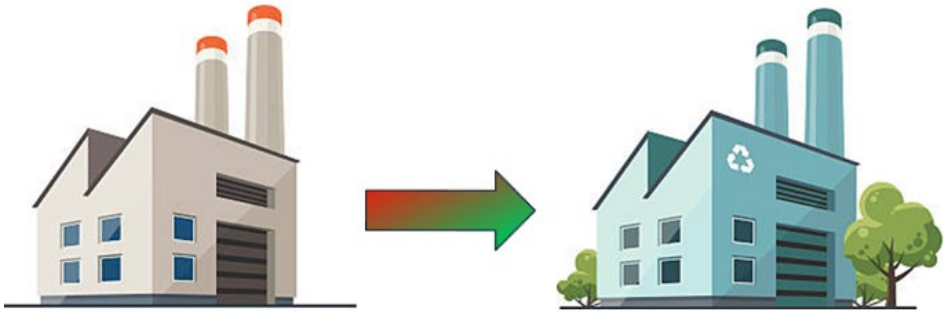
COMMERCE DEPARTMENT
ENERGY RESOURCES



CARD market study: Industrial heat pump interest growing – demonstrations and improved economics required

Industrial heat pump (IHP) development began in earnest in the 1980s, associated with uncertain gas markets, but the technology gained limited penetration in the United States industrial market due primarily to low cost-effectiveness and a lack of incentive for research and development. In recent years, the technology has become relevant to the modern economy due to greater focus on carbon reduction by way of electrification, but many market and mechanical limitations remain.

Objectives

The primary goals for this market assessment were to identify and evaluate best candidates for IHP applications and determine steps needed to establish market adoption. This was accomplished by completing the following tasks:

- Identify existing IHP systems and Minnesota industries with process loads that are candidates for electrification.
- Gather feedback from key stakeholders to understand the barriers related to the adoption of electrification measures.
- Conduct site surveys and evaluate heat pump opportunities of industrial facilities to identify candidates for piloting IHPs.
- Extrapolate findings from the sites and published literature to estimate the technical, economic, and maximum potential for heat pumps applied to Minnesota industrial facilities.
- Create a roadmap for market adoption.

Heat Pump Products and Applicable Processes

The IHP product market can be dissected in a few ways. One categorization is packaged vs. custom units. There is a recent increase in the prevalence of packaged units with a variety of sizes and temperatures available in the U.S. Some select applications and particularly high capacities still require custom component selection. A second categorization is the source/sink fluid and temperatures. Current products are either air or water source, and either water or steam output. IHPs that can produce hot water to just below water boiling temperatures are available using a variety of refrigerants. Many manufacturers have systems with supply temperatures from 212°F (100°C) to 300°F (149°C) and supply temperatures >300°F (149°C) can be produced using a booster steam compressor.

The technical potential for electrifying industrial process loads with IHPs depends on matching the IHP thermal operating constraints to the thermal load requirements. About half of process heat loads require too high of a temperature for commercially feasible IHP units. Large customers are more likely to have optimal applications for heat recovery, while small customers are more likely to have suitable process loads for lower temperature or air source applications. By industry, Food Processing and Pulp and Paper are of particular interest due to their temperature suitability.



Figure 1. Industrial Heat Pump Installation

Stakeholder Interviews

The interviews gathered information from key stakeholders regarding the market potential for heat pumps in Minnesota industrial facilities and identify facilities appropriate for an IHP demonstration project. Interviews with plant managers, industrial designers, manufacturers, and utility representatives revealed growing interest in IHPs, particularly driven by corporate sustainability goals and greenhouse gas reduction targets. While plant managers were generally unfamiliar with IHP technologies, especially for high-temperature applications, they expressed strong willingness to explore pilot projects when aging equipment or sustainability initiatives were present. Manufacturers and consultants were well-informed and noted increasing market traction, particularly in Europe, with investments in packaged IHP systems. Utilities are beginning to support industrial electrification through custom programs and pilot funding, though there was no consensus on whether prescriptive or custom rebates would be most effective. The 2021 Energy Conservation and Optimization Act (ECO Act) and the Natural Gas Innovation Act (NGIA) have opened new pathways for funding and technical support, with demonstration projects underway. Overall, stakeholder feedback highlighted both the promise and the challenges of IHP adoption—while technical capabilities and funding mechanisms are improving, economic viability and operational constraints remain key barriers.

