UC SANTA BARBARA
The 2035 Initiative

Advancing Industrial Electrification in Pennsylvania

Olivia Quinn, Nathan Mariano, Eleanor Thomas, Antoine Merlo, Leah Stokes, and Eric Masanet

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EXECUTIVE SUMMARY

Pennsylvania has one of the largest and most energy-intensive manufacturing sectors in the country, making it a major source of greenhouse gas emissions and local air pollution. This also makes it one of the best near-term opportunities to deploy cleaner, more efficient manufacturing technologies.[1] The Reducing Industrial Sector Emissions in Pennsylvania (RISE PA) program has allocated $396 million to industrial decarbonization, making the Commonwealth an early leader in this area. Here, we explore one way the state can effectively deploy its resources: low- and medium-temperature (LMT) process heat electrification.

Building on our national-scale engineering models, this report identifies how electrification of Pennsylvania's industrial sector can deliver cost-effective emissions reductions, long-term health benefits for Pennsylvanians, and economic growth in the manufacturing sector.[2] We also recommend near-term actions that policymakers can take to accelerate deployment of clean heat technologies.

Pennsylvania's Clean Heat Opportunity

- **Industrial electrification is a major opportunity for Pennsylvania:** The industrial sector as a whole is responsible for 30% of statewide greenhouse gas (GHG) emissions.[3] Within the sector, over 28% of the emissions from large industrial manufacturing facilities comes 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 Pennsylvania's manufacturing sector:** Strategic electrification of LMT heat with technologies available today can reduce process heat emissions at 17 major manufacturing facilities by up to 26% (~13.5 MMT CO_2e) between now and 2050.[5]
- **Pennsylvania's favorable industrial electricity prices make the state uniquely well-positioned for electrification:** Air-source high-temperature heat pumps plus energy efficiency measures present the best project economics on average, especially in the pulp & paper sector and key chemicals subsectors. We find that these technologies approach lifetime cost parity with natural gas equipment, meaning that electrification in Pennsylvania could start saving companies money today.
- **Industrial electrification load growth is manageable and can be planned alongside other large loads:** Electrification of LMT process heat across 17 of the state's largest manufacturing facilities adds ~2–5 TWh of additional annual load, requiring proactive grid planning, load shifting, and off-grid clean heat technologies. This added electricity demand represents a fraction of the ~60 TWh of data center interconnection requests to PPL Electric in the next decade.[6]

1 Strategen for the Ohio River Valley Institute. A Roadmap for Industrial Decarbonization in Pennsylvania. February 2024.

2 See our report, The Clean Heat Climate Opportunity (2025), for a full explanation of our engineering models and national-level results. Our webtool can be used to explore the findings, including for Pennsylvania.

3 Pennsylvania Department of Environmental Protection. GHG Inventory. Accessed March 2026.

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. At the state level, NLR Cambium 23 projects 68.5% clean electricity share in Pennsylvania by 2050.

6 "60 TWh" estimate derived from annualizing 9 GW of reported new load from data centers (Davis, 2026), with a capacity utilization factor of 75% (EPRI, 2026). Max Davis. New Pennsylvania Law Aims to Protect Ratepayers from Speculative Data Center Demand. January 2026.; EPRI. Powering Intelligence 2026. February 2026.

Policy Recommendations

- **RISE PA can form the basis of an ongoing industrial decarbonization strategy:** The RISE PA grant program is slated to invest nearly $400 million of federal climate funding in industrial decarbonization.[7] Our work identifies industrial electrification opportunities in high-value technologies (such as air-source HTHPs) and sectors (such as pulp & paper) as priority areas for support in current and future funding rounds. As projects from previous funding rounds come to fruition, policymakers should convene manufacturers, utilities, clean tech providers, and researchers to evaluate outcomes. Moving forward, the governor and commonwealth officials should work with the legislature to establish a durable financing mechanism that extends support.

- **Rate design can improve the economics of electrification:** In Pennsylvania, the gap between natural gas and electricity prices is lower than most states. However, industrial electricity rates are still roughly two times more expensive than natural gas rates on a per-MMBtu basis.[8] Commonwealth officials should work with the PUC to establish preferential industrial electricity rates for beneficial electrification to mitigate this cost penalty. Setting strict qualification criteria and encouraging off-peak consumption through time-of-use and wholesale market pricing can help ensure that this does not strain the grid or raise rates for other rate classes.

- **Smart policy can modernize the industrial sector, encourage innovation, and cut greenhouse gases and air pollution:** A cap-and-invest program covering industrial emissions can generate revenue to reinvest in electrification and drive down emissions across the sector. Requiring new and existing industrial facilities to use clean heat technologies can address hazardous air quality in communities overburdened by industrial pollution.

7 As of May 2026, RISE PA was accepting applications for Medium-to-Large Awards in its Round 2 applications (through July 15, 2026) and for Small Awards in its Round 4 application (through August 17, 2026). Projects are set to be funded through April 2029.

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



1. WHY ELECTRIFY PENNSYLVANIA MANUFACTURING?

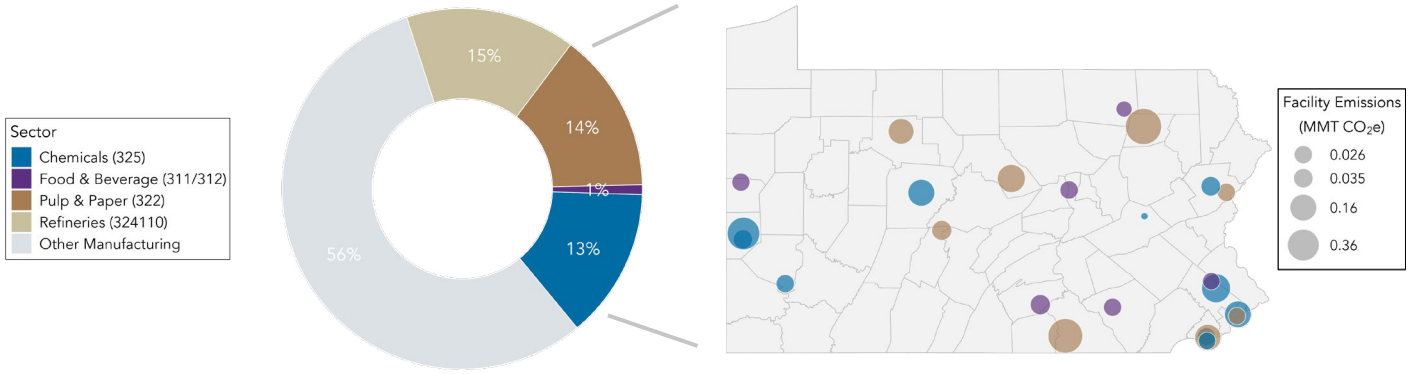


Figure 1: Large Facility Manufacturing Emissions in the Commonwealth of Pennsylvania.

Source: GHGRP (2023). Donut shows the full GHGRP emissions profile of Pennsylvania manufacturing facilities, including process emissions. The map shows emissions from stationary combustion across all of chemicals, pulp & paper, and food & beverage (N=24). 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 pollution in Pennsylvania, accounting for just over 30% of statewide greenhouse gas emissions.[9] The Commonwealth's Climate Action Plan and executive policy framework set greenhouse gas reduction targets of 50% below 2005 levels by 2030, reaching net zero by 2050.[10] 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.[11]

Looking at emissions from Pennsylvania's most polluting manufacturing facilities, about 13% come from the chemicals sector, 14% from the pulp & paper sector, and 1% from the food & beverage sectors (Figure 1).[12] This amounts to 5.7 MMT of GHG emissions in Pennsylvania annually, equivalent to 1.3 million gas-powered vehicles driven for one year.[13]

9 Pennsylvania Department of Environmental Protection. GHG Inventory. Accessed March 2026.

10 Pennsylvania Department of Environmental Protection. Pennsylvania Climate Action Plan. 2024.

11 Strategen for the Ohio River Valley Institute. A Roadmap for Industrial Decarbonization in Pennsylvania. February 2024.

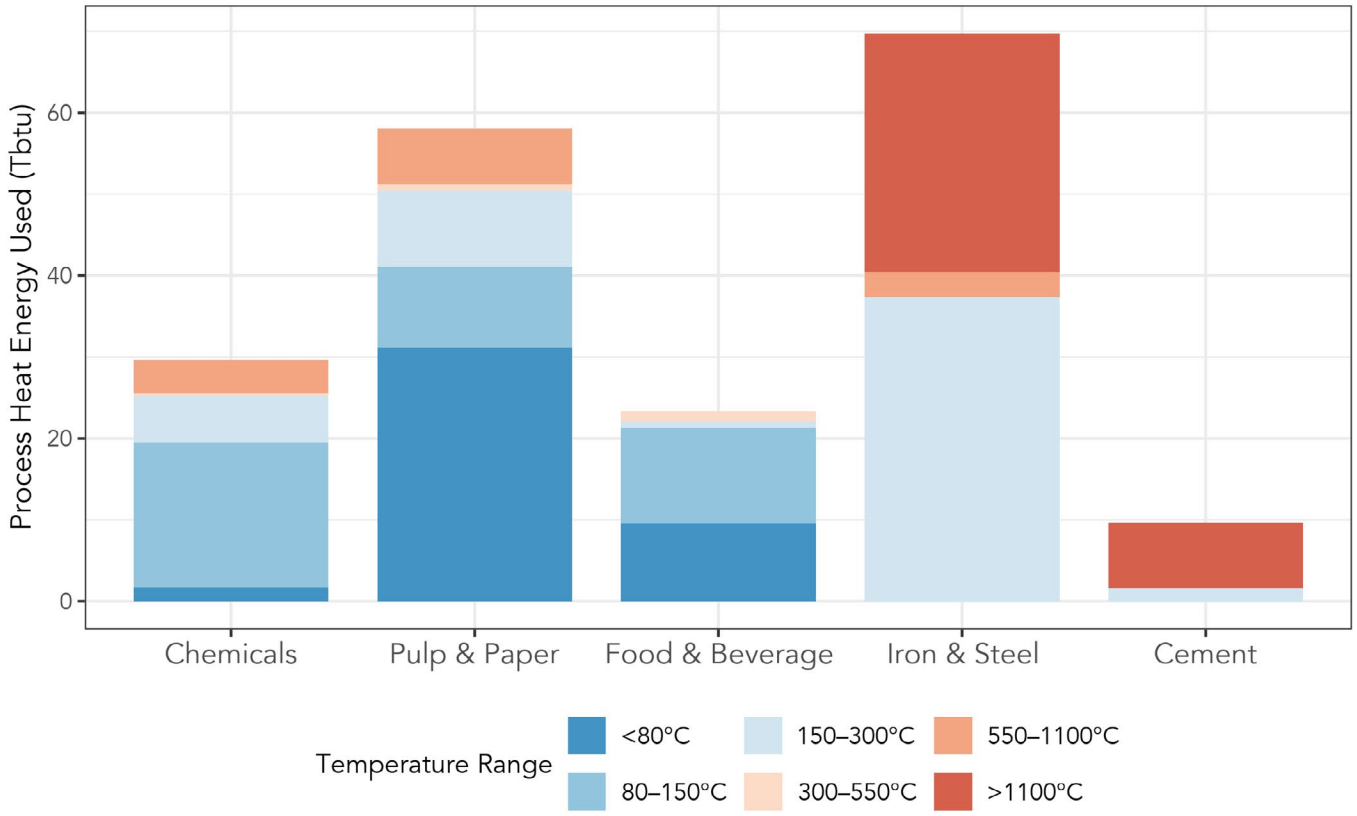
12 The petroleum refining sector (NAICS 324) also contributes about 15% of large facility emissions and a significant amount of medium temperature heat demand, but we exclude it from our analysis because energy efficiency, carbon capture, and transportation sector decarbonization are generally considered more viable paths to net-zero for this sector. See U.S. DOE. Industrial Decarbonization Roadmap. September 2022.

