmark. December 2024.

21 Hungarian Investment Promotion Agency. Procter & Gamble Strengthens Its Position in Hungary with a Series of Investments. November 2025.

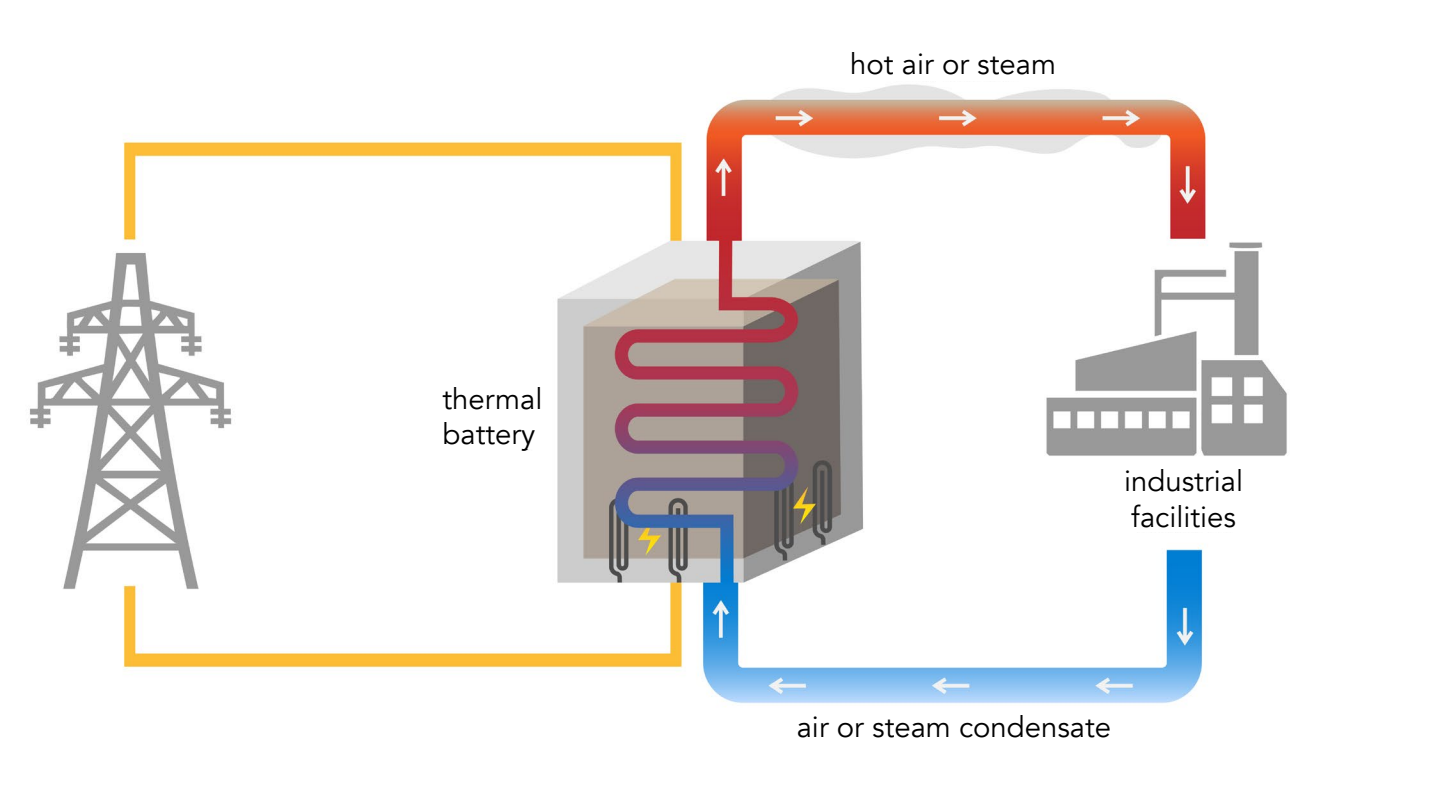
Thermal Energy Storage

Thermal energy storage systems (also known as thermal batteries) offer flexibility in decarbonizing industrial heat in Minnesota by allowing facilities to decouple time-of-use for heat demand from electricity demand. Similar to electric batteries, these systems charge using electricity from the grid at one time and discharge the energy as heat at a later time (as well as charge and discharge simultaneously). Some thermal batteries work by storing energy in "hot rocks"[22], while others store energy in chemical bonds.[23] The systems are capable of delivering heat at high efficiency (~98%) across a wide temperature range—not just LMT—supporting diverse industrial applications.

Thermal batteries can store energy for hours to days, enabling operators to shift electricity use to off-peak periods and mitigate strain on the grid. When coupled with access to wholesale market electricity prices, this also allows facilities to concentrate load when renewable electricity is plentiful and electricity is cheapest, lowering operating costs. Minnesota's growing wind generation increases the availability of low-cost electricity, especially overnight.[24]

However, deployment challenges remain. Upfront costs, facility retrofits, and space constraints limit adoption. Targeted pilot programs, workforce training, and utility demand-flexibility incentives could help overcome these barriers, and are discussed in the policy recommendations section below.

Example Diagram: Thermal Energy Storage



22 See, for example, products by Antora Energy and Rondo Energy.

23 As in products by Cache Energy.

24 U.S. EIA. Electricity Data Browser. Net generation for all sectors, Minnesota. Annual, 2001-24.; Machi, T. "Charged Up: The Grid Benefits of Thermal Energy Storage." *RTC*. March 2025.

2.1.2 Modeling Clean Heat Technologies with Process Archetypes

To capture the complexity of manufacturing processes, we developed process system archetypes for 11 manufacturing subsectors in Minnesota (see table 1). These archetypes model energy and mass flows for a representative plant in a given subsector, allowing us to assess how process heat electrification affects energy use, costs, and direct and indirect emissions.[25]

Using these archetypes, we model electrification of process heat in the LMT range that does *not* rely on combined heat and power (CHP) or byproduct fuel combustion.[26] This affects ten Minnesota facilities that have CHP units.[27] We also model energy efficiency improvements to the electrified systems. Often considered the "first fuel," these upgrades can reduce total energy demand, ease grid impacts, and improve project economics. Waste heat recovery using WHRHPs is a key efficiency measure already deployed at many U.S. facilities.[28]

We simulate five technology scenarios, summarized in Table 2.

Table 2: Technology Scenario Definitions

Scenario Name	Process Heat Steam Source	Direct Process Heat Source	Energy Efficiency Measures	Notes
"Baseline"	Natural gas boiler[29]	Direct Combustion Units	No	Business as usual, process heat (steam and direct-fired units) generated via fossil-fuel combustion
"Drop-In Electrification"	Electrode boiler	Electric resistance ovens and dryers	No	Business as usual facility, steam is generated via electrode boilers, direct-fired units electrified
"Drop-In Electrification (Max Efficiency)" *(EE+)*			Yes	Steam and direct process heat systems optimized for efficiency; steam is generated via electrode boilers, direct-fired units electrified
"Advanced Electrification"	Air-source high-temperature heat pump		No	Business as usual facility, steam is generated via air-source HTHPs, direct-fired units electrified
"Advanced Electrification (Max Efficiency)" *(EE+)*			Yes	Steam and direct process heat systems optimized for efficiency, steam is generated via air-source HTHPs, direct-fired units electrified

25 For more information, see The Clean Heat Climate Opportunity which contains a full review of our methodology.

26 This does not mean that "out-of-scope" process heat is impossible to decarbonize or not worth addressing. With additional improvements in the technology and economics of electrification, further emissions reductions from CHP, byproduct fuels, and higher temperature processes can be achieved in the medium- to long term.

27 These ten facilities are distributed across the food & beverage (311-312), chemicals (325), and pulp & paper (322) sectors.

28 Our modeling scenarios assume that facilities do not have WHRHPs or other energy efficiency measures implemented already, as this information is not made public. If a facility has energy efficiency measures already, the "Max Efficiency (EE+)" scenarios may overestimate the marginal energy savings possible at a given plant.

29 While plants use a variety of fossil fuels (which we account for in the emissions results), the upfront and operating costs of the Baseline scenario are based on the equivalent with a natural gas boiler replacement, instead of fuel-specific boilers like stoker boilers for coal combustion.