Site Surveys and Heat Pump Evaluations

The goal of this task was to identify sites with thermal processes that may be suitable for the installation of moderate- to high-temperature heat pumps that lead to reduced carbon generation and energy cost savings. This was a focused engagement of plant managers through site surveys and follow-up meetings to

discuss system features, estimated costs, opportunities, and barriers most relevant to their needs. Six industrial sites were selected for evaluation of heat pump applications, representing a range of sectors including food and beverage and pharmaceuticals/cosmetics (see Table 1). The surveyed facilities included diverse thermal processes such as cooking, pasteurization, refrigeration, and cleanroom air treatment, with varying heating and cooling demands. Each site provided input to identify feasible heat recovery opportunities, and field surveys were conducted to assess process characteristics, space constraints, and potential for heat pump integration.

Table 1. Key Characteristics of Selected Sites

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Market Sector	Food / Canned Products	Food / Egg Processing	Pharmaceutical / Cosmetics	Food / Diary	Food / Egg Processing	Food / Brewing
Floor Area (sq. ft.)	500,000	150,000	180,000	105,000	323,000	41,800
Approx Annual Electric Use (GHW)	15	30	8	12	30	NA
Approx Annual Gas Use (Dth)	300,000	30,000	6,000	90,000	130,000	NA
Key Process Operations	Sauce making, Blanching, Cooking, Hot water	Cooking, Pasteurization, Hot water	Batch Process Heating, Hot water	Pasteurization/ HTST process has been optimized to include heat recovery and thermal storage	Pasteurization, Sterilization, Cooking, Hot water	Process heating, Hot water
Spark Gap (w/o demand charges)	4.68 (3.51)	5.05 (3.78)	3.98 (2.98)	NA (NA)	5.03 (3.77)	5.03 (3.77)
Years since working with utility programs & sustainability initiatives	10+ yrs	10+ yrs	10+ yrs	10+ yrs	5+ yrs	Relatively new plant 0–2 yrs

IHP feasibility was evaluated using pinch analysis to identify viable source-sink pairings and estimate temperature lift requirements. HWHPs and SHPs were assessed based on their ability to meet heating needs and recover available waste heat. For each site, the hot water heat pump applications provided better economics than steam heat pumps. However, in all cases, both types of IHPs had higher energy costs than the current gas systems that they would replace.

This illustrates why Minnesota's relatively high spark gap (i.e. the ratio of electric cost divided by gas cost per unit of energy) presents a major barrier to cost-effective IHP adoption. Based on Energy Information Administration reported 2023 industrial energy costs (IEA 2025[1]), Minnesota had a spark gap of 4.62 which ranked 41st of the 50 U.S. states. However, excluding electric demand charges from the spark gap calculation improves the economics of heat pump applications. In some cases, this adjustment brings COP_h above the spark gap, suggesting that thermal storage, demand management strategies, or modified rate structures could make certain installations financially viable.

