The Industrial Heat Pump Opportunity Goes Beyond Energy Savings

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Our research indicates that industrial heat pumps (IHPs) can pay back up to $5 per million British thermal units (Btu) of saved energy to implementing facilities through co-benefits, creating an additional 20% to 30% savings on top of the net energy cost savings. These savings can help offset the cost of electrification, as electricity prices for industrials averaged $24.38 per million Btu in 2022.[1] IHP co-benefits also accrue to neighboring communities and the national economy.

This critical decarbonization technology is currently underused, partially because limiting cost-benefit analyses to energy alone will always underestimate the reach of IHP benefits.

According to ACEEE research, IHP savings can include

- up to 32% of the energy use associated with industrial process heat
- 30–43 million metric tons of CO_2 emissions per year by 2050 in several key sectors (Rightor et al. 2022), equivalent to the emissions from 6.5–9.2 million gasoline-powered passenger vehicles driven for one year

However, IHPs are currently underutilized in the United States for several reasons, including challenges buyers and other stakeholders have in comparing the full set of benefits against high capital costs and other barriers like the need for skilled labor.

When we take the many benefits—called co-benefits—of IHPs into account, the value proposition improves and goes beyond energy and emissions savings. While IHP vendors typically explain these to their customers, technical research often leaves them out when evaluating the economics of IHP implementation. Therefore, many manufacturers that are interested in heat pump potential, as well as utility program planners and policymakers, may be unaware of these co-benefits and underestimate the overall positive impact of IHPs on the facility's capital and operational costs. To accurately capture their value, the full set of benefits from IHP deployments should be identified, quantified, and communicated.

Industrial managers are looking for a clear return on investment (ROI) to replace legacy boilers with IHPs. We estimate that as much as $5 per million Btu of saved energy is a reasonable figure for IHP non-energy savings accrued to a facility. Across IHP types and applications, this figure accounts for 20–30% of additional savings on top of the net energy cost savings provided by IHP systems.[2]

Moreover, IHPs can maintain and improve manufacturing competitiveness, create jobs, and reduce costs for manufacturers. In this brief, we describe the many IHP benefits that increase ROI for industrial facility managers and align with bipartisan policy priorities. We conclude with recommended actions for three major stakeholder groups: U.S. agencies and labs, facility engineers and decision makers, and utility managers.

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[1] 2022 is the most recent year for which we have both natural gas and electricity price data for industry.
[2] Source: Paul Scheihing, 50001 Strategies, pers. commun., March 15, 2024.

What is the full scope of benefits from IHPs?

IHPs offer increased efficiency through simultaneous heating and cooling as well as waste heat recovery. Moreover, they can increase the benefits of other decarbonization technologies (including onsite renewable electricity generation, thermal storage, smart manufacturing, and others) by offering improved control and reducing the need for onsite fossil fuel infrastructure. Beyond efficiency gains and savings, IHPs offer several significant co-benefits that are typically highly valued by facility engineers and managers. Some of these benefits include

- workplace health and safety improvements due to reduced onsite combustion and equipment rightsizing
- higher product quality through more precise heat control
- operational cost savings
- improved air quality and reduced pollution in neighboring communities
- specialized jobs created by the manufacturing of new energy-saving technologies
- economic development of the IHP market and transformation of the grid

IHP-related co-benefits offer value to three entities:

- manufacturing facilities
- neighboring communities
- the general workforce and national economy

Benefits for facilities that implement IHPs

Manufacturing companies, large commercial buildings, and district heating systems can retrofit legacy boiler systems with new IHPs to generate low-to-medium temperature process heat. The best time to assess the economic costs and benefits of IHP installation is at the end of service life for existing boilers, when engineers and finance departments can make an accurate comparison between an IHP and a replacement boiler. Equipment replacements provide prime opportunities for industrial facility managers to consider IHPs and compound the total cost savings, the full set of benefits, and the carbon reductions they offer.

By implementing IHPs, and either retiring or avoiding fossil-fuel infrastructure in the first place, manufacturers can gain several non-energy advantages—including reduced costs, risks, and liability—on top of energy and efficiency savings.

- **Workplace Health and Safety:** IHP systems can improve workplace health and safety conditions. They offer reduced noise pollution and fewer safety risks because they do not require combustion, which can be dangerous (Klima Therm 2022).
- **Insurance Costs:** Boiler insurance is a recurring, fixed cost exacerbated by the aging, inefficient technologies typical in industry. Installing an IHP system instead of a boiler system can reduce this operational expense. Mitigated health and safety issues also reduce liability and insurance costs.
- **Maintenance Costs:** IHPs may require less frequent and less intrusive maintenance because their lower component temperatures result in slower component degradations (EECA 2023).

- **Permitting Costs and Risks:** Eliminating natural gas infrastructure reduces environmental permitting for gas piping and gas combustion, and code compliance costs, with less staff time needed to deal with permits and fees. Eliminating combustion also reduces the risk of fees and/or shutdowns from noncompliance with emissions and safety regulations.
- **Product Quality and Throughput:** In manufacturing products, IHPs can improve product quality through more precise temperature control. For example, more controlled heating from IHPs often leads to higher quality dried lumber at higher yields (DOE 2003). IHPs can also remove bottlenecks in processes to increase production at lower costs.
- **Modularity and Space Savings:** Heat pumps are more modular than many alternative technologies. IHPs can be installed in parallel to cascade and reach higher lift temperatures to meet the heat demands of individual processes. Their size relative to boilers makes it easier to place them near where heat is needed in limited plant floorspace. Because of their modular nature, IHPs can accommodate easier replacements and shorter downtimes when components break.
- **Resource Conservation:** When reusing waste heat via IHPs, the need to send waste heat to cooling tower—and the associated operational and maintenance costs—are avoided. Eliminating cooling towers reduces water use, the volume of associated chemicals to treat the water, and the power needed for pumps and fans.
- **Future-Proofing:** IHPs can also future-proof plants and processes. The modularity of IHPs means that facilities are less likely to be locked into long-lifetime systems as new and more efficient alternatives are developed. Greenfield facilities can future-proof for electrification by deploying IHPs and other electric technologies. By eliminating the need for any natural gas infrastructure, new manufacturers can avoid costs associated with retrofitting legacy systems in the future.