2.2 Industrial Electrification Cuts GHG Emissions and Air Pollution in Minnesota

We identify ~3 MMT of annually reported GHG emissions in Minnesota stemming from readily-electrifiable LMT heat, representing 80% of total emissions from process heat across the 33 manufacturing facilities in the subsectors we analyze (Table 1). Figure 3 shows the cumulative emissions impact through 2050 (~62 MMT of CO_2e in total) of electrifying these processes, assuming no changes in production outputs. Figure 4 displays the same results as a year-on-year emissions trend.

Industrial electrification significantly cuts GHG emissions today, with larger climate benefits as the grid gets cleaner. With today's grid, Minnesota would see emissions reductions immediately in the Advanced Electrification with Max Efficiency scenario (Figure 3). As renewables are deployed across the state and grid emissions decrease, electrification could reduce emissions from in-scope LMT process heat by 9 MMT by 2030 and 62 MMT by 2050. These estimates project 95% grid decarbonization by 2050,[30] which is in line with Minnesota's Clean Electricity Standard requiring investor-owned utilities to reach 80% clean electricity by 2030 and 100% by 2040.

To maximize emissions reductions, the state's electricity sector must be decarbonized in parallel. While Drop-In Electrification also yields cumulative emissions reductions, it could lead to short-term emissions increases due to the continued presence of fossil fuels on the grid, especially coal plants (Figure 4).

Minnesota's electricity grid remains moderately carbon-intensive, ranked 25th in carbon dioxide emissions per gigawatt hour of electricity.[31] As the grid gets cleaner, clean heat technologies will cut even more planet-warming pollution.

The pulp & paper sector sees less climate benefits from electrification due to the large proportion of emissions from CHP units, which we do not electrify in our modeling.[32] Though CHP was once heralded as a clean and energy efficient technology, emissions savings from CHP decrease as the grid gets cleaner.[33] This highlights the importance of exploring solutions for CHP in the medium-to-long term to achieve industrial net zero goals. Furthermore, zero-emissions equipment should be prioritized over CHP units at new facilities to avoid locking in future emissions for years to come.

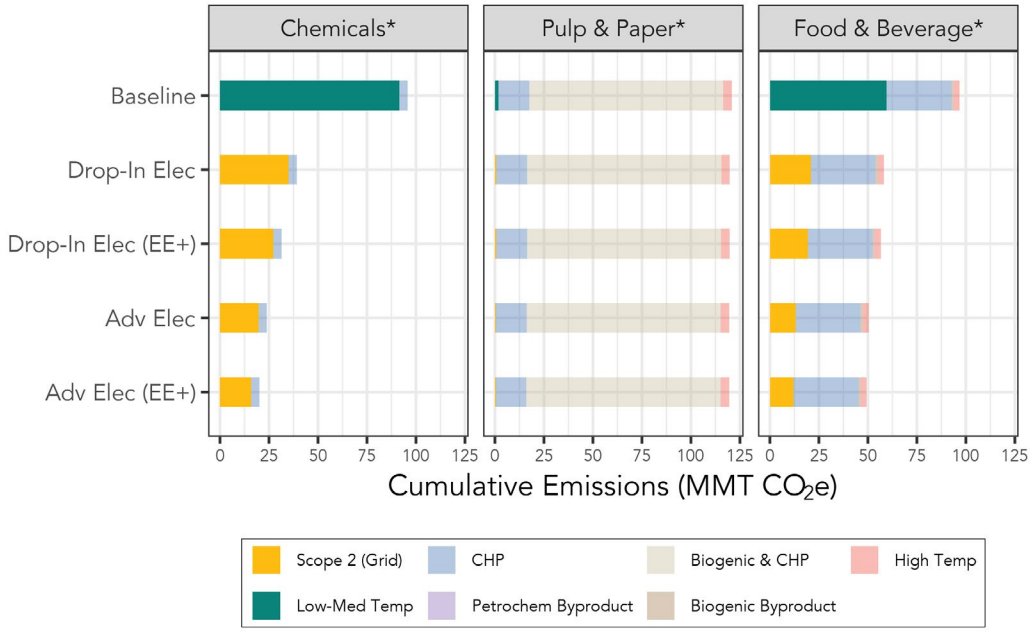
30 See Footnote 5 for eGrid and NLR sources.

31 U.S. Environmental Protection Agency. eGRID Data Explorer. September 2025.

32 CHP couples electricity generation with heat production, meaning that replacing CHP steam with steam from an electric heat technology will also affect the CHP unit's electricity output. This affects both the technical and economic viability of electrification.

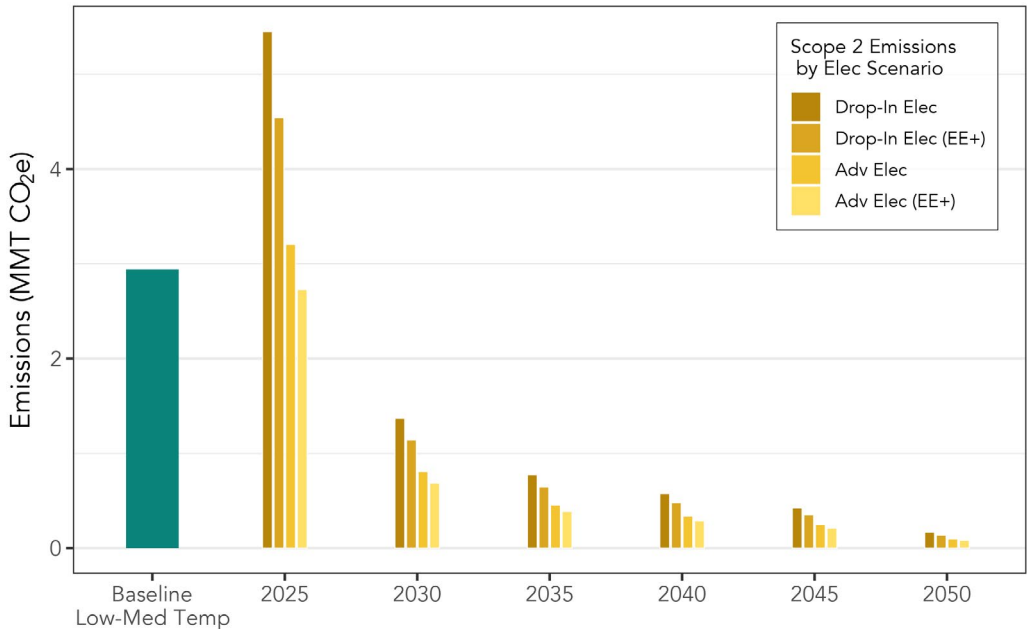
33 O'Neil et al. (*forthcoming*)

Figure 3: Cumulative CO_2e Emissions (2025-2050) by Minnesota Manufacturing Sector and Technology Scenario



*Caption: Horizontal stacked bars report cumulative CO_2e emissions by emission source and modeled electrification technology scenario (see Table 2 for definitions). Emissions from "out-of-scope" processes are partially translucent & assumed to remain constant year-on-year. N=37, reflecting 4 additional facilities without in-scope LMT heat. Scope 2 estimates use eGRID 2023 factors (for 2025) and NLR Cambium 23 "Mid-case with 95% decarbonization by 2050" (for 2026–2050) (see Footnote 5). Results reflect the average of optimistic and conservative cases. *Sector groups only reflect 11 MN subsectors included in study (Table 1).*

Figure 4: Minnesota CO_2e Emissions Reduction Potential Over Time, by Electrification Technology Scenario



Caption: Figure displays shift in emissions over time with LMT heat electrification. Onsite LMT emissions become Scope 2 grid emissions. Scope 2 estimates use eGRID 2023 factors (for 2025) and NLR Cambium 23 "Mid-case with 95% decarbonization by 2050" (for 2026–2050) (see Footnote 5). Colored bars represent emissions differences between electrification technology scenarios, with EE+ denoting energy efficiency scenarios (see Table 2 for definitions). Results reflect the average of optimistic and conservative cases and assume constant production levels to 2050.

Electrification also reduces harmful air pollutants. Many fuels release particulate matter ($PM_{2.5}$), a pollutant that is linked to asthma, cardiovascular disease, and premature death.[34] Natural-gas-fired boilers and heaters release nitrogen oxides (NO_x), which have direct respiratory impacts and contribute to the formation of ground-level ozone (O_3) and secondary $PM_{2.5}$. Burning sulfur-containing fuels emits sulfur dioxide (SO_2), which also reacts in the atmosphere to form secondary $PM_{2.5}$. We find that full electrification of LMT process heat in 33 of Minnesota's high-emitting manufacturing facilities would mitigate ~11,700 metric tons of NO_x pollution and ~4,800 tons of SO_2 pollution through 2030 (see Figure 5). SO_2 emissions are projected to increase initially due to the continued presence of coal on the grid, but these are projected to decline over time. These pollutants are the primary contributors to ozone formation, acid rain, and urban haze. We also find that electrifying LMT heat could remove ~4,000 tons of $PM_{2.5}$ from Minnesota's air through 2030.