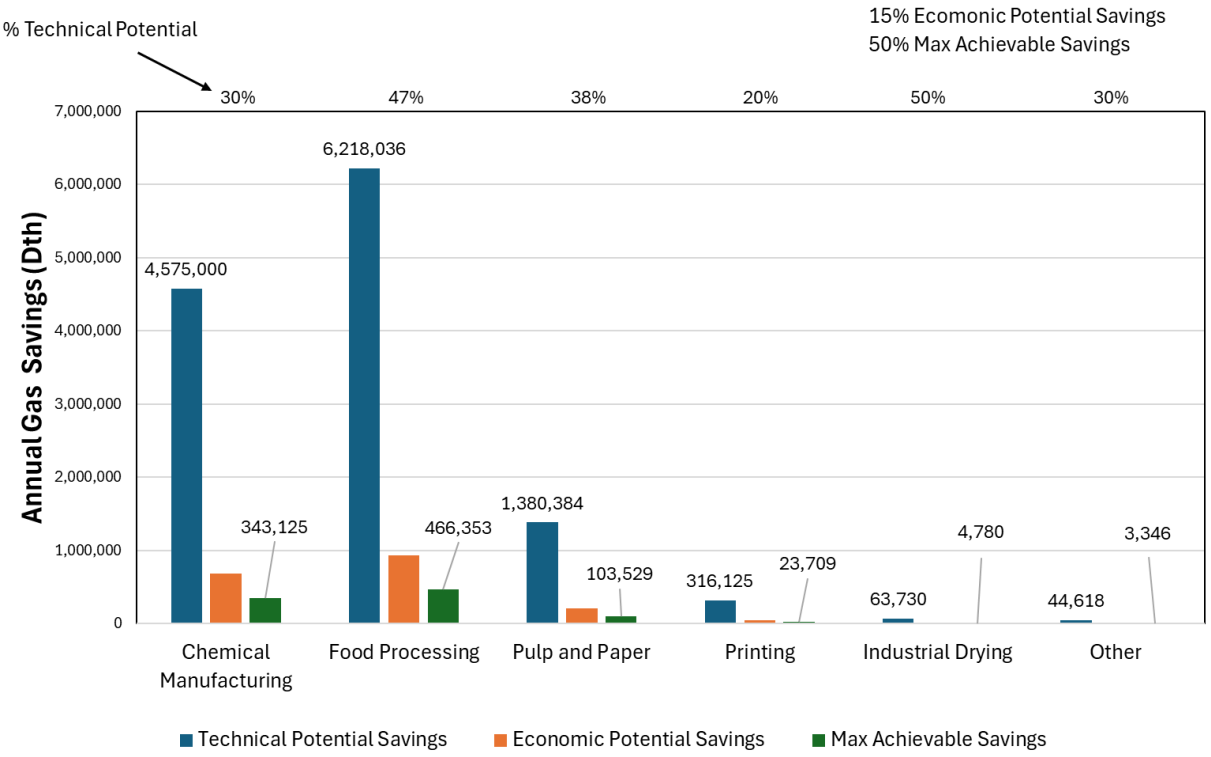
Market Potential

Market potential calculations were used to estimate annual gas use savings for IHP installations in Minnesota. The savings were computed for three levels of potential: technical, economic, and maximum achievable. First, the percentage of industrial thermal process gas use that could be satisfied with IHPs by sector was gathered from published information. Those percentages were then refined using results from project stakeholder interviews and IHP evaluations for Minnesota plant surveys. Finally, the percentages were applied to reported gas use by market sector for Minnesota industrial plants to compute annual gas savings for each of the three levels of potential.

Figure 2 shows results for the eight primary sectors analyzed by a 2010 MnTAP study (2010[2]). Food processing operations typically involve both process heating and process cooling, including operator experience with ammonia refrigeration systems and the associated network of equipment vendors. With these factors — prevalence, thermal suitability, and market connectivity — food sector applications should be the largest focus for development and represent the highest savings potential (6.2 MDth). Pulp and paper and printing sectors are a secondary focus, with good technical potential of 1.4 MDth, but less operational similarity between incumbent systems and IHPs. For all Minnesota industrial plants IHPs have the potential to replace up to 32% of Minnesota's industrial natural gas consumption, equivalent to approximately 12.6 million Dth annually. This technical potential is concentrated in sectors with suitable temperature ranges for heat pump operation. Food processing, pulp and paper drying, and chemical manufacturing emerged as the most promising sectors, with food processing alone accounting for nearly half the total technical potential. However, when economic factors are considered, the potential drops significantly. With current Minnesota industrial gas and electric rates, only 4.7% of industrial gas use is economically viable for heat pump replacement, and just 2.4% is considered maximum achievable under current market and policy conditions.

