

## BACKGROUND

Using low-carbon electricity as a substitute for fossil fuels will be essential for reducing emissions across the economy. Many sectors of the economy are already electrifying, including electric vehicles and residential heat pumps.

The industrial sector is the next frontier of electrification. The vast majority of industrial fossil fuel use is dedicated to process heating - applying heat to raw materials to turn them into finished products. According to the [Department of Energy](#) (DOE), industrial process heat accounts for approximately 9 percent of total U.S. emissions (676 million metric tons of carbon equivalent emissions). Continued expansion of renewables will transform electric grids throughout the country, making electricity an increasingly attractive low-carbon option for process heat. Electrifying industrial heat will enhance the competitiveness of American industry and help the United States achieve its midcentury climate goals.

DOE has identified industrial electrification as one of the four pillars of industrial decarbonization. Several sectors, including food and beverage, glass, pulp and paper, and chemical production are well-positioned to electrify their operations now. The prospects for widespread industrial electrification are brighter than ever because of increased public funding for electrification, refinement of electrification technologies, and unprecedented access to low- and no-carbon sources of electricity.

This guide provides an overview of the benefits that industrial electrification can deliver to facilities and communities. We strongly encourage states and plant managers to utilize our [Technical Assistance Page](#) to obtain more targeted information and guidance regarding industrial electrification.

### *Primary Industrial Electrification Technologies*

Electrified technologies can be used in many industrial settings. Industrial heat pumps and thermal batteries are two technologies with the potential for widespread deployment. They are two examples among several available options, as listed below:

- Industrial Heat Pumps (IHPs)
- Thermal Batteries
- Electric Arc
- Electric Resistance
- Induction
- Infrared Heating

## THE PROCESS HEAT OPPORTUNITY

According to DOE’s Industrial Decarbonization Roadmap, approximately 30 percent of process heat demand requires temperatures at or below 150°C. Several technologies, including heat pumps, microwave technologies, infrared technologies, and solar thermal can provide heat in this range. Many analysts consider electrification of low-temperature industrial applications the “low-hanging fruit” of industrial decarbonization.



Image credit: AGC Heat Transfer. 2022. <https://www.agcheattransfer.com/blog/value-heat-exchangers-bring-to-beverage-production-process>

## INDUSTRIAL SECTORS WITH HIGH ELECTRIFICATION POTENTIAL

All industrial sectors can potentially electrify some or all manufacturing processes. Sectors that rely primarily on low- and medium-temperature heat such as food and beverage, chemicals, and pulp and paper have the greatest short-term electrification potential.

The figure below breaks down CO<sub>2</sub> emissions by industrial sector and highlights that 15 percent of emissions derive from low-temperature applications ripe for electrification. States or regions with high concentrations of facilities that utilize low- and medium-temperature heat and have access to reliable supplies of renewably generated electricity can achieve significant emissions reductions from electrifying industrial operations.

CO<sub>2</sub> emissions breakdown for industrial sectors of focus (2021), %

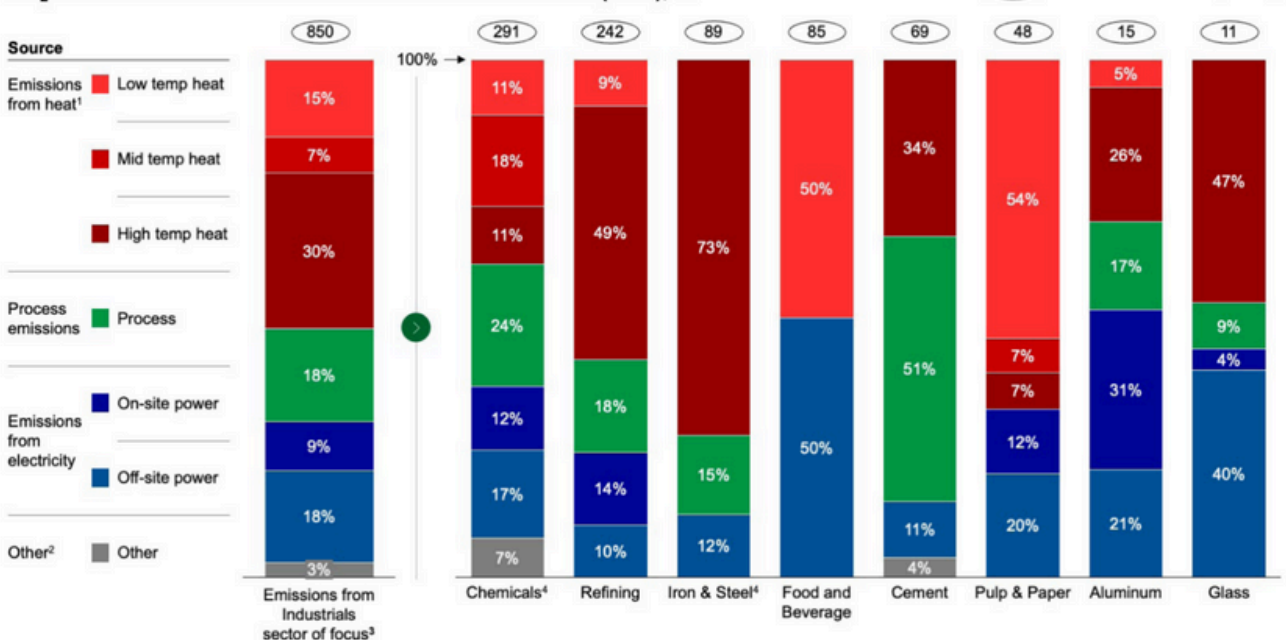


Image credit: US DOE, Pathways to Commercial Liftoff: Industrial Decarbonization, (DOE, Sept. 2023), 15.