These air quality improvements translate into meaningful health benefits for Minnesotans and communities across the U.S. Fewer residents will suffer from asthma, lung disease, and even cancer. Fewer children will miss school due to asthma and fewer workers will call out sick. Most importantly, electrification in Minnesota will prevent premature deaths that would otherwise result from chronic exposure to these harmful pollutants. Table 3 summarizes our quantified estimates of these health benefits.[35]

Table 3: Industrial Electrification Health Benefits

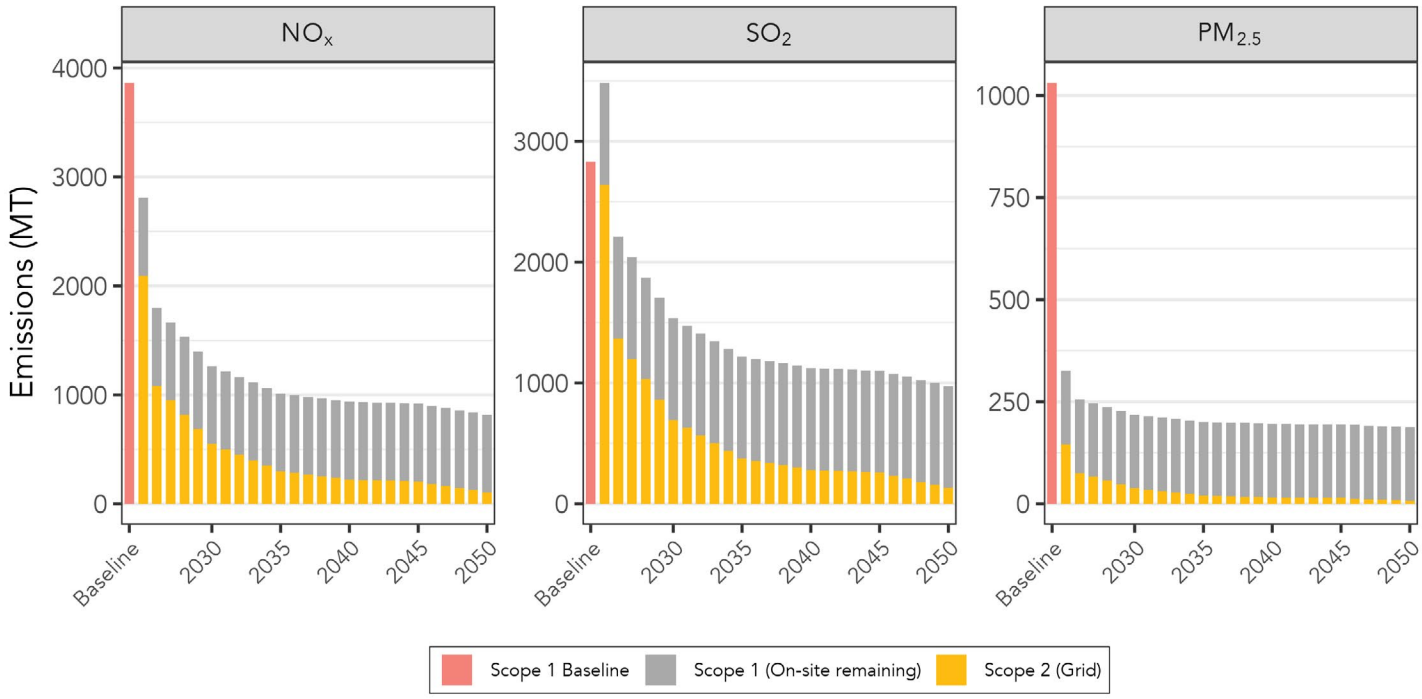
Health benefits in the form of fewer…	Local to Minnesota	Across the U.S.
…Asthma Attacks	135,000	376,000
…Emergency Room Visits	190	670
…Premature Deaths	230 - 400	660 - 1,100
…Lost Workdays	20,000	51,000
…Lost School Days	34,000	109,000
Cumulative Health and Economic Benefits	**$4.2B - $7.2B**	**$12.3B - $20.6B**

34 California Air Resources Board. Inhalable Particulate Matter and Health (PM2.5 and PM10). (n.d.)

35 Air quality impacts and health benefits were modeled using EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA).



Figure 5: Advanced Electrification (EE+) Lowers Air Pollution



Caption: Annual criteria air pollutant (CAP) emissions under Baseline conditions (red, NEI 2020) versus full LMT heat electrification in the Advanced Electrification (Max Efficiency) scenario (stacked bars). Scope 1 (on-site) reflects remaining emissions from non-LMT processes; Scope 2 (Grid) reflects increased electricity demand from LMT electrification. Scope 2 estimates use eGRID 2023 factors (for 2025) and NLR Cambium 23 "Mid-case with 95% decarbonization by 2050" (for 2026–2050) (see Footnote 5). Results are averaged across optimistic and conservative cases and assume constant production through 2050.

2.3 Local Electrification Hot Spots

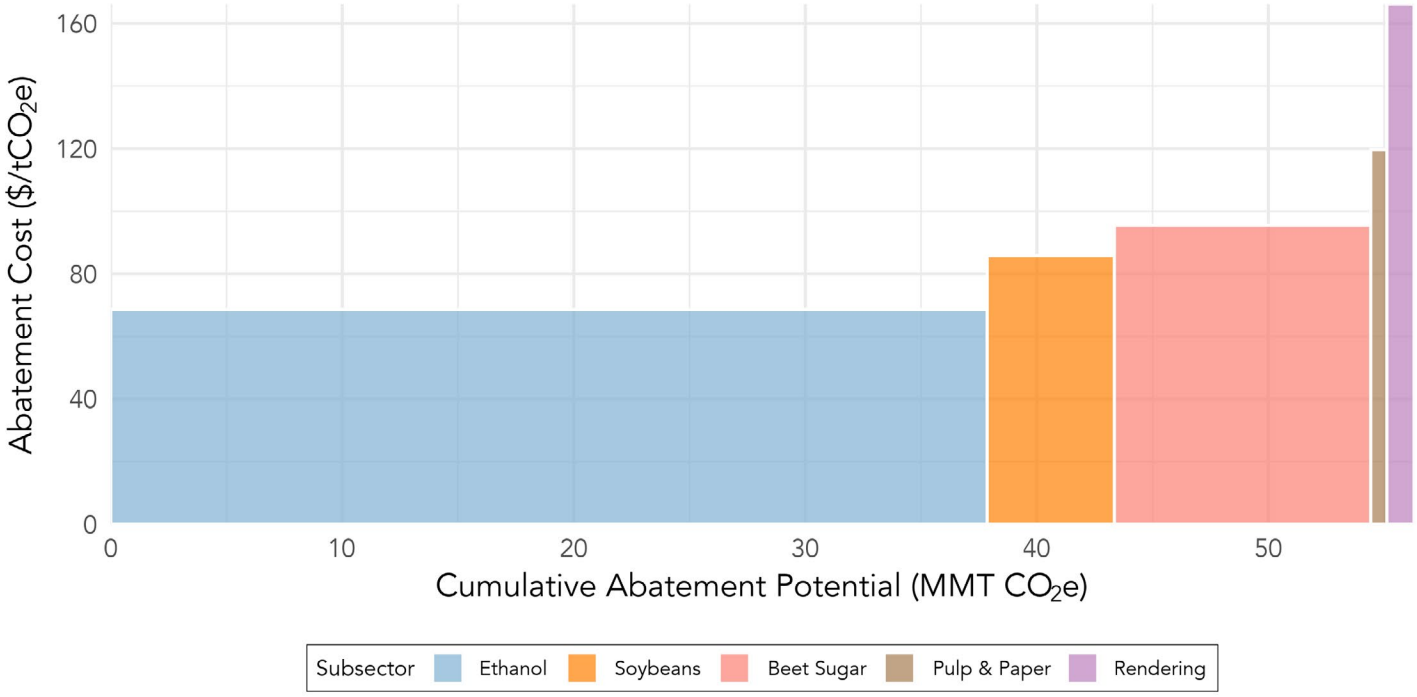
Next, we identify "hot spots" by evaluating which sectors present the most cost-effective opportunities to reduce GHG emissions. Figure 6 shows the marginal abatement cost (the cost per ton of avoided emissions over a project's lifetime) for CO_2e across sectors. Wider bars correspond to greater emissions reductions; shorter bars represent lower-cost emissions reductions.