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

Much of the emissions in these sectors comes 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 Pennsylvania's manufacturing sector, LMT process heat delivers thermal energy for activities like paper drying, grain mashing for ethanol, and petrochemical distillation.

The economy as a whole is being transformed by the "electrotech revolution"[14], with rapid advancements in technologies like electric vehicles, solar, and batteries. The industrial sector is not far behind, with the emergence of commercially available clean heat technologies such as air-source high-temperature heat pumps (HTHPs) and thermal energy storage. These systems are cleaner, more efficient, and provide companies with more useful data than fossil-fuel fired equipment.

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



Source: McMillan (2019)[15]

Beyond emissions reductions, modernizing Pennsylvania's manufacturing sector can generate long-term economic benefits and help ensure that goods made in Pennsylvania remain competitive in global markets. In 2025, Pennsylvania reported $12.6 billion in exports to European Union (EU) member states.[16] This included $3.6 billion in pharmaceuticals, $655 million in basic chemicals, and $20.8 million in soybeans. All of these sectors use large amounts of LMT process heat. These exports are now subject to the EU's emis-

14 Ember Futures. The Electrotech Revolution. September 2025.

15 Colin McMillan. Manufacturing Thermal Energy Use in 2014. NREL Data Catalog. 2019. Note: The source data includes estimates of thermal energy use from fuels combusted for process heating, boilers, and combined heat and power/cogeneration. It also estimates energy use for all U.S. manufacturing facilities, including small plants not reporting to GHGRP.

16 European Commission. The European Union's Trade and Investment Footprint in the United States: Pennsylvania. 2025.

sions trading laws, with the EU carbon border adjustment mechanism fully implemented in January 2026.[17] Lowering the carbon intensity of Pennsylvania's manufacturing will make these exports more competitive.

As a historical manufacturing hub, Pennsylvania is a strong candidate to manufacture clean heat technologies themselves. Growing domestic clean technology supply chains would provide high-quality jobs for Pennsylvania workers. The supply chain for electric heat technologies is relatively nascent, but it is likely to develop quickly as costs come down and the regulatory environment in more places shifts to prioritize cleaner production. Pennsylvania has a chance to be ahead of the curve.

In our national-level report, The Clean Heat Climate Opportunity, we simulate the direct electrification of LMT heat across 798 large manufacturing facilities across the country, spanning 32 manufacturing subsectors. **Here, we downscale this analysis to Pennsylvania, covering 13 manufacturing subsectors and 17 large manufacturing facilities.**

Table 1. In-Scope Subsectors Represented in Pennsylvania[18]

Chemicals (325)	Pulp & Paper (322)	Food & Beverage (311-312)
• Petrochemicals (325110) • Other Basic Inorganic Chemicals (325180) • Ethanol (325193) • Wood Chemicals (325194) • Plastics & Resins (325211)	• Paper Mills (322120) • Paperboard Mills (322130)	• Breakfast Cereal (311230) • Specialty Canning (311422) • Cheese (311513) • Other Dairy (311514) • Meat (non-poultry) (311611) • Rendering (311613)

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

18 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. MODELING INDUSTRIAL ELECTRIFICATION IN PENNSYLVANIA

Industrial emissions are often labeled "hard-to-abate,"[19] but for LMT process heat, many clean technologies are already commercialized and ready to deploy.

2.1 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[20] can meet the primary steam demands of large-scale industrial facilities and have already been deployed in U.S. manufacturing[21]:

- **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. Across 17 Pennsylvania industrial plants, we estimate that an air-source HTHP can achieve a "coefficient of performance" (COP) of around 1.3 to 2.8.[22] This means they would produce 1.3 to 2.8 times as much heat as electricity they use.

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

20 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.

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

22 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 (ground-source or geothermal 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, explores how geothermal can be harnessed for industrial process heat in-depth.[23]

There are numerous examples of geothermal direct use for industry in places such as Nevada,[24] Arizona,[25] and New Zealand.[26] Pennsylvania has plenty of geothermal resources at temperatures that are suitable for supplying LMT process heat, as well as space heating. The Future of Geothermal Energy in Pennsylvania: Leveraging the Commonwealth's Legacy of Energy Leadership report by Penn State University and Project Innerspace noted that "if Pennsylvania's energy industry employed its resources and workforce to drill for geothermal [...] within a year, geothermal could produce enough energy for all of the Commonwealth's commercial heating and low-temperature (<120°C) industrial processes."[27]

There are geothermal options for higher-temperature industrial processes, too. At one of its manufacturing sites in Budapest, Hungary, Procter & Gamble combined a lower-temperature hydrothermal resource with an HTHP to replace its steam-generating boiler.[28] Companies like Eavor and Fervo Energy are drilling deep wells using techniques from the oil and gas industry (such as directional drilling and hydraulic fracturing) to produce heat at steam temperatures in places that don't traditionally harvest geothermal energy. Last, geothermal also offers a promising way to repurpose abandoned oil & gas wells[29] and provide employment for Pennsylvania oil & gas workers.[30]

23 Nathan Mariano et al. Unlocking Next-Generation Geothermal Heat for Industry. The 2035 Initiative. July 2025.

24 Alexander Richter. Utilising geothermal energy for dehydrating onions – a unique plant in Fernley, Nevada. ThinkGeoEnergy. September 2019.

25 Carlos Cariaga. Copper extraction project in Arizona aims to harness geothermal heating. ThinkGeoEnergy. May 2024.

26 Carlos Cariaga. New Zealand tissue and toilet paper company shifts to 100% geothermal. ThinkGeoEnergy. March 2025.

27 Penn State Center for Energy Law and Policy. The Future of Geothermal Energy in Pennsylvania. 2024.

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

29 U.S. Department of Energy Geothermal Technologies Office. Wells of Opportunity.

30 International Energy Agency. Overview of synergies between the oil and gas and geothermal industries.

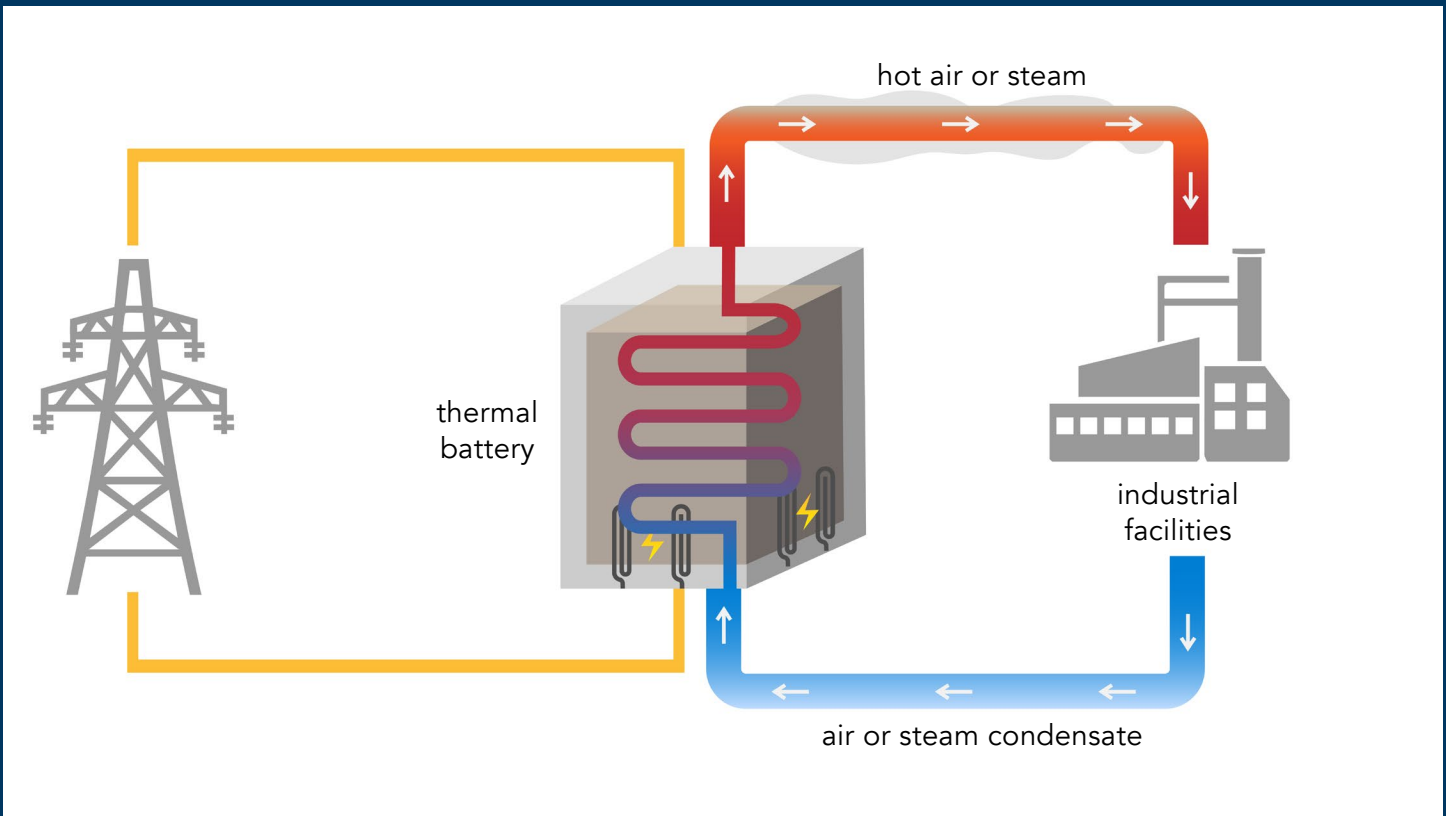
Thermal Energy Storage

Thermal energy storage systems (also known as thermal batteries) offer flexibility in decarbonizing industrial heat in Pennsylvania 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",[31] while others store energy in chemical bonds.[32] 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.