[1] Energy Information Administration. *State Energy Price and Expenditure Estimates: 1970 Through 2023*. DOE/EIA-0376(2023), June 2025. https://www.eia.gov/state/seds/archive/seper2023.pdf
[2] MnTAP Energy Conservation Market Analysis. 2010. http://www.mntap.umn.edu/wp-content/uploads/simple-file-list/Publications/Source/MnTAP-Energy-Conservation-Market-Analysis.pdf

Figure 2: Minnesota Industrial Heat Pump Potential Energy Savings by Sector



Roadmap for Market Adoption

IHPs have had limited penetration in the United States industrial market due primarily to low cost-effectiveness that did not incentivize research and development for the U.S. market. More recently, IHPs have become relevant due to greater focus on carbon reduction by way of electrification, but many financial, market, and mechanical limitations remain. We identified a five-step roadmap to accelerate IHP market adoption:

1. Identify high-potential sectors and processes, especially in food and pulp/paper industries.
2. Develop screening tools and design guides to simplify feasibility assessments.
3. Implement and publicize demonstration projects to build market confidence.
4. Expand utility program services, including identification of best opportunities, incentives, and rate design innovations.
5. Educate stakeholders and promote IHPs through workshops, peer learning, and targeted outreach.

Successful implementation will require collaboration among utilities, manufacturers, plant managers, and policymakers. Improved screening tools, adjustments to rate structures, and broader education efforts are essential to overcome current barriers and unlock the full potential of industrial heat pumps in Minnesota. Demonstration projects will be a key step to build confidence and showcase successful applications. Demonstration sites should ideally be widely applicable, economically viable, and capable of replacing a significant portion of heating loads. Lower-impact but replicable installations (e.g., recovering heat from cooling towers for hot water) are good candidates for utility support. Two utility-led pilots—CenterPoint Energy's NGIA Industrial Electrification Pilot and Xcel Energy's Strategic Electrification Incentive Program—have been approved. These projects will provide full or partial

funding for heat pump installations and performance verification, helping to address economic and technical uncertainties.

Conclusions

- IHPs that can produce hot water to just below water boiling temperatures are available using a variety of refrigerants. Temperatures up to 300°F can be generated using multiple stages of compression and supply temperatures >300°F using a booster steam compressor.
- The stakeholder interviews revealed growing interest in IHPs, particularly driven by corporate sustainability goals and greenhouse gas reduction targets. While plant managers were generally unfamiliar with IHP technologies but expressed strong willingness to explore pilot projects. Manufacturers and consultants were well-informed and noted increasing market traction, particularly in Europe.
- The site surveys of six industrial plants found both hot water and steam IHPs had higher energy costs than the current gas systems that they would replace. This is due to the relatively high spark gap for Minnesota which ranked 41st of the 50 U.S. states. IHPs are financially viable when demand charges are reduced or eliminated through thermal storage, demand management strategies, or modified rate structures.
- The market potential analysis indicated that industrial heat pumps IHPs have the potential to replace up to 32% of Minnesota's industrial natural gas consumption, equivalent to approximately 12.6 million Dth annually. Food processing, pulp and paper drying, and chemical manufacturing emerged as the most promising sectors. However, IHP replacement is economical for only 4.7% the gas use and 2.4% is considered maximum achievable.
- The roadmap for greater adoption of IHPs included identification of high-potential sectors, improved screening tools, and broader education efforts. Demonstration projects will be a key step to build confidence and showcase successful applications. Two Minnesota utilities have approved demonstration projects. In addition, refined metrics, rate innovation, program bundling, and enhanced customer services — create a pathway for utilities to accelerate industrial electrification.

Detailed results from this project are available in the final report, "Industrial Electrification Through Heat Pump Adoption for Process Loads." For more information, contact project manager Adam Zoet or CARD program administrator Lindsay Anderson.