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Accelerating Industrial Heat Electrification in Europe: Barriers and Policy Recommendations to Heat Pump Adoption

Cordin Arpagaus[a*], Jan Rosenow[b], Sem Oxenaar[b], Elian Pusceddu[c]

[a] OST – Eastern Switzerland University of Applied Sciences, Institute for Energy Systems (IES), Buchs, Switzerland
[b] Regulatory Assistance Project (RAP), Brussels, Belgium
[c] Cleantech Exergy Consulting, Berlin, Germany

*Corresponding author: cordin.arpagaus@ost.ch, Tel. +41 (0)58 257 34 94

Abstract

Accelerating the electrification of industrial energy use is essential for achieving net-zero climate goals, given its significant potential to decarbonize energy consumption and enhance efficiency, particularly in process heating. Mature electrification solutions, such as industrial heat pumps and resistive heating systems, are already available. Advanced solutions for very high temperatures have existed for decades, with innovations emerging regularly. Despite these technological advancements, the industrial sector remains hesitant to adopt electrification. It is hindered by several persistent barriers, including economic constraints, technical limitations, knowledge gaps, and insufficient infrastructure. This paper examines the current landscape of industrial electrification policies in Europe, with a focus on industrial heat pumps. It categorizes policy instruments and assesses their implementation at the EU level and in 10 selected countries: Austria, Belgium, the Czech Republic, Denmark, Finland, Germany, Italy, the Netherlands, Switzerland, and the UK. To supplement the policy review, a survey was conducted with national experts from each country to evaluate the effectiveness of existing policy instruments supporting industrial electrification. Findings reveal that regulatory frameworks are often inadequate, and electrification continues to receive low priority among policymakers. While a few countries have emerged as leaders with comprehensive and innovative policy approaches, most still lack the robust policy frameworks necessary to drive meaningful change. Addressing these policy gaps is vital for accelerating industrial decarbonization. A well-coordinated and ambitious policy approach is essential at both the EU and national levels. Only an integrated set of policies – including strong carbon pricing, clearly defined electrification targets, and fossil fuel phase-out timelines – can achieve the scale and speed of transformation needed to meet Europe's climate and energy goals.

Keywords: industrial electrification; heat pumps; decarbonization; policy instruments; energy transition

1. Introduction and Method

The recent surge in energy prices and the risk of natural gas shortages pose an existential threat to many industrial companies, particularly SMEs. Industrial heat pumps (IHPs) can be a viable option for low and medium-temperature heat needed in many industries [1]. They significantly reduce energy demand and dependence on natural gas. According to the IEA, commercially available IHPs could meet nearly 30% of the heat demand in the chemical, paper, and food industries, with an installation potential of 15 GW across 3,000 European facilities [2].

Rising gas prices have made IHPs the most cost-effective option for process heat, even in countries with high electricity-to-gas price ratios (e.g., Germany, Italy, the UK) [3]. Consequently, a wide range of industrial high-temperature heat pumps (HTHPs) is now available, and industry interest is high. Promising business models are purchasing an HTHP [3]. Yet, actual deployment remains limited [4]. Why?

This paper provides a high-level review of industrial electrification technologies and policies in Europe, with a focus on industrial heat pumps (IHPs) [2], [4], [5], [6], [7]. It categorizes relevant policy instruments and assesses their implementation at the EU level and across 10 countries: Austria, Belgium, the Czech Republic, Denmark, Finland, Germany, Italy, the Netherlands, Switzerland, and the UK. Policy gaps are identified based on a survey of national experts evaluating the effectiveness of existing instruments supporting industrial electrification [7]. A more extended version of the survey results has been published recently [7]. Here, the main findings are summarized.

2. Results and Discussion

2.1. Industrial Electrification Technologies

Industrial electrification replaces fossil fuel-based processes with electrically powered technologies. Table 1 outlines technology options for electrifying industrial process heat, ranging from established solutions, such as electric boilers, IHPs, and resistance heating, to emerging technologies, such as plasma torches and shock-wave heating. Each serves specific applications and temperature ranges [7].

Electrification of processes at <100 °C to <500 °C is expected to scale more quickly than high-temperature applications. These technologies are widely available, require lower upfront investment, and offer strong efficiency gains (especially heat pumps), improving overall financial viability. Electric boilers provide a simple, scalable replacement for fossil-fuel boilers but can entail higher operating costs when electricity prices exceed those of natural gas. IHPs deliver substantial efficiency benefits but may need process adaptations, particularly when redesigned for waste-heat recovery.

Industries such as food and beverage, dairy, paper, chemicals, and other non-energy-intensive sectors (e.g., textiles) are well-suited for rapid electrification due to their large process heat demand at low- and mid-temperatures. Many of these sectors include SMEs, making coordinated action across stakeholders essential to accelerate deployment.

Table 1. Overview of Industrial Electrification Technologies by Temperature Range and Development Stage (based on [7], [8]).