However, deployment challenges remain for each of these technologies. 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



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

32 As in products by Cache Energy.

2.2 Modeling Clean Heat Technologies with Process Archetypes

To capture the complexity of manufacturing processes, we develop process system archetypes for 13 manufacturing subsectors in Pennsylvania (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.[33]

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.[34] This affects six Pennsylvania facilities that have CHP units.[35] We also model energy efficiency improvements. 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.[36] Across Pennsylvania facilities with opportunities for WHRHPs, we estimate COPs between 2.5 and 5.3 – meaning up to 530% as much heat output as electricity consumed.

We simulate five technology scenarios, summarized in Table 2.

33 For more information, see The Clean Heat Climate Opportunity which contains a full review of our methodology. All results in this report display "average" outcomes, which is an average of the optimistic and conservative scenario assumptions discussed in *The Clean Heat Climate Opportunity*.

34 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 pollution reductions from CHP, byproduct fuels, and higher temperature processes can be achieved in the medium- to long term.

35 The six facilities include facilities in the chemicals (325), and pulp & paper (322) sectors.

36 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.



Table 2. Technology Scenario Definitions

Scenario Name	Process Heat Steam Source	Direct Process Heat Source	Energy Efficiency Measures	Notes
"Baseline"	Natural gas boiler[37]	Direct Combustion Units	×	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	×	Business as usual facility, steam is generated via electrode boilers, direct-fired units electrified
"Drop-In Electrification (Max Efficiency)" (EE+)			✓	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		×	Business as usual facility, steam is generated via air-source HTHPs, direct-fired units electrified
"Advanced Electrification (Max Efficiency)" (EE+)			✓	Steam and direct process heat systems optimized for efficiency, steam is generated via air-source HTHPs, direct-fired units electrified

37 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.

3. EMISSIONS AND ECONOMIC IMPACTS OF INDUSTRIAL ELECTRIFICATION

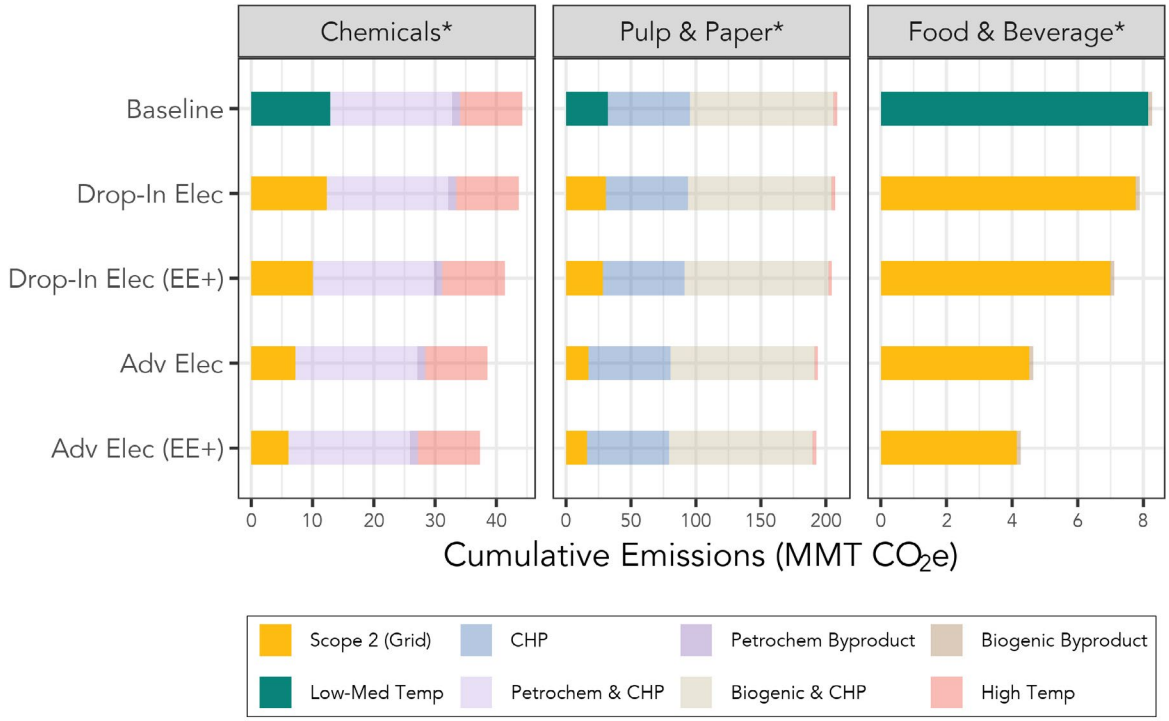
3.1 Industrial Electrification Cuts GHG Emissions and Air Pollution in Pennsylvania

We identify over 1 MMT of annually reported GHG emissions in Pennsylvania stemming from readily-electrifiable LMT heat, representing 52% of total emissions from process heat at large facilities in the chemicals, pulp & paper, and food & beverage sectors. Figure 3 shows the cumulative emissions impact through 2050 of electrifying these processes, assuming no changes in production outputs within this group of facilities. 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 the technologies in the Advanced Electrification (Max Efficiency) scenario, we estimate that electrifying all of Pennsylvania's LMT heat would eliminate ~340,000 MT of CO_2e emissions, given the current grid mix. This amounts to a 17% reduction in CO_2e emissions from process heat in our target subsectors.



Figure 3: Cumulative CO_2e Emissions (2025-2050) by Pennsylvania 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). Note that axes ranges vary. Emissions from "out-of-scope" processes are partially translucent & assumed to remain constant year-on-year. N=21, 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). *Sector groups only reflect 13 PA subsectors included in study (Table 1). This excludes 3 PA GHGRP chemicals facilities in Biological Product (325414) and Industrial Gas (325120) Manufacturing.*

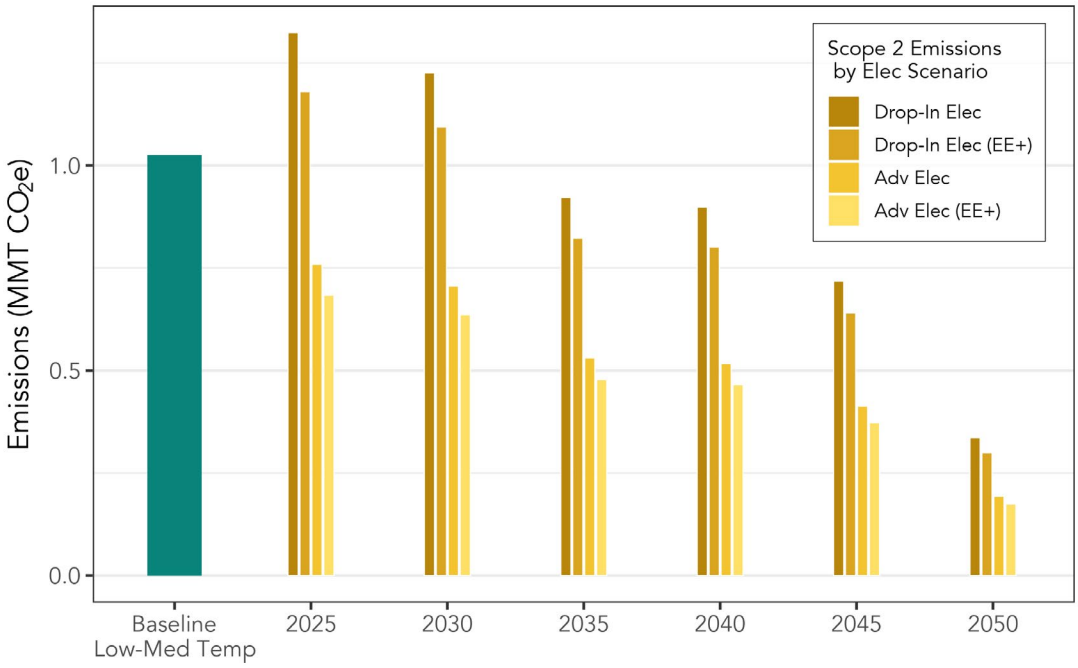
Emissions reductions increase over time as the grid gets cleaner. By 2050, we estimate that electrifying LMT process heat today leads to 13.5 MMT CO_2e emissions avoided by 2050 in the Advanced Electrification (Max Efficiency) scenario – a 26% decrease compared to the Baseline scenario. These estimates utilize a grid scenario from NLR's Cambium that projects a 68.5% clean electricity share for Pennsylvania in 2050.[38] This is roughly consistent with Pennsylvania's target of reducing economy-wide emissions by 80% from 2005 levels by 2050.

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. Pennsylvania's electricity grid remains moderately carbon-intensive, ranked 20th cleanest in carbon dioxide emissions per gigawatt hour of electricity.[39] **To maximize pollution reductions – and meet Pennsylvania's target of reducing economy-wide greenhouse gas emissions by 80% from 2005 levels by 2050 – the state's electricity sector must be decarbonized in parallel.**

38 See Footnote 5 for grid modeling assumptions.

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

Figure 4: Pennsylvania 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.[40] 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 $PM_{2.5}$.

These pollutants place the greatest burden on communities located near industrial facilities. Across the U.S., industrial sites are more likely to be located near Black, Hispanic, and other communities of color, reflecting decades of racial segregation and inequitable siting practices.[41] As a result, people of color and low-income households are consistently exposed to higher levels of $PM_{2.5}$, NO_x, and ozone, even after decades of air-quality improvements.[42] Layered on top of existing socioeconomic challenges, these unequal pollution burdens leave marginalized communities facing more illness and greater health risks.

These concerns are especially salient in Pennsylvania, which has several counties that do not meet Clean Air Act (CAA) standards for air quality. Bucks, Chester, Delaware, Montgomery, Allegheny, and Philadelphia Counties are in CAA nonattainment with high levels of ozone and/or $PM_{2.5}$.[43] Regions in nonattainment under the CAA have legal authority to set stricter emissions controls to improve local air quality. Missing attainment deadlines can lead to stricter emissions controls and/or federal funding penalties.

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

41 Mohai and Saha. Which came first, people or pollution? Assessing the disparate siting and post-siting demographic change hypotheses of environmental injustice. November 2015.

42 Liu et al. Disparities in Air Pollution Exposure in the United States by Race/Ethnicity and Income, 1990–2010. December 2021.

43 U.S. Environmental Protection Agency. Pennsylvania Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants. February 2026.; American Lung Association. Clean Heat, Clean Air: Health Benefits of Modern Industrial Technologies. August 2025.