Industrial electrification delivers high-value CO_2e reductions across the board in Minnesota. Ethanol, soybeans, and beet sugar manufacturing all deliver abatement costs less than $100/ton, making them prime targets for first-movers.[36] These abatement costs are well below the Biden Administration estimates of the social cost of carbon, which was $190/ton in 2023.[37]

36 Marginal abatement cost is calculated as the additional lifetime cost of electrification under the Advanced Electrification (Max Efficiency) scenario, relative to the natural gas Baseline, divided by lifetime emissions reduction in tons.

37 Frazin, R. "EPA lays groundwork for stronger climate rules." The Hill. December 2023.

Figure 6: CO_2e Marginal Abatement Cost Curves for Advanced Electrification (EE+) by Minnesota Manufacturing Sector



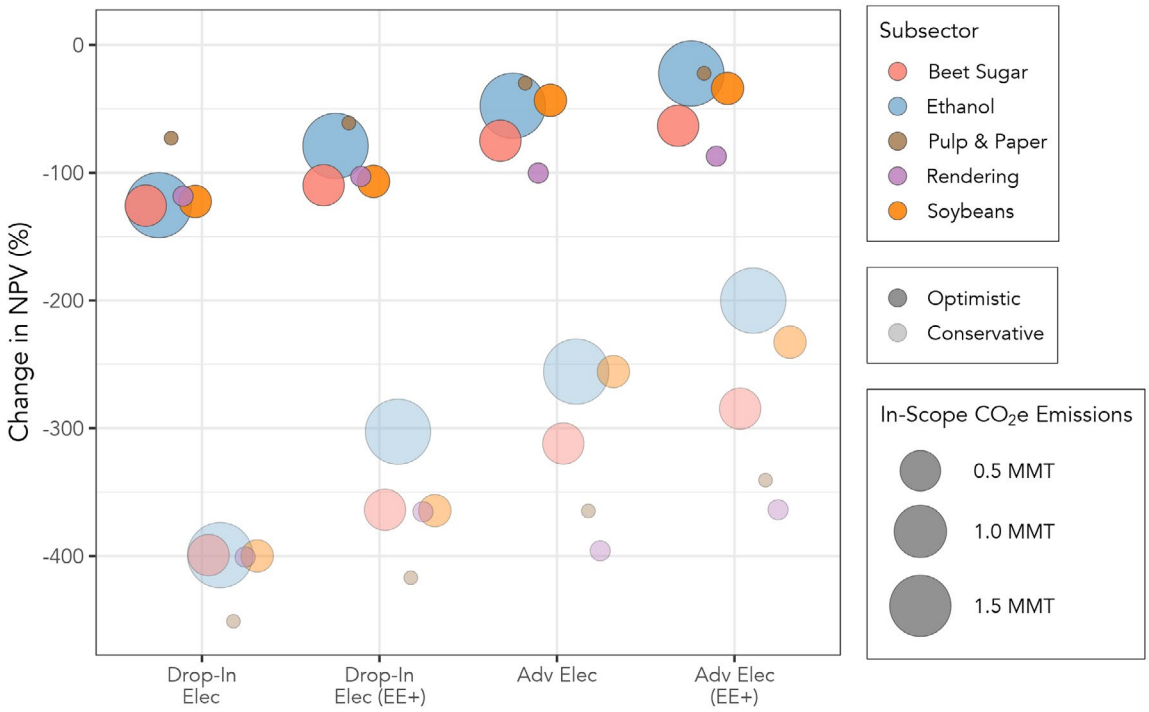
Caption: Area of each box represents the total cumulative abatement potential in dollars per ton of CO_2 equivalent, colored by manufacturing subsector (see Table 1 for sector definitions). Scope 2 estimates use eGRID 2023 factors (for 2025) and NLR Cambium 23 "Mid-case with 95% decarbonization by 2050" (for 2026–2050) (see Footnote 5). Results reflect the average of optimistic and conservative cases in the Advanced Electrification (Max Efficiency) scenario. Results assume constant production levels to 2050.

We also identify "hot spot" opportunities where electrification can be cost-competitive with natural gas equipment. Figure 7 first measures project costs to facilities as Net Present Value (NPV), which is simply an estimate of lifetime project costs (upfront + operating), with future costs discounted. A higher (or less negative) NPV means a project is lower-cost; a positive *change* in NPV represents a decrease in costs.

Using an HTHP in the Advanced Electrification scenarios, **the ethanol, soybeans, pulp & paper sectors emerge as the most cost-effective electrification opportunities**. Beet sugar is very close behind and represents the second largest sector by in-scope emissions. Cost differences across subsectors are driven by factors such as process temperature and waste heat recovery opportunities, which affect heat pump efficiency. Under the "optimistic" set of assumptions,[38] electrification in the ethanol and pulp & paper sectors can approach lifetime cost competitiveness with Baseline fossil fuel technologies.

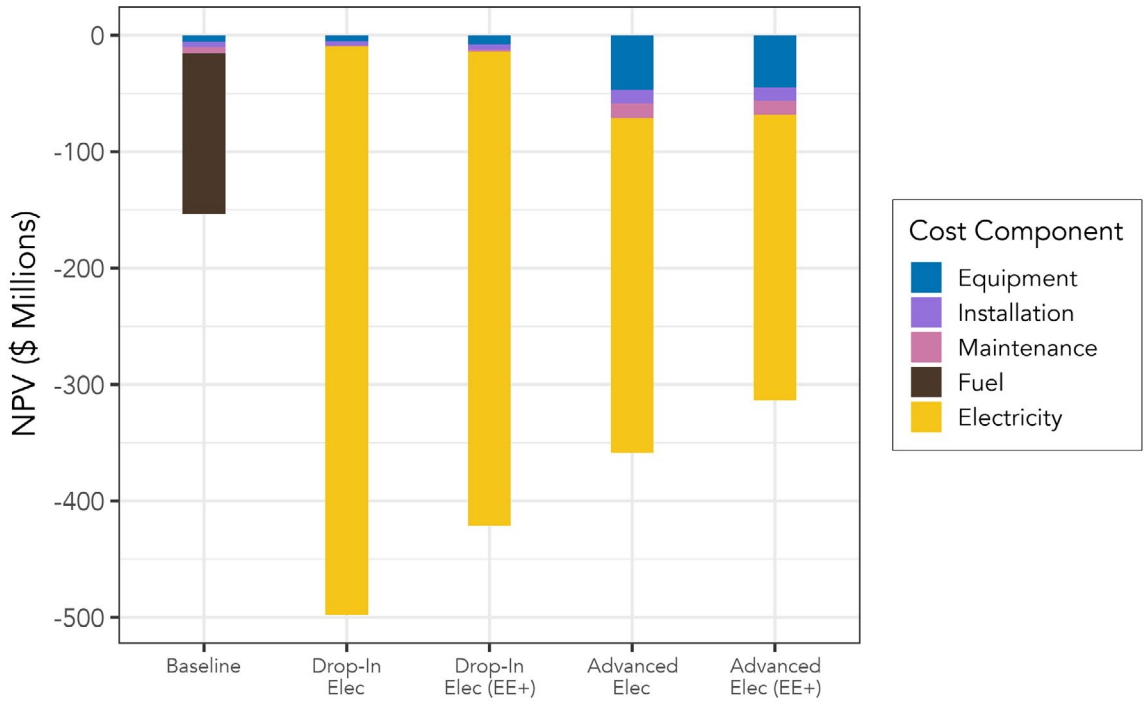
38 Optimistic and conservative cases differ in the assumptions used for parameters such as equipment efficiency, equipment costs, fuel prices, and operations & maintenance costs. See *The Clean Heat Climate Opportunity* report for more information on modeling parameters.

Figure 7: Equipment Efficiency Produces Differences Across Subsectors



Caption: Plot shows difference in lifetime NPV from Baseline across Minnesota subsectors in each technology scenario. More negative numbers equate to higher costs ("negative value"). The optimistic case uses a higher-cost Baseline reference, whereas the conservative case uses a lower-cost Baseline reference.