# WHAT ARE THE PRIMARY BENEFITS OF INDUSTRIAL ELECTRIFICATION?

Below are some examples of the types of benefits that industrial electrification can deliver to facilities and communities.

## FACILITY LEVEL BENEFITS

### *Efficiency/Process Improvements*

- Industrial heat pumps (IHPs) can reduce the energy use associated with process heat by up to a third, because they typically transfer two to three times more process heat than the energy required to drive them (this ratio is referred to as the coefficient of performance, or COP). As a result, they outperform even efficient fossil-fuel fired and electric boilers. The efficiency gains associated with heat pumps are greatest at low temperatures (up to 100°C) but are still significant up to 165°C.
- Industrial heat pumps increase the temperature of waste heat produced in a facility to a temperature where it becomes useful, providing an incentive to re-use this heat. If waste heat can be re-used instead of sent to cooling towers, facilities can reduce the need for pumps and fans.
- Industrial heat pumps and thermal batteries can be sized to match thermal needs to minimize capital and operating costs. Multiple industrial heat pumps can be distributed around a site close to the heating sink, reducing distribution network heat losses and improving heating system efficiency.
- Heating with electricity can increase product quality by enabling more precise heat control.
- Heating with electricity does not create hot exhaust gases or form water vapor (H<sub>2</sub>O), two important heat loss modes. According to the [Department of Energy](#), between 20 and 50 percent of industrial energy input is lost as waste heat in the form of hot exhaust gases, cooling water, and heat lost from hot equipment surfaces and heated products. Fossil fuel combustion tends to transfer heat to the environment, rather than the material being manufactured, leading to a lot of wasted energy.
- Facilities that install on-site generation or source their electricity directly from a renewable energy provider can dramatically reduce their Scope 1 and Scope 2 emissions.

### *Safer Work Environment*

- Electrification can promote workplace safety because electrified equipment makes less noise than boilers and reduces accident risk that can arise from combustion.
- Replacing fossil fuel-powered machines and vehicles with electric ones can improve indoor and outdoor air quality.

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## CONTINUED: FACILITY LEVEL BENEFITS

### *Financial Savings*

- In some cases, industrial heat pumps (IHPs) can deliver heat at a lower cost than a facility would pay for an externally supplied heat source, like natural gas. IHPs reduce the need to purchase steam or natural gas. Depending on the cost of installation and electricity vs. natural gas rates, the payback period for IHPs can be two years or less.
- IHPs and thermal batteries have relatively low maintenance needs relative to boilers and steam systems, which can result in savings.
- IHPs save water and other costs by avoiding the need to send waste heat to cooling towers.
- Insurance costs for electrified equipment are generally lower than for equipment powered by combustion.
- Reduced operational costs associated with heat pumps, often referred to as co-benefits, create an additional 20 to 30 percent savings on top of the net energy cost savings resulting from the greater efficiency of electrified equipment. These savings can help offset the price advantage of natural gas relative to electricity in many parts of the country.

## SOCIETAL BENEFITS

### *Greenhouse Gas Emissions Reductions*

- Substituting low-carbon electricity for fossil fuels can substantially decrease a facility's carbon footprint.
  - Read more about one company's journey to electrify: [Trane Technologies](#)
- Electrifying a plant with power sourced from the grid can provide incremental emissions reductions over time because grids are becoming cleaner each year. In [2023](#), renewables accounted for 40 percent of American electricity generation. Energy Information Administration (EIA) [state profiles](#) contain information on electricity sources in each state. The federal government is striving to make electricity generation carbon-free by 2035. As a result, electrification can reduce emissions in both the short and long term.
- As noted in the facility level benefits, facilities that install on-site generation or source their electricity directly from a renewable energy provider can dramatically reduce their Scope 1 and 2 two emissions. This also contributes to a societal benefit of reduced greenhouse gases for everyone.

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### *Health & Air Pollution Benefits*

- Electrification offers manufacturers a path to decreasing emissions of contaminants that contribute to air pollution. Electrification reduces emissions of sulfur dioxide and nitrogen oxides, the primary contributors to ozone pollution. Curtailing fossil fuel combustion can also lead to reductions in particulate matter, a leading cause of asthma and respiratory problems.
- Air quality improvements are one of the most important benefits of electrification for the communities that host industrial facilities. Highlighting the potential public health benefits of electrification can be a way to overcome skepticism about the need to reduce emissions.