We find that full electrification of LMT process heat in 17 of Pennsylvania's high-emitting manufacturing facilities would remove ~2,350 metric tons of NO_x pollution and ~2,400 metric tons of $PM_{2.5}$ pollution through 2030. As the grid gets cleaner, these air quality benefits compound, with ~13,400 fewer tons of NO_x and ~12,500 fewer tons of $PM_{2.5}$ pollution through 2050.

These air quality improvements translate into meaningful health benefits for Pennsylvanians, as well as communities in neighboring states (Table 3). 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 Pennsylvania 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.

Importantly, our models estimate that electrification will increase SO_2 emissions in the short term. This is due to the continued presence of coal on the grid. While our analysis shows that electrification still yields large public health improvements on the net, this highlights the importance of deploying clean energy to unlock the full benefits of electrification for Pennsylvanians.

Table 3. Industrial Electrification Health Benefits through 2050

Health benefits in the form of fewer…	In Pennsylvania	Across the U.S.
…Asthma Attacks	121,000	280,000
…Emergency Room Visits	230	560
…Premature Deaths	300–580	600–1,110
…Lost Workdays	25,000	52,000
…Lost School Days	17,000	56,000
Cumulative Health and Economic Benefits	$5.5B–$10.2B	$11.2B–$20.1B

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



3.2 The Economics of Industrial Electrification

Reductions in pollution and emissions mean better health and a safer environment for Pennsylvanians. But first, industrial facilities must be willing to invest in clean heat technologies. We analyze which technologies and sectors present the most cost-effective opportunities for electrification and assess how policy support can help.

3.2.1 Lifetime Economics Favor "Advanced" Electrification

Figure 5 shows lifetime project costs by technology scenario, measured in terms of Net Present Value (NPV). NPV 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.

The figure breaks down lifetime project costs by cost component. Electricity and fuel make up the bulk of lifetime project costs, meaning fuel prices are a primary driver of project economics. The "spark gap" between the price of electricity and the price of natural gas is thus a central challenge. Because electricity is more expensive than natural gas per unit of energy, electric technologies must be more efficient (use less energy) than combustion-fired equipment to be cost-competitive.

Fortunately, Pennsylvania already has one of the lowest spark gaps in the nation. We find that **Advanced Electrification with an air-source HTHP can approach lifetime cost parity with natural gas equipment in Pennsylvania today.** This is true despite the fact that this technology carries higher upfront costs: the higher efficiency of HTHPs allows them to use less electricity and operate more cheaply, saving money over time.

However, electricity is still around two times more expensive than natural gas in Pennsylvania.[44] As a result, Drop-In Electrification has weaker project economics over equipment lifetimes. Even though electrode boilers are more efficient than a natural gas boiler and cost about the same upfront, the efficiency advantage is not enough to cover the fuel cost increase. In Section 3.2.2, we show how policy support can change this.

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

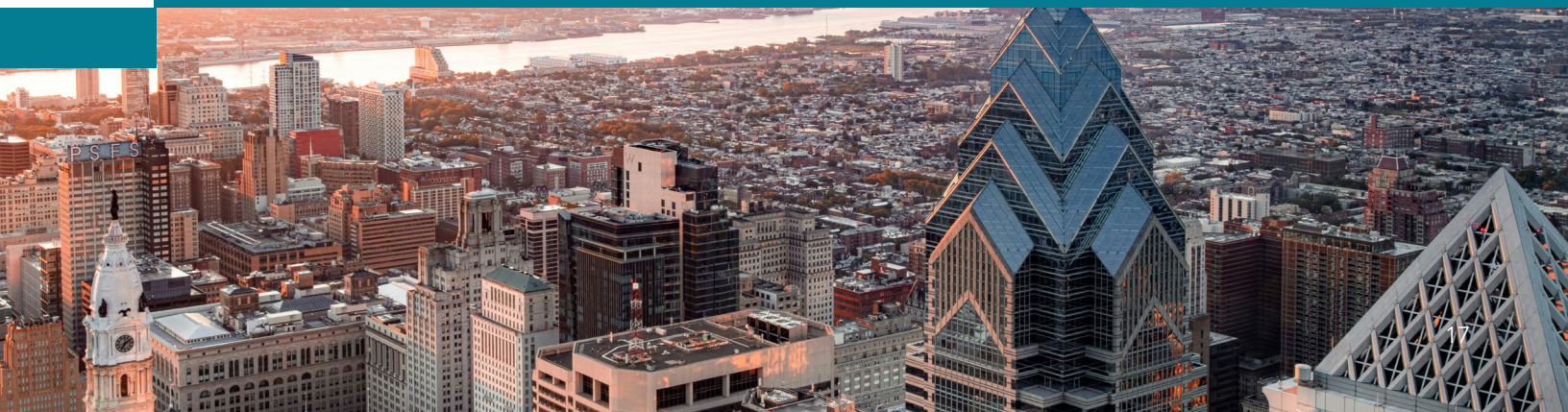
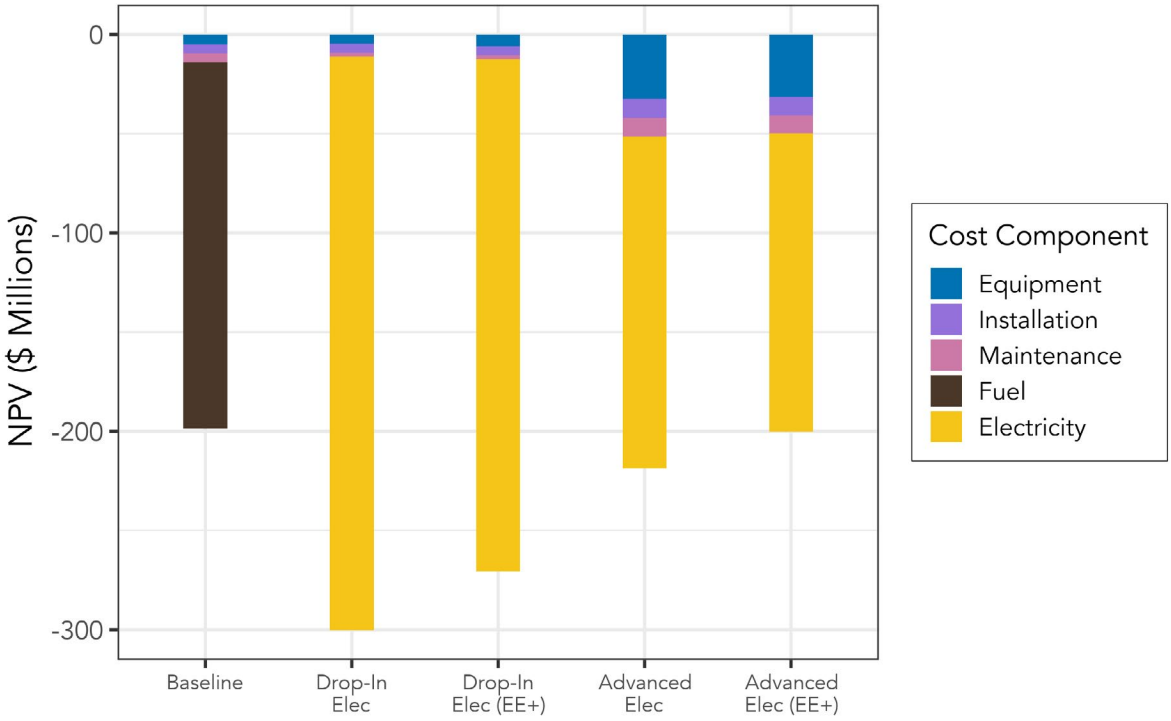


Figure 5: Project Cost Breakdown by Electrification Technology Scenario



Caption: Plot shows NPV cost component breakdowns across Pennsylvania facilities (n=17) 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.

3.2.2 Local Electrification "Hot Spots"

Next, we identify "hot spots" by evaluating which sectors present the most cost-effective opportunities for electrification in Pennsylvania. We also assess what level of policy support can help bring projects "in the money."

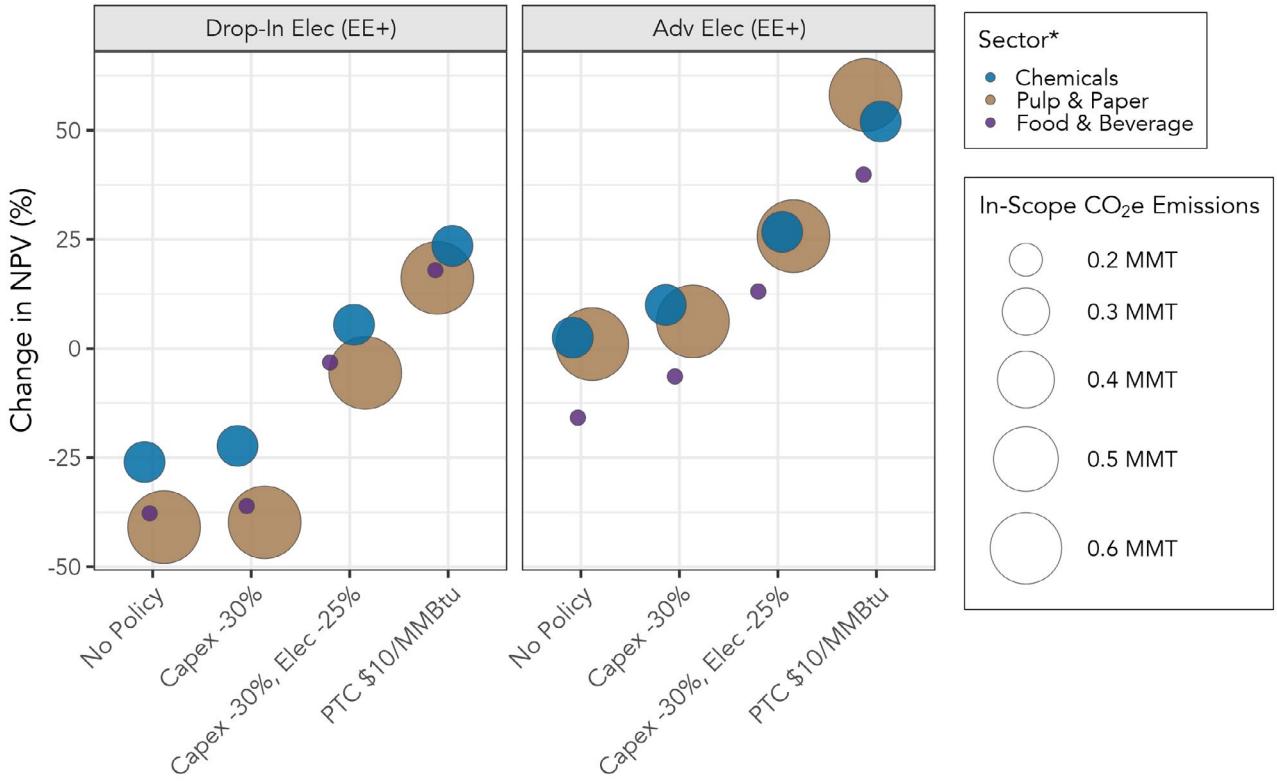
In Figure 6, we see that Advanced Electrification (EE+) can already be cost competitive with natural gas technology in the pulp & paper and chemicals sectors. With highly efficient steam generation from an air-source HTHP and efficiency measures lowering overall energy demand, efficiency gains with clean heat technologies are enough to overcome the "spark gap." While it is important to note that barriers such as technology risk and design complexity still matter,[45] this means that in pure cost terms, electrification in these Pennsylvania sectors could start saving companies money today.