Figure 8: Electricity & Fuel Make Up the Bulk of Lifetime Project Costs



Caption: Plot shows NPV cost component breakdowns across Minnesota facilities (n=33) in each technology scenario. More negative numbers equate to higher costs ("negative value"). Bars represent the contribution of each cost component for an average facility. Results assume constant production levels to 2050.

On average, though, electrification is usually more expensive than the Baseline scenario. In Figure 8, we show estimated industrial electrification project costs vs Baseline using average assumptions, broken down by cost component. We see that electricity and fuel make up the bulk of lifetime project costs, meaning fuel prices are a primary driver of project economics. However, this differential is smaller for "Advanced" electrification with an HTHP than "Drop-In" electrode boilers, thanks to the high efficiencies of heat pumps which reduce operating costs over the project lifetime.

2.4 Policy Support Can Bring Down Operating Costs in Minnesota

Operating costs ("opex") are a key driver of investment decisions. If electric heat technologies are more expensive to operate than fossil-fuel fired equipment, facilities have little financial incentive to electrify their process heat.

The central challenge is the "spark gap," or the price differential between electricity and natural gas. Although electric technologies are more energy-efficient than conventional combustion equipment, Minnesota's spark gap is large enough to undermine those efficiency gains on a cost basis. Electricity is 4.2 times more expensive than natural gas in Minnesota, one of the highest differentials in the nation.[39]

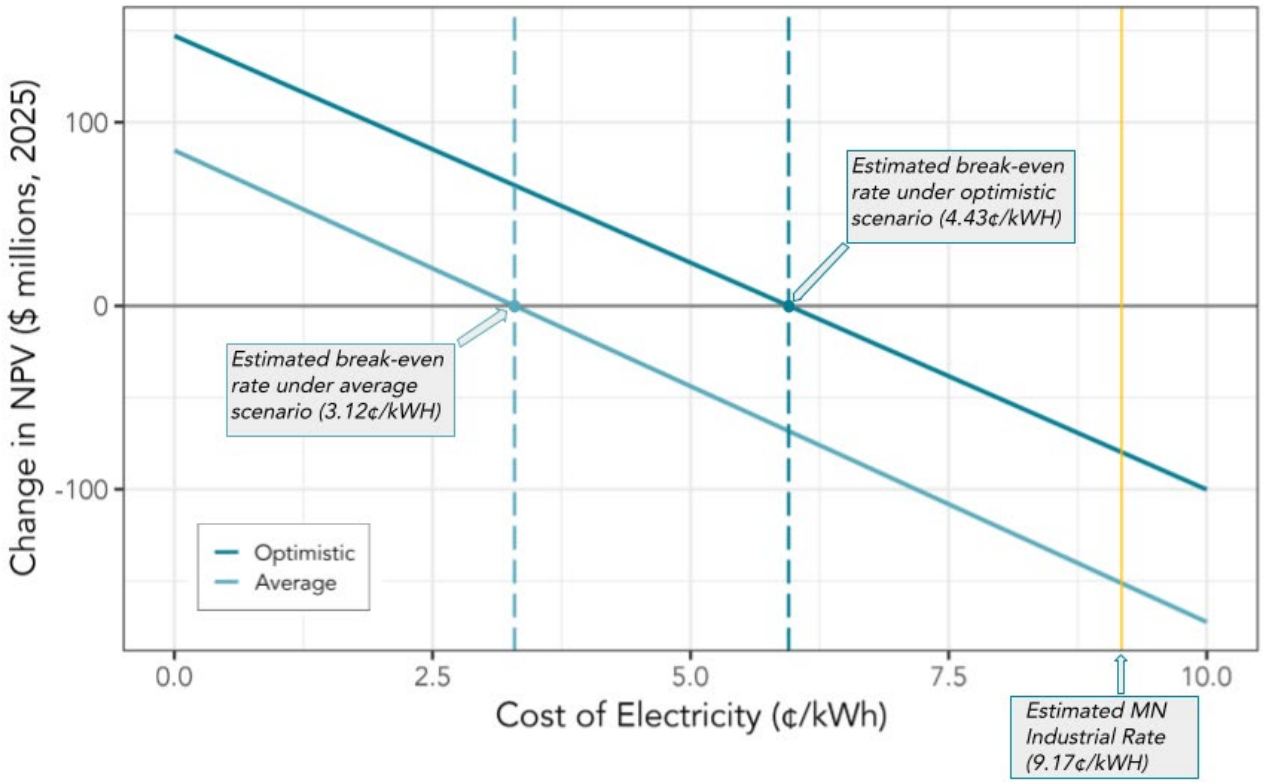
But, state policies that reduce operating costs, such as beneficial industrial tariff structures, can help improve project economics. Figures 10 and 11 below show the effect of electricity prices and policy support on cost outcomes. We discuss policy details in Section 3.1.

Figure 9 shows how the economics of electrification vary as a function of electricity price, across all Minnesota manufacturing facilities. At the current rate (9.17¢/kWh), Advanced Electrification (Max Efficiency) is more expensive than the Baseline, resulting in a negative change in NPV. The plot highlights the price at which lifetime project costs would break even with Baseline: 4.43¢/kWh with optimistic assumptions, and 3.12¢/kWh with average assumptions. A beneficial tariff for electrified process heat that brings the industrial rate closer to these levels would make electrification projects more cost-competitive.

39 U.S. EIA. Electric Sales, Revenue, and Average Price (Table 8). October 2025.; U.S. EIA. Natural Gas Monthly Report (Table 22). November 2025.



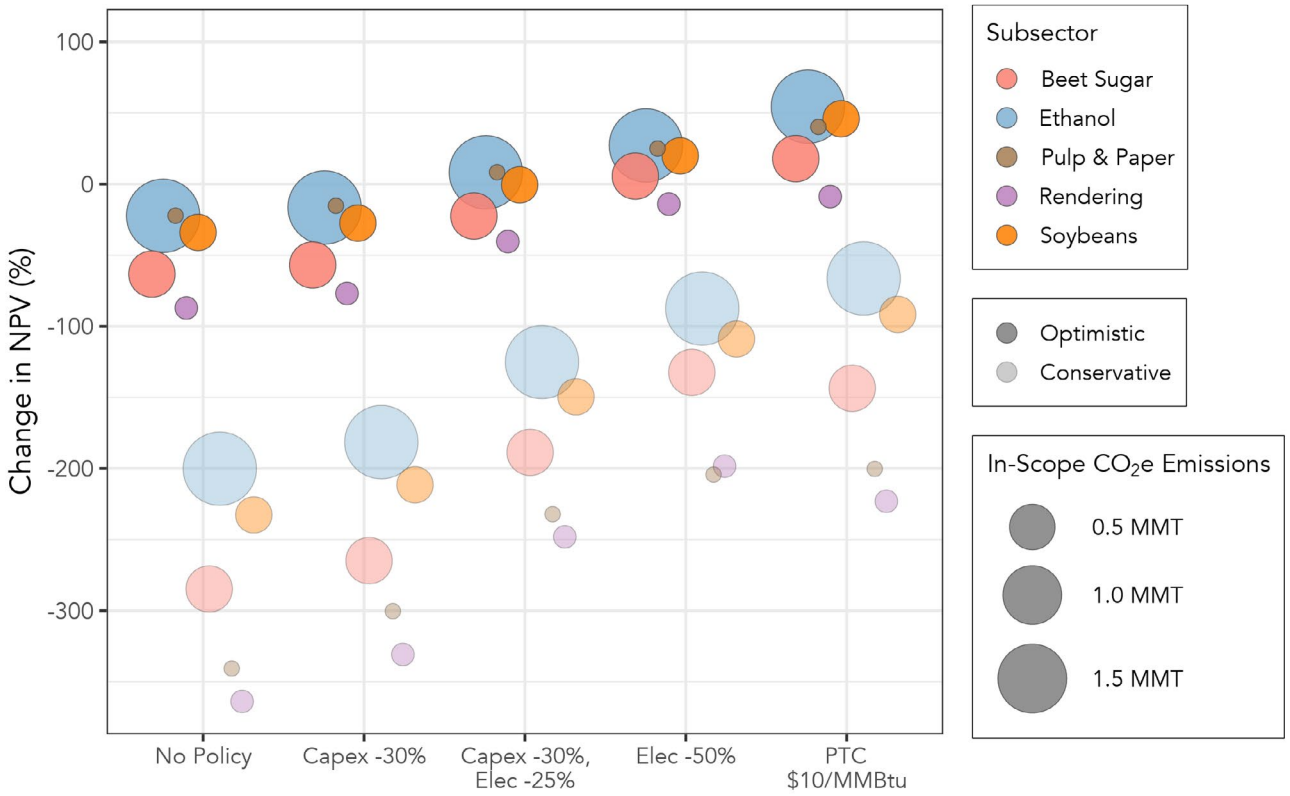
Figure 9: Minnesota Spark Gap is a Barrier to Electrification



Caption: Figure shows how Adv Elec (EE+) lifetime cost varies by electricity price. Costs are shown as changes in NPV from Baseline. Zero on the Y axis represents no change from Baseline; a positive value represents a decrease in lifetime costs; a negative value represents an increase in lifetime costs. Results averaged across all MN subsectors.