The financial rewards of these benefits will obviously vary from facility to facility, but they could be equal to or greater than the cost of the energy per Btu. Based on conversations with industry experts, we estimate that $5 per million Btu of saved energy is a reasonable figure for non-energy savings. The quantification of co-benefits can significantly offset potentially prohibitive payback periods for IHP systems and components, accelerating adoption timelines across applications.

The lower cost of natural gas compared to electricity has been a key barrier to IHP adoption. The cost of gas averaged $7.66 per million Btu in 2022 (EIA 2024). The U.S. average for industrial electricity in 2022 was $24.38 per million Btu (EIA 2023). Hence, the full realization of co-benefits—valued at $5 per million Btu—can help reduce the average U.S. spark gap—the ratio of the electricity price to the natural gas price—from 3.2 to 2.5, where 3.0 is often considered a reasonable threshold for estimating whether projects will proceed.[3]

Benefits for neighboring communities

IHP deployment can help alleviate some of the disproportionate health and environmental impacts often imposed by the industrial sector on low-income communities, communities of color, and rural communities across the United States. Electrified technologies like IHPs lower local pollution and improve air quality in communities adjacent to industrial sites by displacing onsite combustion of natural gas or other emissions-intensive fuels. In addition to air quality benefits, the decreased need for

[3] Spark gap ratios of 3.0 or lower typically result in payback timelines that are feasible for implementing facilities.

wastewater treatment reduces the risk of harmful water discharge from boiler steam blowdown and cooling towers, leading to healthier waterways.[4]

Communities situated near manufacturing centers can also benefit from IHPs through the good-paying jobs and economic benefits they create, with more assured longevity in the transitioning economy.

Benefits for the workforce and economy

As a desirable decarbonization pathway, the large-scale demand for IHPs will create production and installation jobs and support economic development across the U.S. manufacturing sector. To ensure equitable employment, public funding for IHP manufacturing and IHP implementation should prioritize retraining and reskilling of workers whose jobs may be phased out due to the clean energy transition, with particular attention to frontline communities who have experienced adverse health and environmental impacts resulting from industrial activity.

DOE's $169 million Heat Pump Defense Production Act (DPA) program will boost electric heat pump manufacturing in 13 states. While there are challenges in developing an extensive workforce that can support IHP deployment, the DPA ensures that each project is committed to the White House's Justice40 initiative through developing Community Benefit Plans, establishing Community Workforce Agreements, and prioritizing fair and equitable hiring of local workers.

Widespread IHP adoption can also have major economic advantages. With a transition to IHPs, domestic gross domestic product (GDP) has the potential to increase by billions of dollars in the coming decades due to greater efficiencies in production and the divestment of otherwise committed capital to fossil fuel use, while creating thousands of additional jobs in electricity supply, equipment manufacturing, construction, and other important sectors of the economy (Rissman 2022).

How can stakeholders help overcome barriers?

IHPs are not only advantageous in terms of energy savings; they also have multiple other benefits that can increase product quality, improve operational and process efficiencies, drive workforce and economic development, and reduce greenhouse gas emissions. To maximize the potential impact of IHP deployment, it is vital to remove structural hurdles currently preventing the technology from scaling. These hurdles include high up-front system costs, a lack of customer awareness, inconsistency around regulatory and certification requirements, and workforce gaps.

Federal agencies and labs can help overcome these barriers by

- increasing education about the array of IHP co-benefits through trainings and technical assistance
- determining a standardized process to quantify the full spectrum of IHP benefits with evaluations from IHP vendors
- increasing funding and incentives for IHP demonstrations

[4] Blowdown is the intentional use of water to drain the boiler of various impurities that accrue during steam evaporation.

Industrial facility decision makers, engineers, and managers can help overcome these barriers by

- evaluating legacy versus IHP systems through technical research, with a comprehensive view of costs and benefits
- future-proofing facilities with electric technologies and infrastructure to avoid locking in long-lifetime fossil fuel–based systems

Utility managers can help overcome these barriers by

- evaluating their service territories and finding candidate sites for IHP demonstrations in facilities requiring low-to-medium temperature process heat, preferably where product quality improvement can be monitored and documented
- structuring incentives to support IHP implementation and maintenance
- planning for adequate electrical resources to accommodate the electrification transition

All three stakeholder groups should quantify co-benefits so that they can be included in cost-benefit analyses, which will help lower perceived risks and barriers for interested manufacturers and decrease payback periods. The estimated $5 per million Btu of saved energy for non-energy savings can make the difference in project feasibility in numerous applications. Facility managers can determine monetary savings based on metrics such as job retention and creation, operational and process cost savings, and pollution reduction metrics (particulate matter, NO_x, SO_2, volatile organic compounds, others). Fixating on energy savings alone will always underestimate the reach of IHP benefits, including for communities near industrial facilities. Possible metrics for policymakers to incorporate into IHP incentives could include job creation (especially in Justice40 and rural communities), workforce and economic development, and pollution reduction.

Emphasizing co-benefits as part of marketing, engineering design, and education strategies (for technical assistance institutions) could also help influence policies and programs to drive IHP uptake. Considering the full array of benefits is critical for government authorities and interested manufacturers when evaluating the costs and benefits of additional support for decarbonization technologies like IHPs.

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