Policy support that brings down upfront costs ("Capex") or industrial electricity rates ("Elec") by some percentage makes electrification even more attractive. Figure 6 also shows the effect of programs such as grant funding or an investment tax credit, or of a beneficial electrification tariff (policies that we discuss in-depth in Section 5).

While Drop-In Electrification (EE+) is more expensive without policy support, a moderate combination of capex and opex support can make these projects into a positive value proposition for the chemicals sector. Overall, a $10/MMBtu production tax credit (PTC), which offers a tax rebate per unit of clean heat produced, is the most effective policy at improving project economics.

45 In The Clean Heat Climate Opportunity, we discuss non-cost barriers to electrification extensively (Section 5.4). See also McMillan and Wachs (2024).

Figure 6: Pennsylvania "Hot Spots": Effect of Policy Support on Electrification Economics

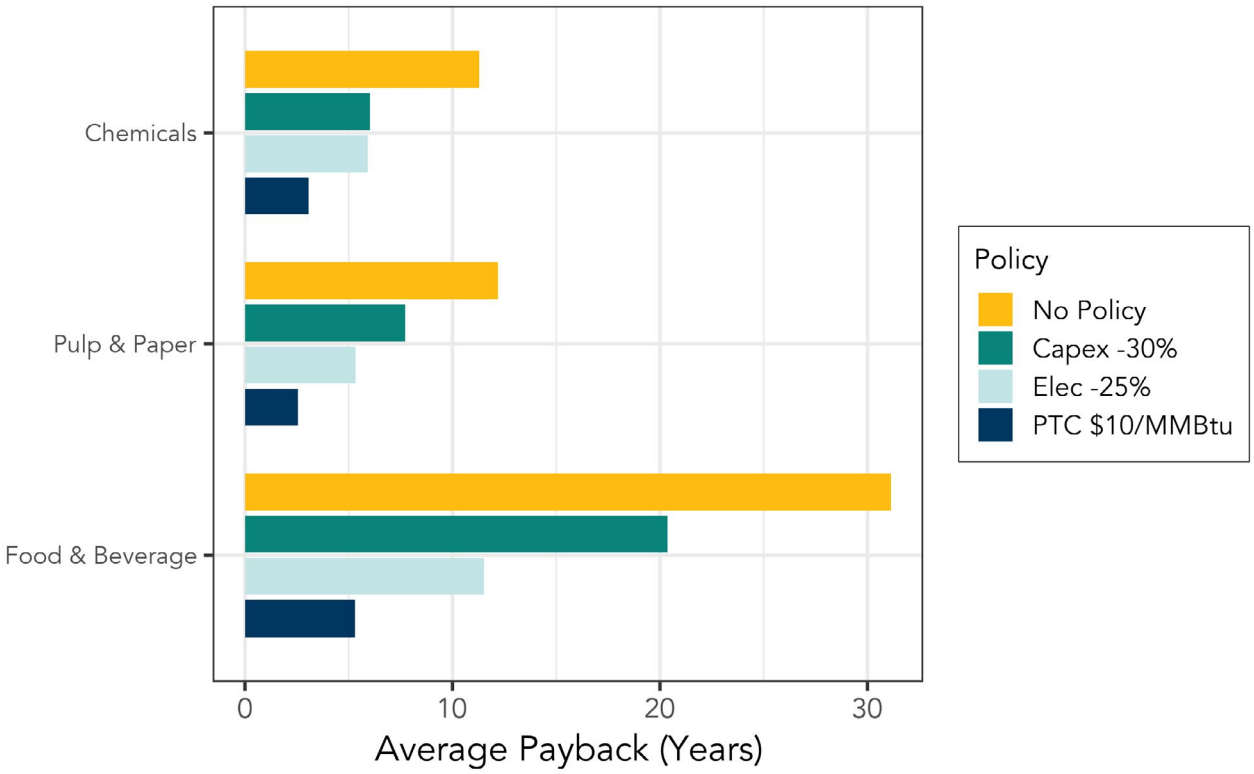


*Caption: Bubble plots show change in NPV from Baseline scenario by sector and following policy intervention. A positive change in NPV represents a decrease in costs. Bubble size corresponds to annual in-scope CO_2e emissions. Results reflect the average of optimistic and conservative cases. *Sector groups only reflect subsectors with a GHGRP facility in Pennsylvania.*

In Figure 7, we look at the sectors where investments pay back the fastest. "Payback" is the time it takes for the operating cost savings of electrification to cover the additional upfront costs of the equipment. Most companies require investments to pay back within ~5 years, while companies committed to sustainability goals may be willing to have investments take ~10–15 years to pay back.

For chemicals and pulp & paper plants in Pennsylvania, investments in electrification can approach 10 year project paybacks with no policy intervention. Policy support brings payback periods down into the 3–7 year range, where more companies will start to consider adoption. For food & beverage facilities, we find that it takes longer for investments in electrification to pay off, but policy support shortens payback periods into ranges that facilities may be willing to consider.

Figure 7: Average Industrial Electrification Project Payback in Pennsylvania

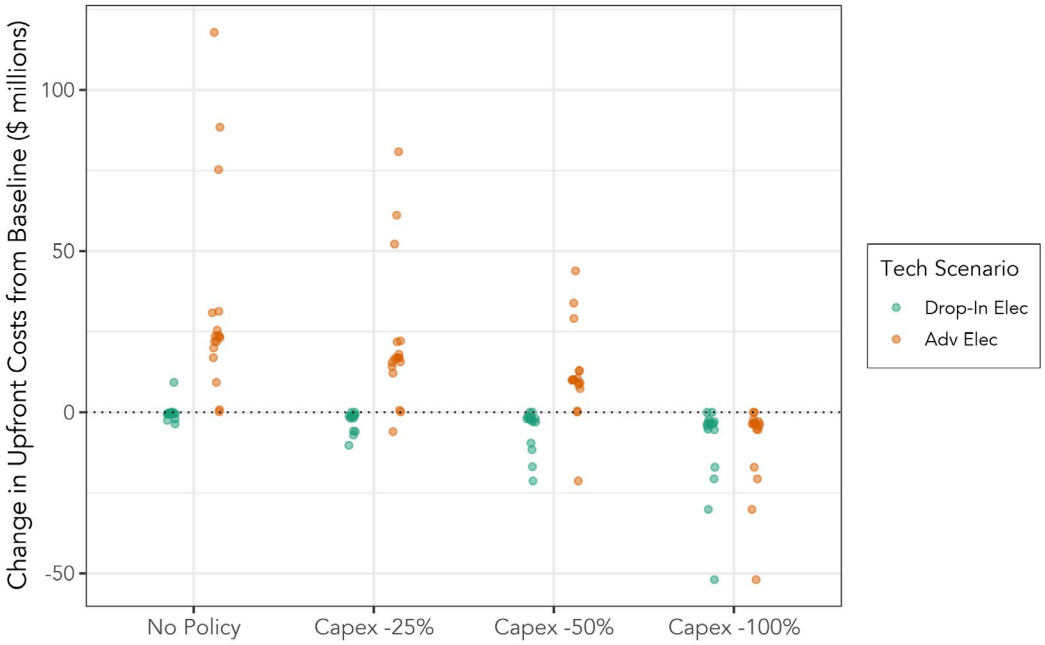


Caption: Bar plots show average electrification payback in years by state-sector pair and following policy intervention. Results show outcomes under the Advanced Electrification (Max Efficiency) scenario.

However, even when industrial electrification saves money in the long run or pays back quickly, clean heat technologies can cost more upfront than natural gas technologies, especially HTHPs. Raising capital for investment can be a barrier to adoption. Figure 8 shows estimated upfront costs for Pennsylvania electrification projects by facility, comparing them to natural gas equipment ("Baseline").

Advanced Electrification with an air-source HTHP is more expensive upfront, though this is offset by lower operating costs over time. The figure shows how capex policies such as grants or an investment tax credit could bring costs into a range that is more competitive with natural gas technology. Meanwhile, the upfront costs of Drop-In Electrification are in the range of those for natural gas equipment. For facilities with shorter time horizons, this lower upfront cost might make Drop-In Electrification more appealing, even if it carries a higher operating cost in the future.

Figure 8: Facility-Level Upfront Costs by Policy Support



Caption: Plot shows distributions of change in total upfront costs from Baseline technology scenario by facility (n=17). "Baseline" reflects costs associated with installing new combustion-fired equipment. Capex policies reflect a percent reduction in the upfront costs of electrification.

3.2.3 Electrification Delivers Cost-Effective Pollution Reductions

The relatively favorable economics of electrification in Pennsylvania means that electrification can deliver cost-effective pollution and emissions reductions. Figure 9 (a, b, c) show the marginal abatement cost – the cost per ton of avoided emissions over a project's lifetime – across sectors for CO_2e, NO_x, and $PM_{2.5}$, respectively. Wider bars correspond to greater emissions reductions; shorter or negative bars represent lower-cost emissions reductions.

Industrial electrification delivers high-value CO_2e reductions across the board in Pennsylvania. The cost of abatement comes in well below Biden Administration estimates of the social cost of carbon, which was initially set at $51/ton and then increased to $190/ton.[46] The chemicals and pulp & paper sectors deliver emissions reductions at the lowest cost, with chemicals sector electrification estimated to save money over the course of project lifetimes.