Targeting facilities with the most favorable electrification conditions—such as high COP potential for HTHPs—is a key consideration for policy design. Figure 10 shows NPV outcomes by subsector and level of policy support. Policies that reduce operating costs can turn the best electrification opportunities into positive value propositions. When combined with capex support, this is true even with a moderate (25%) reduction in industrial rates. As in Figure 6, ethanol and soybeans stand out as better-value subsectors with significant emissions reduction potential. The most effective policy is a $10/MMBtu production tax credit (PTC), which provides a tax rebate per unit of clean heat produced.

Figure 10: Minnesota "Hot Spots": Effect of Policy Support on Electrification Economics



*Caption: Plots show change in net present value of Advanced Electrification (Maximum Efficiency) from Baseline scenario, by subsector and following policy intervention. Triangle size corresponds to annual in-scope CO_2e emissions. *Results filtered to subsectors with at least two facilities.*

There are additional pathways to bring down operating costs not modeled in this analysis—in particular, concentrating electricity demand at times when prices are lower. Thermal energy storage systems can charge during times when electricity is cheaper. Some HTHP systems are installed alongside the existing natural gas system, allowing a facility to switch to natural gas when prices are high (although this reduces the emissions reductions benefits). We discuss how rate policy can support these systems in Section 3.1.

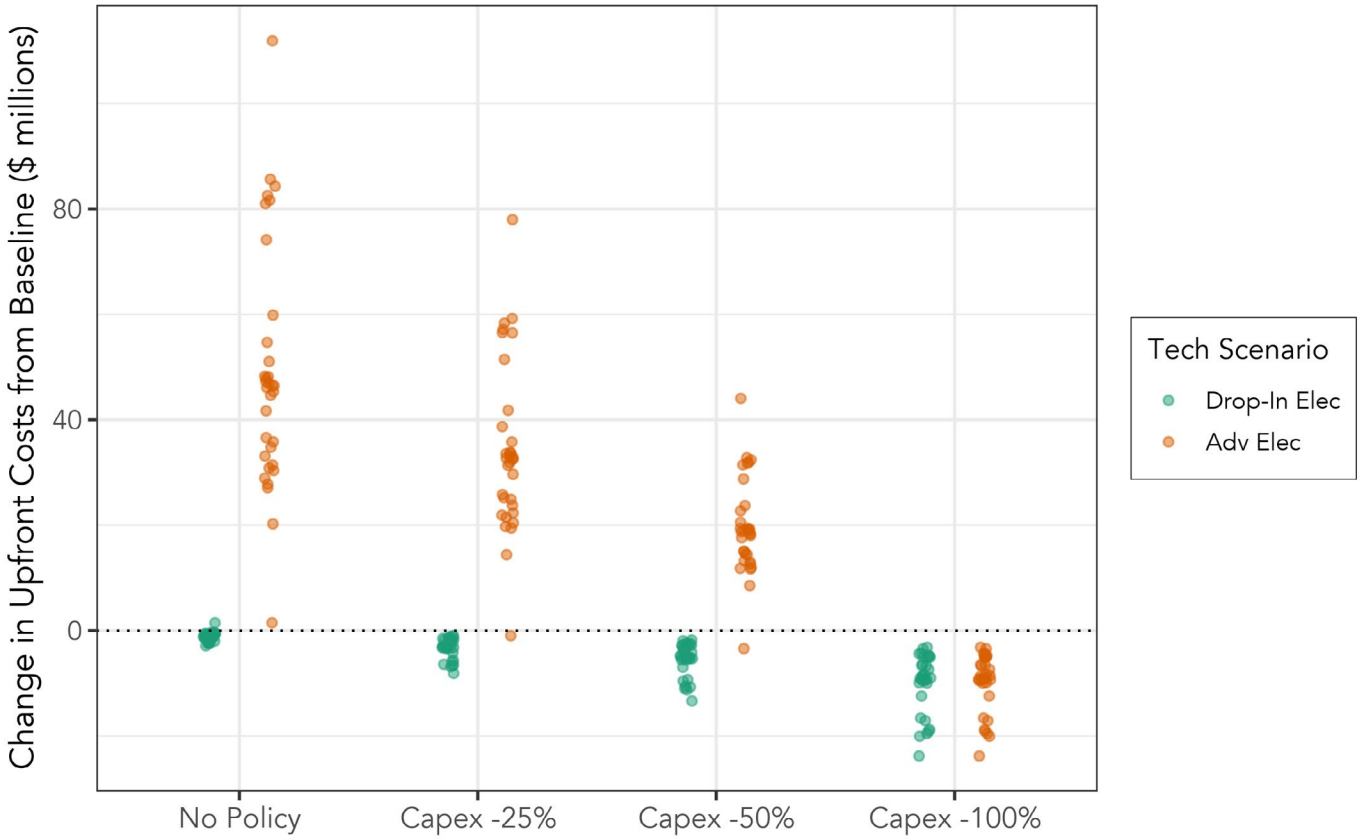
2.5 Lowering Upfront Costs Makes Electrification More Cost-Competitive

While operating costs are spread out and discounted over time, upfront ("capex") costs represent a sizable near-term expense that may require external financing. Policy support for upfront costs can make investing in clean heat technology more appealing to businesses.

Figure 11 shows the difference in upfront costs from the Baseline for Minnesota electrification projects with different levels of capex policy support. We find that Drop-In Electrification with electrode boilers is already competitive with the Baseline equipment without policy support. Given the lower capex and "plug-and-play" nature of electrode boilers, this equipment could be a better fit for facilities where energy costs are a low proportion of total operating costs.

Meanwhile, Advanced Electrification with an air-source HTHP is more expensive upfront. Policy support can help close this gap. A full grant allows these investments to save upfront costs relative to the Baseline technologies, but even partial support can meaningfully improve project economics. Figure 11 reflects project costs for 33 of Minnesota's largest manufacturers, but smaller grants could move the needle for small-and-medium manufacturers as well.

Figure 11: Facility-Level Upfront Costs by Policy Support



Caption: Plot shows distributions of change in estimated total upfront costs from Baseline technology scenario by facility (n=33). "Baseline" reflects costs associated with installing new combustion-fired equipment. Capex policies reflect a percent reduction in the upfront costs of electrification. Results reflect the average of optimistic and conservative cases.

2.6 Industrial Load Growth Can Be Managed With Careful Planning

Accelerating load growth, particularly from large loads like data centers and major electrification projects, may strain Minnesota's grid. Meeting this increasing demand with additional clean capacity will require careful resource planning from the regional grid operator—Midcontinent Independent System Operator (MISO)—and the MPUC. The Minnesota Department of Commerce recently circulated a request for proposals for a "Pathways to Carbon Free 2040 Study," meant to help guide long-term power system planning in service of the state's clean electricity standard.[40]

40 Minnesota State Register. Volume 50, Number 24. December 2025.

We estimate that electrifying all LMT process heat in our scope would increase industrial electricity consumption by ~6.5 - 13 TWh annually, depending on the technologies deployed (Table 4). To put this in context, 15 planned data center projects in the state are projected to add a total of 1,820 MW of load—equivalent to roughly 12 TWh per year if fully built out.[41] Industrial LMT electrification would therefore represent a relatively modest addition to grid load, likely less than the planned data center buildout already underway.