### *Job Creation*

- Industrial electrification will generate new jobs across the energy sector, including at the plants where heat pumps and other electrification technologies are manufactured, within industrial facilities, and in the construction and maintenance of new electrification infrastructure. Rewiring America estimates that electrifying all aspects of the US economy has the potential to create 15 million to 20 million jobs over the next decade, with 5 million being permanent jobs.

# WHAT ARE SOME PRIMARY BARRIERS TO INDUSTRIAL ELECTRIFICATION?

## *Economic Factors*

- Capital costs are significant, with industrial heat pumps typically costing anywhere in the range of \$800,000 to \$2.5 million depending on capacity and other factors.
- Operating expenses are often cited as the single biggest deterrent to electrification. The reason is simple: in some parts of the country, natural gas is substantially cheaper than electricity. This price differential is sometimes referred to as the spark spread. Manufacturers are understandably reluctant to opt for a higher cost source of heat.

***These cost concerns are real, but it is worth noting a few points.***

- Many analysts predict that as individuals, households, and businesses electrify many daily activities, the cost of electricity will likely decrease while natural gas costs are forecast to increase.
- Until then, the combination of greater efficiency and other co-benefits derived from electrifying manufacturing operations can offset the lower cost of gas.
- Costs for electrification technologies will likely decrease as adoption increases. Recent federal support for heat pump production will also increase supply, leading to lower prices.

## *Unfamiliarity with Electrification Technologies*

- Few domestic manufacturers are familiar with heat pumps, largely because they have not been widely available for purchase in the United States. Similarly, thermal battery manufacturers have only recently begun commercial production. Plants can be reluctant to embrace new equipment that operates on different technical principles. Technical experts and service providers can introduce companies to novel technologies and help them determine whether heat pumps or another electrification technology are a good fit for their facility.

## *Reliability Concerns*

- Some manufacturers may be reluctant to rely on the electric grid for thermal process heat. They perceive gas infrastructure as more reliable than the electric grid. Concerns about service interruption may deter manufacturers from switching to electrically generated heat.

# HOW CAN STATES SUPPORT INDUSTRIAL ELECTRIFICATION?

## *Track and document projects:*

In a May 2024 [report](#) on industrial decarbonization, the Department of Energy (DOE) identified inefficient information flow as a major barrier to accelerating industrial emissions reductions. It can be challenging to track completed and planned projects. This is one of the reasons I<sup>3</sup> compiled a project [contact sheet](#) for recent Industrial Demonstration Project awards selected by DOE's Office of Clean Energy Demonstrations (OCED).

States, tribes, and municipalities that received Climate Pollution Reduction Grants (CPRG) from the Environmental Protection Agency for industrial projects should provide periodic updates about these projects on their websites. Sharing this information will allow facilities to learn and benefit from the experiences of other companies, making it more likely that they will pursue similar projects after seeing successful examples. CPRG awards are only one potential source of funding for electrifying industrial facilities.

## *Disseminate information on funding opportunities:*

DOE's [Industrial Efficiency and Decarbonization Office \(IEDO\)](#) and [the Office of Clean Energy Demonstrations \(OCED\)](#) routinely provide funding for industrial emissions reduction projects. For a list of federal funding opportunities for industrial projects, see Clean Air Task Force's [Federal Funding Programs for Clean Industrial Innovation: A Guide for States](#).

Industrial Assessment Centers have [grants available](#) to support projects that modernize small and medium manufacturers' facilities with improved energy and material efficiency.

Over half the states have nonprofit or public lenders, often called [Green Banks](#), that provide funding for a range of decarbonization projects.

Many states have [Energy Efficiency Resource Standards \(EERS\)](#) that set targets for energy savings that utilities must meet through customer energy efficiency programs. Utilities use dedicated funding to help customers improve energy efficiency. Manufacturers may be able to draw on these funds to electrify their operations.

## *Connect manufacturing facilities with technical assistance:*

Each region of the country has technical assistance providers who can help manufacturers assess the potential for electrifying their facilities. States can play the vital role of connecting manufacturers to technical experts. We strongly encourage states and plant managers to utilize the Technical Assistance Page in the toolkit to obtain more targeted information and guidance regarding industrial electrification, including who they can contact in their area for assistance.

# CONCLUSION



In June of 2024, Schneider Electric's Sustainability Research Institute released a report forecasting that by 2030, the share of electricity in the industry energy mix could increase from 31 percent to 45 percent, reducing fossil fuel demand by 25 percent and emissions by 100 MtCO<sub>2</sub>/yr. As the report observed, electrification will yield broader benefits:

*"Once electrified, industry can better optimize energy use through digitization and the aggregation of real time data – driving efficiencies well beyond energy use, including improving processes, maintenance, and even workplace safety."*

Industrial electrification can deliver tangible benefits to industrial facilities, the communities that host them, and the larger society. State officials and industry leaders will play key roles in promoting and implementing electrification. We hope that this guide will contribute to your success.