We also find that **industrial electrification can deliver cost-effective reductions in local criteria air pollutants.** We estimate marginal abatement costs for NO_x of around $200,000/ton.[47] While this is far more than the $7,500/ton threshold set by the state's air quality regulators for incremental NO_x pollution control retrofits,[48] it is far less than the more extreme measures that other regulators often consider when standards tighten. For example, California's South Coast Air Quality Monitoring District is considering a $400,000/ton threshold for cost-effective NO_x reductions.[49]

46 Kevin Rennert et al. Social Cost of Carbon 101. Resources for the Future. August 2019.

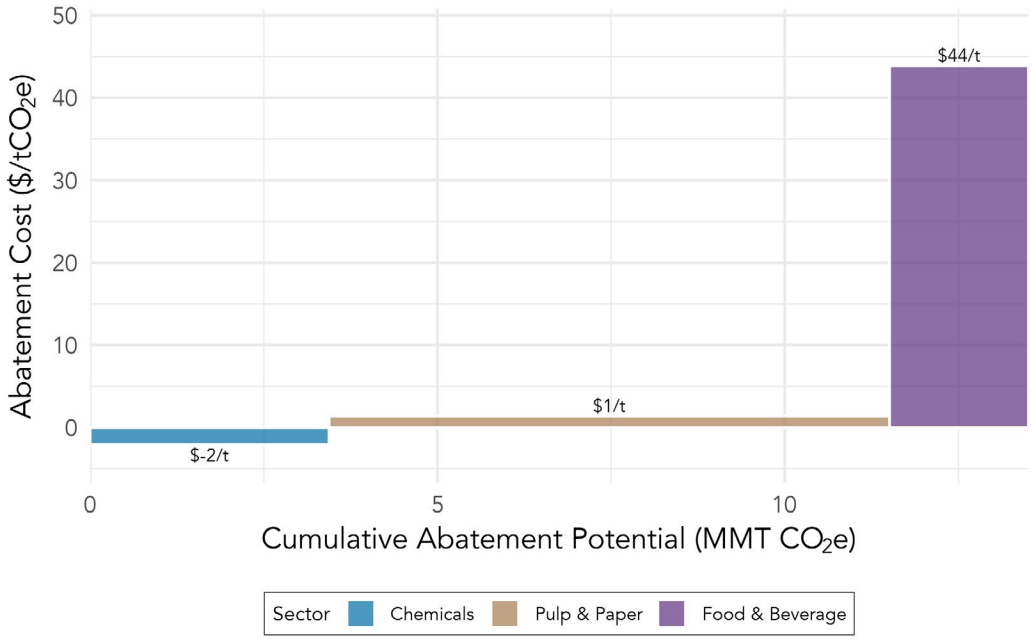
47 Marginal abatement cost is calculated as the additional lifetime cost of electrification under the Advanced Electrification (Max Efficiency) scenario, relative to the natural gas Baseline, divided by lifetime pollution reduction in tons.

48 Pennsylvania Environmental Quality Board. Additional RACT Requirements for Major Sources of NOx and VOCs for the 2015 Ozone NAAQS. November 2022.

49 South Coast Air Quality Monitoring District. Event Proposed Amended Rule 1146 /1146.1 - Working Group Meeting #3. February 2026.

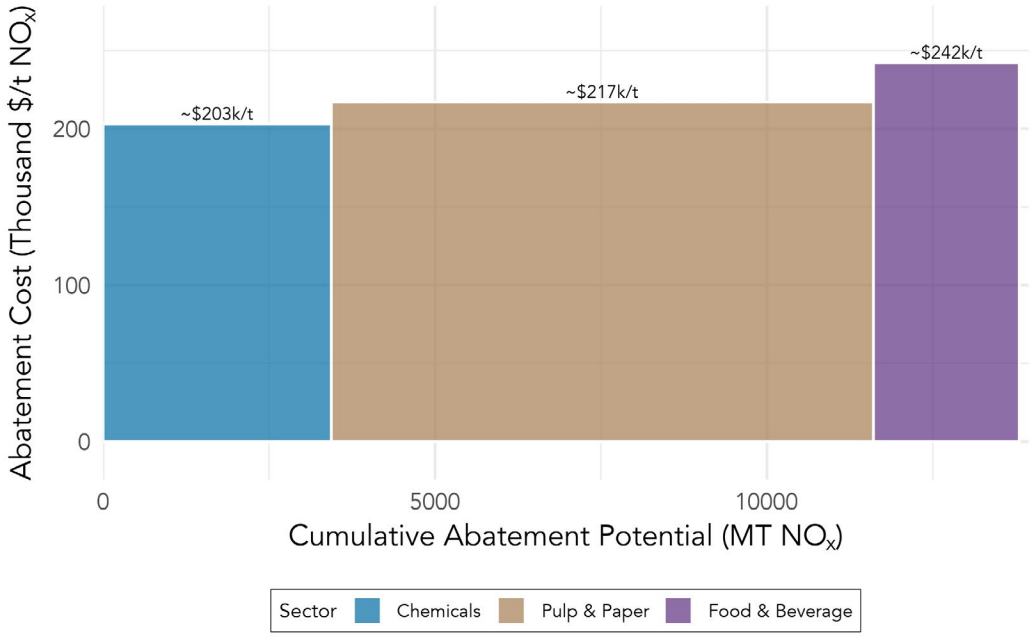
Figure 9 (a,b,c): Marginal Abatement Cost Curves for Advanced Electrification (EE+) by Pennsylvania Manufacturing Sector

(a) CO_2e Marginal Abatement Costs

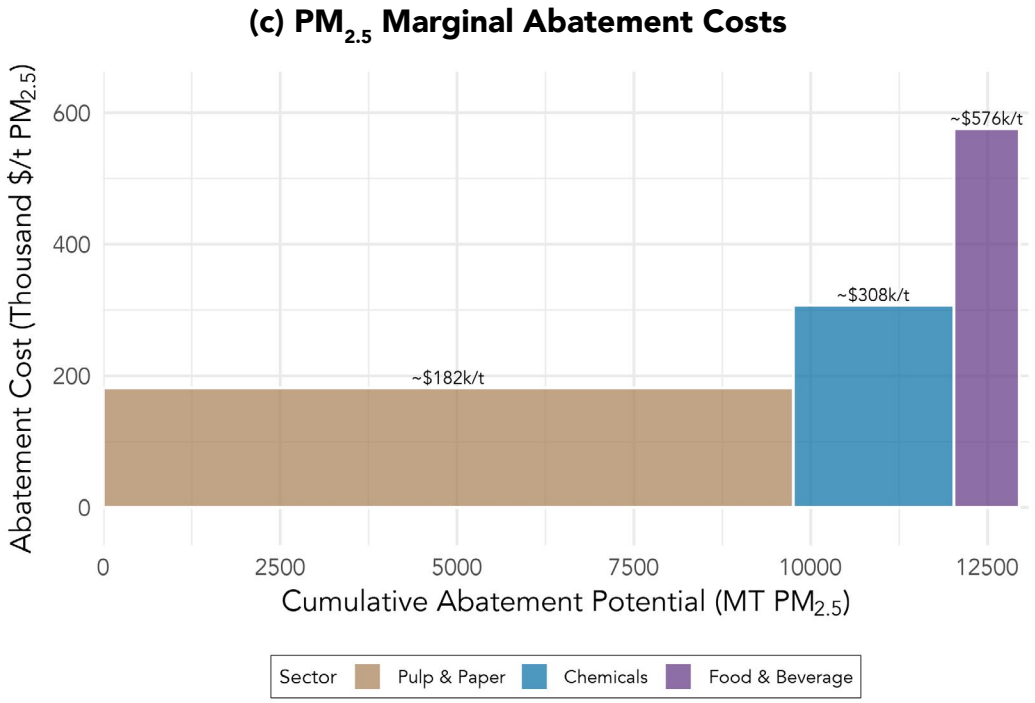


Caption: Area of each box represents the total cumulative abatement potential in dollars per ton of CO_2 equivalent, colored by manufacturing sector. Cumulative results assume constant production levels to 2050. Results reflect the average of optimistic and conservative cases.

(b) NO_x Marginal Abatement Costs



Caption: Area of each box represents the total cumulative abatement potential in dollars per ton of NO_x colored by manufacturing sector. Cumulative results assume constant production levels to 2050. Results reflect the average of optimistic and conservative cases.



Caption: Area of each box represents the total cumulative abatement potential in dollars per ton of $PM_{2.5}$ colored by manufacturing sector. Cumulative results assume constant production levels to 2050. Results reflect the average of optimistic and conservative cases.

The challenge of electrifying petrochemical manufacturing

While our analysis identifies the chemicals manufacturing sector as capable of delivering cost-effective CO_2e abatement opportunities in PA, policymakers should consider individual facilities in a broader context. Specifically, our findings only reflect the cost of replacing natural gas-fired equipment with electric technologies and do not account for the full emissions profile or long-term economic viability of specific plants or subsectors.

Some petrochemical facilities in Pennsylvania are among the Commonwealth's largest emitters of greenhouse gases and other pollutants. Recent research and reporting by the Ohio River Valley Institute finds that the Shell Petrochemicals facility in Beaver County accounts for approximately two-thirds of subsector emissions and a substantial pollution burden for nearby communities.[50]

However, much of this pollution stems from byproduct fuel combustion. Petrochemicals and plastics & resins manufacturing yield petrochemical byproducts as a result of processing hydrocarbon feedstocks into other chemical products. These byproduct fuels are frequently combusted onsite for steam and heat generation. Replacing natural gas-fired equipment at these facilities (i.e. electrification falling within our scope) would only address a portion of total emissions.

Policymakers should weigh whether electrifying a subset of manufacturing equipment at highly polluting facilities is the most effective use of public funds.

50 Julia Stone and Eric de Place. Beaver County Data Analysis: 2025 Update. Ohio River Valley Institute. 2025; Strategen for Ohio River Valley Institute. A Roadmap for Industrial Decarbonization in Pennsylvania. February 2024.

3.3 Industrial Load Growth Can Be Managed With Careful Planning

Pennsylvania has more favorable economics for LMT process heat electrification than most other states. But the rate of deployment may depend on the available clean capacity and resource adequacy of the electric grid. Accelerating load growth, particularly from large data centers, is straining the PJM Interconnection. After PJM reported a 6.5GW shortfall in its December 2025 capacity auction, state and federal leaders urged it to hold emergency capacity auctions to accommodate data center load growth.[51]

We estimate that electrifying all of Pennsylvania's LMT process heat in the scope of our analysis would increase industrial electricity consumption by ~2.4–4.7 TWh annually, depending on the technologies used (Table 4). To put this in context, PPL Electric alone has reported 9 GW of data center requests in advanced stages — equivalent to roughly 60 TWh per year if fully built out.[52] Industrial LMT electrification would therefore represent a relatively modest addition to grid load compared to the data center buildout already underway.

Our analysis may not capture all of the potential load growth from industrial electrification. We only consider facilities in the 13 subsectors we model for Pennsylvania (Table 1); we also exclude process heat at higher temperatures, from CHP units, and from byproduct fuel sources.[53] Nonetheless, our findings suggest that early-stage industrial electrification can be accommodated in Pennsylvania's resource planning.