Nonetheless, our estimates reflect only the 33 GHGRP facilities in the chemicals, pulp & paper, and food & beverage sectors, excluding process heat at higher temperatures, CHP units, and byproduct fuel sources. Economy-wide industrial electrification from other sectors, smaller facilities, and processes that we exclude from our modeling would add additional load. This represents a substantial increase, but one that will be phased in gradually as facilities electrify and can be planned for with grid investments. In the near term, load growth from individual projects can be managed on a case-by-case basis. In Section 3.1.4, we also discuss how policies and rate contracts that incentivize demand flexibility can allow for electrification using existing grid capacity.

Table 4: Load Growth From In-Scope Industrial Electrification Relative to Baseline

Total Annual Minnesota Industrial Grid Demand (2023, Baseline) = ~20,560 GWh				
Scenario	**MN Chemicals***	**MN Pulp and Paper***	**MN Food and Beverage***	**Scenario Total**
Drop-In Electrification	+8,015 GWh ▲ 39 %	+154 GWh ▲ 0.8 %	+4,799 GWh ▲ 23 %	+12,969 GWh ▲ 63 %
Drop-In Electrification (Max Efficiency)	+6,248 GWh ▲ 30 %	+143 GWh ▲0.7 %	+4,418 GWh ▲ 21 %	+10,810 GWh ▲ 53 %
Advanced Electrification	+4,524 GWh ▲22 %	+94 GWh ▲0.5 %	+3,010 GWh ▲ 15 %	+7,628 GWh ▲ 37 %
Advanced Electrification (Max Efficiency)	+3,630 GWh ▲18 %	+87 GWh ▲0.4 %	+ 2,779 GWh ▲ 14 %	+6,496 GWh ▲ 31 %

41 "12 TWh" estimate derived from annualizing 1,820 MW of reported new load from data centers (Thomas, 2026), with a capacity utilization factor of 75% (EPRI, 2026).; Thomas, M. Data Centers in Minnesota. *Cleanview*. Updated April 2026.; EPRI. Powering Intelligence 2026. February 2026.



3. WHAT MINNESOTA CAN DO NEXT: NEAR-TERM POLICY RECOMMENDATIONS

With a large industrial manufacturing sector and a state government committed to climate action, Minnesota is well-positioned to be a leader on clean heat for industry. Industrial electrification is not only a technical question—it also depends on enabling conditions across policy, financing, and infrastructure. Policymakers should take a diversified approach to helping manufacturers overcome barriers.

3.1 Support Electrification by Reducing Operational Costs

There are several mechanisms by which ratemaking policy can help support industrial electrification. Effective policy can be implemented without straining the grid or imposing costs on other rate classes, especially in the early adoption phase.

3.1.1 Offer a special rate for industrial electrification projects

Industrial customers in Minnesota experience low natural gas rates and high electricity rates, which makes the economic proposition of switching from natural gas to electricity a challenge. Policymakers can make process heat electrification more cost-competitive by implementing policies that help close this "spark gap."

The MPUC and utilities should coordinate to implement beneficial electricity rates for facilities that install electric heat technologies. Targeting rate reductions to clean heat facilities, rather than industrial customers broadly, can improve electrification project economics while minimizing cost shifts to other customer classes. Precedent exists across sectors: utilities commonly offer economic development rates to attract industrial customers, and residential and commercial customers who install heat pump water heaters can already access special rates in some jurisdictions.

A beneficial electrification rate could be incorporated into large-load or new-load tariffs and designed to avoid shifting costs across other customer classes. For example, the new load's contribution to transmission and distribution cost recovery across the rate base could be required to partially or fully offset price increases to other customers. Revenue generated through large load tariffs for Minnesota's data centers could also help offset the cost of preferential rates for industrial facilities that electrify.[42]

42 HF 16 (2025) instructs the Minnesota PUC to establish a "very large customer" tariff which would apply to data centers, but could be expanded to include industrial electrification projects.

3.1.2 Provide access to real-time pricing

Shifting demand to off-peak periods can bring down electricity costs for industrial customers and mitigate their impact on the grid. Thermal energy storage enables facilities to "charge" thermal batteries when the cost of electricity is low and use the heat when electricity demand is high. Alternatively, industrial facilities could "load shift" operations so that electric equipment runs during off-peak periods.

However, realizing these operating cost savings requires access to real-time pricing, or the hourly wholesale electricity price. If facilities pay a flat rate per kWh, they see no cost savings by shifting demand to times when electricity is lower. Minnesota utilities do offer some "time-of-day" and other time-varying tariffs, which typically have a two-tiered "off-peak"/"on-peak" price structure.[43] These are beneficial, but do not offer enough price variation for load-shifting measures—especially thermal energy storage—to reach their full economic potential.

The MPUC should ensure that facilities have access to rates that offer wholesale market price pass-through. Dynamic pricing that reflects the marginal cost of electricity generation allows facilities to respond in real-time, making choices that reduce their own costs and improve grid stability.

3.1.3 Reform non-coincident demand charges

In addition to charges for the amount of electricity consumed, industrial customers typically pay a "demand charge" that is set by the maximum amount of power they consume at any given time over the course of a month. In Minnesota tariffs, this is often measured as the customer's maximum 15-minute demand within the billing period.[44]

A demand charge can be "non-coincident," meaning that the amount is the same regardless of when the maximum power draw occurs. Or, it can be "coincident," meaning that customers are charged for their power draw during peak periods, specifically.[45] Non-coincident demand charges disincentivize industrial customers from pursuing thermal energy storage and other electrification solutions that take advantage of off-peak pricing. By broadly disincentivizing customers from shifting demand to off-peak periods, non-coincident demand charges also increase strain on the grid and make it more difficult to add new load.

The MPUC should encourage utilities to offer coincident demand charges, improving economics for clean heat solutions and minimizing their contribution to system peak.

3.1.4 Incentivize demand flexibility and load management

In discussions about accommodating data center load growth, stakeholders are increasingly exploring load flexibility as a solution. If a data center can curtail its consumption during periods of peak demand, new load can be added to the grid without driving up costs or compromising reliability.[46] In fact, spreading fixed costs across a larger base of ratepayers tends to reduce bills for existing customers. New load, managed well, can be a net benefit rather than a burden.

43 Xcel Energy. Minnesota Commercial and Industrial Electric Prices. Effective 2019; Minnesota Power. Commercial/Industrial Rates and Rules. Effective October 2023.

44 Ibid.

45 Sierra Club, Industrious Labs, ACEEE, Synapse Energy Economics. Unlocking Industrial Electrification in California. December 2025.

46 Norris, T. et al. Rethinking Load Growth: Assessing the Potential for Integration of Large Flexible Loads in US Power Systems. Nicholas Institute for Energy, Environment, & Sustainability, Duke University. 2025.

The same logic can apply to industrial electrification. A facility that curtails its load during peak periods can be added to the system without straining the grid. Minnesota utilities already offer interruptible or curtailable service options, under which large industrial customers receive reduced rates in exchange for allowing utilities to curtail load during peak conditions.[47] This demand flexibility arrangement could be formalized within an industrial electrification tariff, in which participating facilities agree to reduce consumption during defined peak periods in exchange for favorable rates.

Demand flexibility can be tractable for electrified manufacturing facilities through several possible strategies. Thermal energy storage systems have demand flexibility built-in, as they are designed to charge during off-peak hours and discharge during peak hours. With an electrode boiler or HTHP, some facilities may be able to plan for a few hours of load curtailment by shifting production schedules. Others may opt to pay other customers to curtail their load, a solution being pursued by some data centers. Last, in some cases, a facility may elect to keep its natural gas system as backup to the electric system; there are also some HTHP systems that run on electricity most of the time but switch to gas backup during price spikes, such as the Skyven Arcturus.[48] In these cases, the gas backup system can enable demand flexibility, although this reduces the emissions reduction benefits of electrification.

3.1.5 Clean Heat Production Tax Credit

The legislature could also fund investments in industrial decarbonization by providing a production tax credit (PTC) for facilities that electrify. A clean heat PTC offers manufacturers a fixed tax rebate per MMBtu of heat they produce from clean technologies such as air-source HTHPs or electrode boilers. Because it is pegged to clean heat output, this policy offers operating cost support for facilities.

A clean heat PTC would allow other state revenue sources to offset some of the costs of electrification, as opposed to having a special industrial electrification rate (paid for by other customer classes and/or utilities) as the only policy measure. At the federal level, Senator Martin Heinrich's Industrial HEAT Act offers a model for PTC policy design. **Minnesota's state legislature could implement a similar policy so electricity suppliers and regulators are not entirely responsible for bringing down operating costs for industrial manufacturers**.