Table 4: Estimated Industrial Electricity Demand Before and After Electrification by Scenario

Total Annual Pennsylvania Industrial Grid Demand (2023, Baseline) = ~50.1 TWh				
Scenario	**PA Chemicals***	**PA Pulp and Paper***	**PA Food and Beverage***	**Scenario Total**
Drop-In Electrification	+1.3 TWh ▲ 2 %	+2.8 TWh ▲ 6 %	+0.7 TWh ▲ 1 %	+4.7 TWh ▲ 9 %
Drop-In Electrification (Max Efficiency)	+ 0.9 TWh ▲ 2 %	+2.6 TWh ▲ 5 %	+0.6 TWh ▲ 1 %	+4.1 TWh ▲ 8 %
Advanced Electrification	+0.7 TWh ▲ 1 %	+1.6 TWh ▲ 3 %	+0.4 TWh ▲ 1 %	+2.6 TWh ▲ 5 %
Advanced Electrification (Max Efficiency)	+0.6 TWh ▲ 1 %	+1.5 TWh ▲ 3 %	+0.4 TWh ▲ 1 %	+2.4 TWh ▲ 5 %

51 Zachary Skidmore. PJM facing up to 60GW power shortfall over next decade - report. February 2026.

52 "60 TWh" estimate derived from annualizing 9 GW of reported new load from data centers (Davis, 2026), with a capacity utilization factor of 75% (EPRI, 2026). Max Davis. New Pennsylvania Law Aims to Protect Ratepayers from Speculative Data Center Demand. January 2026.; EPRI. Powering Intelligence 2026. February 2026.

53 This leads to 17 facilities from 13 subsectors included in the final analysis. There are 4 facilities in our subsectors that do not have any "in-scope" LMT process heat, and thus are not included in the 17. There are 3 additional PA facilities in the chemicals sector (325) that are not in the 13 subsectors we model.

3.4 Data Center Waste Heat as a Potential Resource for Industrial Electrification

The same data center buildout straining PJM's capacity also creates an opportunity. Data centers require extensive cooling to prevent servers from overheating. Rather than releasing the excess heat that servers generate into the atmosphere, this heat could be recovered for use in industrial processes (as well as for district heating, agriculture, and more).[54]

The temperature of waste heat from a data center depends on the cooling system. Air-cooled systems yield waste heat at 25–35°C and water-cooled systems at 50–60°C.[55] These temperatures are high enough to be used in some lower-temperature process heat applications, such as paper stock preparation.

For other manufacturing applications, the waste heat must still be upgraded with an HTHP. However, using waste heat could still lower costs and improve emissions savings from electrification. The key efficiency lever is the temperature lift between source and sink: the smaller the lift, the higher the COP of an HTHP. Because data center exhaust is substantially warmer than the ambient air that an air-source HTHP would otherwise draw from, using data center waste heat as the source can theoretically improve the unit's COP and reduce electricity use, resulting in lower costs.

Figure 10 illustrates this relationship for six representative Pennsylvania manufacturing process temperatures using our modeled COP values. At a 9.8°C source temperature (PA's annual-average air temperature),[56] the COP for a 75°C dairy pasteurization sink is around 2.4. With a 60°C source temperature representative of water-cooled data center exhaust, the same process reaches a COP near 7. This means that with data center waste heat, an air-source HTHP would use much less electricity than it would without that heat source.

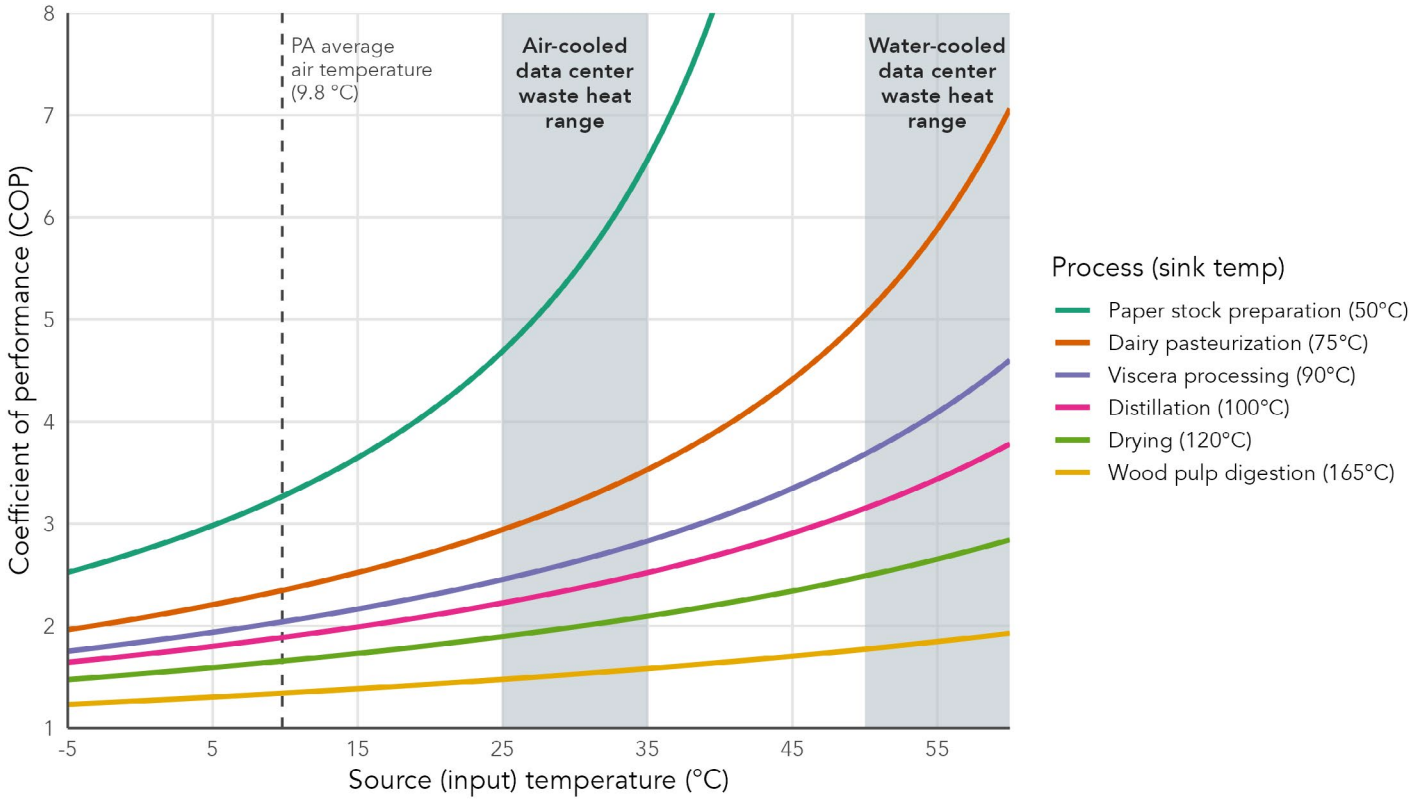
54 David Gardiner and Associates. Data Center Heat Reuse: The Opportunity for States. September 2025.; ReImagine Appalachia. Catching Heat: The Opportunities and Challenges of Using Waste Heat from Appalachian AI Data Centers. February 2026.

55 Pengtao Wang, et al. "District heating utilizing waste heat of a data center: High-temperature heat pumps." Energy and Buildings. July 2024.

56 NOAA National Centers for Environmental Information. Climate at a Glance: Statewide Time Series. May 2026.



Figure 10: Modeled Heat Pump Efficiencies by Source Temperature for Select Pennsylvania Manufacturing Processes



Caption: Lines show modeled coefficients of performance (COP) for industrial heat pumps serving six representative Pennsylvania manufacturing process sinks across a range of source (input) temperatures. Shaded bands indicate typical waste heat output temperatures of air-cooled and water-cooled data centers (Wang et al. 2024). COP values capped at 8 for legibility.

4. EXISTING PENNSYLVANIA POLICY LEADERSHIP

Pennsylvania is uniquely positioned to lead the nation in modernizing industrial facilities, reducing pollution, and strengthening economic competitiveness. The RISE PA program is already set to provide funding support to clean heat projects. Meanwhile, Governor Shapiro's Lightning Plan emphasizes affordable, reliable and clean electricity as foundational to good governance and economic growth, offering an opportunity to ensure that grid modernization and industrial modernization move in tandem. The Commonwealth's status as an early leader in this area can serve as a foundation for further industrial decarbonization policymaking.

4.1 Supporting Electrification via RISE PA

The "Reducing Industrial Sector Emissions in Pennsylvania" (RISE PA) program is leveraging $396 million in federal Climate Pollution Reduction Grant (CPRG) program funding, authorized by the Inflation Reduction Act in 2022. RISE PA, administered by the Pennsylvania Department of Environmental Protection (DEP), provides grants to small, medium, and large-scale industrial decarbonization projects. This is the largest single investment of federal CPRG funding into industrial decarbonization across the U.S.

Eligible facilities include any producer of industrial process emissions, encompassing manufacturers, energy producers, and mining facilities. Recipients can reduce sector emissions through a variety of decarbonizing technologies, including electrification, energy efficiency, waste reduction, fuel switching, and on-site renewable energy. Projects must reduce total Scope 1 and 2 emissions by 20% annually once operational, and satisfy apprentice-to-journeyworker ratio requirements.[57]

In April 2026, Governor Shapiro and DEP announced $267.8 million in awards to 31 projects under the Medium- and Large-scale Award Tracks, with $52 million remaining for a second application round opening in May 2026.[58] DEP projects these 31 awardees will collectively avoid more than 1.3 million metric tons of CO_2e and save Pennsylvania businesses over $3.1 million annually in energy costs within the first year of implementation.

All three of the large-scale awards fund electrification or electrification-adjacent projects, accounting for roughly half of the awarded funds. These include a geothermal heating and cooling system and electrified chiller at a pharmaceutical plant; energy efficiency, refrigeration electrification, and fuel switching at a cheese manufacturing facility; and replacement of a combustion turbine with an electrified compressor turbine at a natural gas transmission and distribution facility. Many smaller awards were announced to fund on-site solar (often paired with battery storage) and energy-efficiency retrofits, including waste heat recovery.

57 Pennsylvania Department of Environmental Protection. RISE PA Grant Program Guidance: Medium- and Large-Scale Award Track Applicants. January 2025.

58 Pennsylvania Department of Environmental Protection. Shapiro Administration Invests More Than $267 Million to Reduce Air Pollution, Cut Energy Costs, Create Jobs, and Combat Greenhouse Gas Emissions in Communities Across Pennsylvania. April 2026.

In its novelty and scope, RISE PA is a pioneering program that should inform future Pennsylvania disbursements and position the Commonwealth as a national model for decarbonization grantmaking.

With remaining funds, the DEP could continue to support electrification projects in the priority areas we identify. This includes efficient electrification technologies such as HTHPs, as well as sectors with more favorable economics such as pulp & paper.

As awards go out, the DEP should also partner with grantees and research institutions to conduct an implementation study. Such a study could assess:

- Which technologies achieved projected emissions reductions
- Real-world equipment and operating costs relative to projections, with particular attention to the three Large-scale Award electrification projects given their scale
- Grid interconnection timelines and challenges for the newly electrified loads
- Unforeseen barriers faced by manufacturers

4.2 Continuing Support for First-Movers

Technical assistance and facilitation programs help bridge gaps between manufacturers, clean tech companies, and research partners. For example, PennTAP (Pennsylvania Technical Assistance Program) is administered by PennState University, providing industrial facilities with no-cost Pollution Prevention & Energy Efficiency Assessments to identify where they can lower energy use, emissions, and operating costs.[59] Catalyst Connection, an economic development agency in southwestern Pennsylvania, serves as a strategic partner with RISE PA, providing technical assistance and zero-cost assessments to small and medium manufacturers to take advantage of funding opportunities.[60] Finally, the Pennsylvania Industrial Resource Center Network coordinates seven Industrial Resource Centers (IRCs) across the state to provide training and technical expertise to manufacturers adopting new technologies.[61]

These institutions can play a central role in supporting first-movers. However, as RISE PA and other projects move from the award stage to implementation, **the Commonwealth should develop a structured forum to synthesize and learn from existing decarbonization programming and plan the next phase of policy interventions.**

Following this first wave of RISE PA awards, the DEP should convene manufacturers, state policymakers, regulators, researchers, utilities, and clean heat technology providers (including companies that make HTHPs, electrode boilers, geothermal systems and thermal energy storage systems) for **a formal technical briefing and feedback session.** A key product could be a state-specific clean heat solution inventory that benchmarks technology performance and cost outcomes.

59 Penn State. The Pennsylvania Technical Assistance Program (PennTAP) at Penn State helps PA businesses thrive through expert support and innovation.

60 Catalyst Connection. Catalyst Connection Helps Manufacturers Access New RISE PA Grants to Cut Emissions, Improve Efficiency, and Drive Innovation. March 2025.

61 PA IRC Network. The Pennsylvania Industrial Resource Center Network.

5. WHAT CAN PENNSYLVANIA DO NEXT? NEAR-TERM POLICY RECOMMENDATIONS

RISE PA is a historic starting point. But more policy support is necessary to make industrial electrification both practical and economical. Policymakers should take a diversified approach to helping manufacturers overcome capital, operating cost, technical, and market barriers.

5.1 Finance and Facilitate Deployment to Reduce Risk

Following RISE PA, the Commonwealth could (1) provide additional financing opportunities for clean heat electrification upgrades and (2) build the technical support networks necessary to drive deployment.

5.1.1 Finance: Provide durable state investment

RISE PA represents a historic investment, but it is time-limited. To sustain momentum, Pennsylvania could develop a durable financing mechanism that fits the Commonwealth's industrial base and budget capacity. One pathway is for the state legislature to convert the RISE PA model into an ongoing program through a revolving loan fund capitalized by initial public funds and replenished through repayments; performance-based grants tied to verified emissions reductions; or, tradable clean heat or industrial decarbonization credits. Where possible, incentives should be structured so that funding can be used for a direct buy-down of capex, as this is more useful to businesses than a rebate.

Alternatively, the legislature could fund investments with an investment tax credit. Colorado offers a model: the state recently launched its semi-annual Industrial Tax Credit Offering (CITCO), providing $168 million in refundable tax credits for industrial emissions reductions projects.[62] 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.

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

5.1.2 Facilitate: Build technical and supply-chain capacity

Many industries do not pursue process heat electrification or energy efficiency improvements even if they are likely to save money in the long run, resulting in an "implementation gap."[63] This highlights how industrial electrification also requires technical assistance and adequate supply chain capacity.

Pennsylvania already has strong technical support infrastructure that can help manufacturers evaluate their electrification options and find funding opportunities, such as the PennTAP, Catalyst Connection, and the Industrial Resource Center Network. Expanding these programs to include specialized expertise in industrial HTHPs, electrode boilers, thermal energy storage, and geothermal systems could expose more manufacturers to these technologies and their benefits.

From the supply side, the state could become a manufacturing hub for the clean technologies that electrification requires. House Bill 1556, introduced by Representative Fielder and passed in the House this year, would expand Pennsylvania's Economic Development for a Growing Economy (PA EDGE) tax credits.[64] H.B. 1556 would offer a tax credit of 30% of qualified production (or operation) costs for advanced clean manufacturing projects, which includes clean steel, clean aluminum, clean cement, clean glass, electric grid modernization equipment, energy-efficient heat pumps and turbines, or hydrogen electrolyzers.

Importantly, qualified production costs eligible for the credit include capital investments and ongoing operating costs. A Pennsylvania manufacturer making industrial clean heat technologies, including industrial heat pumps and thermal batteries (or other energy storage technologies), could receive the 30% credit for qualified production costs.

While the bill faces political headwinds in the Pennsylvania Senate, it is aligned with both industrial economic development and electrification goals. Such incentives attract and grow the manufacturing of clean heat equipment locally. Building this supply chain would lower deployment costs, create high-quality jobs, and turn Pennsylvania into a hub for advanced technology manufacturing.

5.2 Reduce Operating Expenses

Because Pennsylvania's industrial customers pay more for electricity than they do for natural gas, electric technologies such as electrode boilers can cost more to operate. Policymakers can help make electrification more competitive by implementing policies that help lower this "spark gap."

5.2.1 Offer lower electricity rates for industrial electrification projects

The Pennsylvania PUC, utilities, and independent suppliers could coordinate in creating beneficial electricity rates for facilities that install electric heat technologies. This improves project economics for industrial customers while only benefiting facilities that electrify, as opposed to targeting industrial electricity prices generally. This helps to ensure that the beneficial rate does not raise prices for other customer classes.

63 Colin A. McMillan and Liz Wachs. Industrial process heat decarbonization: A user-centric perspective. NREL. June 2024.

64 Pennsylvania General Assembly. H.B. 1556. 2025.

A beneficial electricity rate for electrification projects could be implemented as part of the Pennsylvania PUC's proposed large-load model tariff, for example.[65] The policy could also consider spreading price increases across non-electrified facilities to ensure that any rate reductions are revenue neutral.

5.2.2 Provide access to real-time pricing

One way that industrial facilities can both bring down the cost of electricity and mitigate their impact on peak loads is by shifting demand to off-peak times. Electric heat technologies such as thermal energy storage (also known as thermal batteries) allow facilities to do this. Just like a chemical battery, a thermal energy storage system can charge during times of day when electricity is plentiful and then discharge that energy as heat later. Alternatively, industrial facilities could "load shift" operations so that electric equipment runs at times of day when prices are typically lower.

However, in order for these measures to bring down operating costs, facilities must have access to real-time pricing. Real-time pricing means that customers pay the hourly or every-15-minute wholesale price, allowing a thermal energy storage system to charge when electricity prices are low and save the customer money.

This pricing structure is not always available to industrial customers, who often pay a flat rate, a rate that varies by amount of energy consumed, or at best have a rate differentiated between "on-peak / off-peak" usage. **By offering real-time pricing to industrial customers, electricity generation suppliers can encourage industrial electrification without straining the grid or lowering revenues.**

5.2.3 Reform non-coincident demand charges

In addition to paying for total 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. 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 instead charged on the basis of how much power they draw during system peak periods.[66]

As with real-time pricing, the PA PUC should encourage utilities to offer coincident demand charges to help lower the cost of electrification for customers who shift load to off-peak times. This also helps encourage electrification without adding to peak loads.

5.2.4 Create a clean heat production tax credit

A clean heat production tax credit (PTC) offers manufacturers a fixed tax rebate per MMBtu of clean heat they produce from clean technologies, such as a high-temperature industrial heat pump or thermal battery. Because it is pegged to clean heat output, this policy offers operating cost support for facilities that invest in electrification or other clean heat technologies, such as geothermal.

At the federal level, Senator Martin Heinrich's Industrial HEAT Act offers a model for PTC policy design. Pennsylvania's state legislature could implement a similar policy so electricity suppliers and regulators are not entirely responsible for bringing down operating costs for facilities.

65 Pennsylvania Public Utilities Commission. PUC Announces Publication of Tentative Order on Model Tariff for Large Load Customers. November 2025.

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

5.3 Design Smart Pollution Regulations

As of last year's budget negotiations and amid political opposition, Pennsylvania will not join the Regional Greenhouse Gas Initiative (RGGI) following years of effort beginning in 2019. However, prior to this decision, Governor Shapiro introduced his Lightning Plan, which includes a proposal for a statewide cap-and-invest program for electric power generators (the Pennsylvania Climate Emissions Reduction Act (PACER) Program). While the immediate focus is on the power sector, these developments signal that the Commonwealth is actively exploring market-based mechanisms to cut emissions.

In parallel, a petition filed with the state's Environmental Quality Board proposes that Pennsylvania's DEP – acting on constitutional authority – adopt an economy-wide cap-and-trade program called the Stability and Affordability Via Emissions Reductions (or SAVER) regulation. The SAVER regulation aims to reduce Pennsylvania emissions 40 percent by 2030.[67] Similar to California's cap-and-trade system, the program could be designed to cover not only power plants, but also transportation, residential and commercial buildings, and industrial facilities. It could explicitly include industrial process emissions, with allowances allocated to protect energy-intensive or trade-exposed industries. Critically, proceeds from allowance sales could be reinvested in industrial electrification initiatives such as technical assistance programming or direct capital improvement grants following a cap-and-invest design, along the lines of California's INDIGO program.[68]

Pennsylvania's Air Quality Monitoring Division can also incentivize clean heat technology adoption via stricter pollution standards for nonattainment areas under the CAA. As noted above, there are several counties with NO_x, $PM_{2.5}$, and SO_2 levels that qualify for CAA nonattainment, many of which are in "Serious" nonattainment. Regulators can require that new and existing facilities use the "best available" zero-emissions technologies, or signal that a requirement will be phased-in over time.

For example, the South Coast Air Quality Monitoring District (which covers the nonattainment areas in the majority of Los Angeles, Orange, Riverside, and San Bernardino counties) implemented a zero-NO_x standard for smaller boilers, with plans to phase in stricter requirements for larger boilers, including those used in industrial facilities. This phase-in schedule allows time for companies to plan and test zero-NO_x-emissions technologies, like electrode boilers and industrial HTHPs.

67 Kiley Bense. Pennsylvania Must Act to Limit Greenhouse Gases, Lawyers Argue. February 2026.

68 California Energy Commission. Assembly Bill 209 Clean Energy Programs - 2024 Annual Report. August 2025.