3.2 Continue to Reduce Upfront Cost Barriers

The Minnesota Pollution Control Agency (MPCA) has $60 million earmarked for industrial innovation in Climate-Smart Food Systems, funded by a federal Climate Pollution Reduction Grant. This funding will go towards technical assistance and planning (TAP) and implementation grants, which could help support investments in clean heat technology and energy efficiency upgrades. This program represents a historic investment in clean technology for industry and serves as an excellent foundation to further modernize Minnesota manufacturing.

47 Xcel Energy. Minnesota Commercial and Industrial Electric Prices. Effective 2019; Minnesota Power. Commercial/Industrial Rates and Rules. Effective October 2023.

48 Skyven Technologies. Arcturus | Decarbonized Steam Solutions.

3.2.1 Provide durable state investment with cap-and-invest or an ITC

Minnesota can develop a durable financing mechanism tailored to its industrial base and budget capacity. A clear pathway is for the state legislature to establish a cap-and-invest program which sets a limit on total emissions across the industrial sector and requires facilities to purchase permits to pollute. Permit sales provide a revenue stream that can be re-invested into Minnesota industry via technical assistance programming or direct capital improvement grants.

Similar to California's cap-and-trade system, the program could be designed to cover not only industrial facilities, but also transportation, residential and commercial buildings, and power plants. Or, Minnesota could design a program specifically for manufacturers, like Colorado's Greenhouse gas emissions and Energy Management for Manufacturers (GEMM) 2 program.[49] Under GEMM 2, covered facilities are assigned individual emissions reduction targets and must submit compliance plans, with the option to purchase credits from facilities that have reduced emissions beyond compliance. Allowances could be allocated to protect energy-intensive or trade-exposed industries. Illinois has now proposed a similar program as part of its climate action plan for industry.[50]

Alternatively, the legislature could fund investments with an investment tax credit (ITC). Colorado offers a model for this kind of policymaking. The state recently launched its semi-annual Industrial Tax Credit Offering (CITCO), providing $168 million in refundable tax credits for industrial emissions reductions projects.[51] The program covers a wide range of interventions, including feasibility studies, facility improvements, and equipment installations and replacement. Because the credit is refundable, firms without substantial tax liability can participate.

3.2.2 Fund industrial projects through MN Climate Innovation Finance Authority

Industrial decarbonization projects that are not funded through a climate-smart food systems grant could leverage their application to seek a loan on favorable terms from the MN Climate Innovation Finance Authority. This "green bank" is committed to funding projects that reduce greenhouse gas emissions and energy use, such as the installation of industrial heat pumps. **Investors at the MN Climate Innovation Finance Authority should prioritize industrial decarbonization projects as one of the highest-impact opportunities for greenhouse gas mitigation**.

3.2.3 Risk-sharing mechanisms for first-of-a-kind projects

Clean heat technologies such as air-source HTHPs[52] and thermal energy storage[53] are all proven to work in the field. That being said, risk remains a factor for industrial manufacturers who prize reliability and plant managers who may be unfamiliar with these new systems.

Minnesota can support electrification projects by taking on some of the project risk. Revenue insurance and performance guarantees can protect project owners against risk that the technology underperforms or

49 Colorado Department of Public Health & Environment. GEMM Phase 2 Rule. Accessed April 2026.

50 Illinois Environmental Protection Agency. Illinois Comprehensive Climate Action Plan (CCAP). June 2026 Draft.

51 Colorado Energy Office. Colorado Industrial Tax Credit Offering. 2026.

52 Stephens, H. "Breweries invest in heat pumps to decarbonize, cut costs." Manufacturing Dive. October 2025.

53 Gallucci, M. "Startup unveils heat battery it says can decarbonize almost any factory." Canary Media. January 2026.; Rondo Energy. "Rondo Energy to deploy 100 MWh heat battery for Heineken, powered by solar from EDP." November 2025.; Mims, C. "The 2,000-Year-Old Cement Battery That Could Reduce Our Reliance on Fossil Fuel." The Wall Street Journal. March 2026.

that the economics shift unfavorably. Contracts-for-difference can stabilize project revenues by guaranteeing a minimum return, even if energy prices move against the project. For projects that require debt financing, first-loss capital or state credit support can improve the risk profile enough to unlock private lending at workable rates. Together, these tools allow the state to absorb the portion of project risk that private markets are unwilling to bear, without requiring the state to fund projects outright.

3.3 Smart Regulations

In addition to economic incentives, there are many nonfinancial policy levers available to state policymakers that encourage industrial electrification.

3.3.1 Reform line extension policy in Integrated Resource Plans & Future of Gas Docket

After Winter Storm Uri caused gas prices to spike in 2021, MPUC required utilities to submit Integrated Resource Plans which consider practices around energy provision and capacity expansion. Xcel Energy, CenterPoint Energy, and Minnesota Energy Resources must submit their Integrated Resource Plans in 2026, 2027, and 2028, respectively. **The MPUC should require that utilities demonstrate industrial electrification has been considered before approving new gas line extensions serving industrial customers**.

The Natural Gas Innovation Act also required the Minnesota Public Utilities Commission to open a "Future of Gas" docket, which evaluates policy and regulatory changes needed to meet legislated climate goals. One policy under consideration is a change to how natural gas line extensions are financed.[54] Currently, new customers can connect to the natural gas grid for free, subsidized by the existing ratebase. Given Minnesota's climate goals and the increasing applicability of electric technologies, continuing this subsidy for electrifiable industrial operations is misguided.

One reform would be to **require new industrial users to pay for some or all of the costs of line extension**, incentivizing them to consider alternatives to natural gas from the outset. As of June 2025, eight states have implemented similar policies.

3.3.2 Consider zero-emissions boiler standard

While Minnesota has typically followed EPA standards for boilers and water heaters, MPCA has clear legal authority to set more stringent energy efficiency and pollution control standards under state law.[55]

Starting with rules for smaller, lower-temperature boilers and water heaters—where electrified options are more readily available—can acclimate stakeholders and industrial users to electrification where these technologies are more proven. Regulators could then phase-in similar rules on large boilers implemented through BACT. For example, California regional air districts are phasing in zero-emissions standards for smaller units, while new rulemaking is underway to address emissions from larger boilers.[56]

54 Javelina Energy. Evaluation of Minnesota Investor-Owned Gas Utilities' Line Extension Subsidies. July 2025.

55 MN Statutes. Chapter 116, Sec. 116.07.

56 Yorke Engineering. SCAQMD Amended Rule 1146.2 – Control of NOx from Large Water Heaters, Small Boilers, and Process Heaters. June 2024.

3.3.3 Expedited interconnection and permitting pathways for electrification

For an industrial electrification project to come online, it must go through an interconnection and permitting process. The interconnection process involves applying to a utility for permission to connect to the grid, which can require undertaking a study to assess potential grid impacts. Facilities may also require electrical permits for panel upgrades to increase amperage at the site and building permits for structural modifications.

The Minnesota legislature can create pathways to speed up interconnection and permitting for industrial electrification projects. These reforms would lower administrative barriers that discourage electrification.

3.4 Build Technical Capacity Across the State

Even when process heat electrification or energy efficiency upgrades save on costs, manufacturers may elect not to pursue these investments due to perceived risk, technical barriers, or aversion to change. Technical assistance programs and peer-to-peer knowledge sharing can help overcome this "implementation gap."[57]

The MPCA already plans to offer technical assistance and planning grants through the Climate-Smart Food Systems program. These grants will "help grantees identify and evaluate facility-specific efficiency projects and decarbonization efforts."[58] These grants can play a central role in supporting first-movers. There is also the Minnesota Technical Assistance Program (MnTAP), which offers process energy assessments and workshops.[59]

Minnesota should develop a structured forum to synthesize and incorporate electrification into existing technical assistance programming. Regulators could coordinate with MnTAP to ensure public access to case information from Climate-Smart Food Systems TAP grants. Clean heat technologies could also be incorporated as an option in MnTAP and Industrial Training and Assessment Centers (ITAC) energy assessments, which focus mainly on energy efficiency.

57 McMillan, C. and Wachs, L. Industrial Process Heat Decarbonization: A User-Centric Perspective. NREL. June 2024.

58 MPCA. Minnesota climate-smart food systems. Accessed April 2026.

59 University of Minnesota. Minnesota Technical Assistance Program. Accessed April 2026.

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