Technology	Description	Maximum temperature (°C)	
		Now	By 2030
Industrial heat pump	• Commercially available, with growing installation rates across Europe. • Highly efficient for lower-temperature heating in all sectors. • It can be coupled with a waste-heat source to increase efficiency and/or achieve higher-temperature lifts cost-effectively. • Example uses are hot water and steam generation in the paper, food and chemical industries	165	>200
Electric boiler	• Widely established alternative to fossil-fuel boilers and combined heat and power generation. • Versatile and easy to install. • Potential for higher temperatures than heat pumps, but less efficient. • Example uses are steam generation in the paper, food and chemical industries	500	500
Shock-wave heating	• Commercial launch expected in 2025 for industrial applications at medium-to-high temperatures. • Example uses are the cement and chemical industries	700 to 1,000	1,500
Combined thermal storage	• Currently used on a small scale in the industry. • Resistance heating is frequently used to generate heat for storage, such as in bricks or salt. • It can reach higher temperatures than water-based storage.	1,000	1,500
Electric arc furnace	• Mature technology providing high-temperature heat for steel production from scrap and melting metals. Substantial energy savings compared with steel production from primary material.	1,800	1,800
Resistance heating	• Broadly applicable for medium to high temperatures. • It is efficient but has a high-power requirement. • Offers precise temperature control, rapid heating, and low maintenance costs. • Example uses are storage, calcination, production of aluminum and glass	1,850	2,000
Induction heating	• Established solution for high-temperature heat. Less efficient than resistance heating. • Example uses are metal production	3,000	3,000
Plasma torch	• It is an innovative alternative to fossil fuel burners, but less efficient. • Example uses are cutting/welding/melting metal, in the future for cement and clinker industries	5,000	5,000

2.2. Summary of Policy Gaps

Numerous well-documented barriers hinder industrial electrification. Table 2 summarizes the main economic, technical, knowledge, and infrastructural barriers (based on [7]). These include:

- regulation, targets, and standards
- energy efficiency obligation schemes
- carbon pricing
- (carbon) contracts for difference
- electricity tariffs
- grants and loans
- fiscal incentives
- electrical grid planning and optimization
- electricity demand-flexibility market access
- information provision and value-chain cooperation
- R&D programs

Table 2 provides a high-level gap analysis of identified barriers and policy instruments, revealing a fragmented policy landscape with major gaps. Table 2 also highlights suggestions for missing instruments. Understanding why countries choose specific policy approaches is an important research question. While residential heating has received some analysis, industrial electrification has received less.

To reduce the required investment in the electricity grid and cushion the rise in peak-load demand, flexibility mechanisms and time-dependent tariffs could be introduced, e.g., via flexible grid contracts that enable large consumers to consume electricity mainly outside peak hours [8].

Despite strong potential, IHP deployment remains limited due to low standardization and few real-world installations [3]. Most systems are custom-designed for specific processes, requiring specialized planning, design, manufacturing, and installation. This increases risk, cost, and complexity for companies seeking predictable and timely solutions. At the same time, manufacturers lack the customer base needed to develop standardized, lower-cost products.

Accelerating market development requires coordinated action across all stakeholders and a competitive business ecosystem that supports rapid deployment. This should be a central mission of the heat-pump industry.

In recent years, numerous national and international R&D projects on IHP and HTHP have emerged [9], some advancing technology, others focusing on case studies. Yet the critical need is to improve framework conditions for real-world implementation.

Key actions required are [4]:

- develop guidelines and training for qualified personnel (e.g., planners, manufacturers, designers) for optimal implementation of industrial heat pumps based on realized examples
- implement pilot projects to reduce risk and expand application potential
- support rapid deployment to avoid lock-in to suboptimal fossil-based solutions

3. Conclusions

Industrial electrification, especially of process heat, is essential for achieving Europe’s climate, renewable energy, and energy security goals. Yet policy frameworks remain fragmented, and electrification receives low political priority. Only a few countries lead with coherent, ambitious policies; most lack clear carbon pricing, electrification targets, or fossil-fuel phase-out timelines. Industrial heat pumps offer major efficiency and system benefits, including waste-heat recovery and grid flexibility, but deployment is slowed by technical, economic, and knowledge barriers. An integrated EU and national policy strategy supported by the European Electrification Action Plan and targeted approaches for low- and mid-temperature heat is crucial to accelerate adoption.

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Table 2. Key barriers to industrial electrification (i.e., economic, technological, knowledge, and infrastructure) [7], [8] and observed gaps in current EU & national policies.

Barrier category	Specific barrier	Potentially relevant policy instruments	Observed gaps in current EU & national policies
Economic	High capital costs	• Grants & Loans • Fiscal incentives • Access to capital	• Gap in uptake/scale: While various EU funds exist (e.g., Innovation Fund, Modernization Fund), the paper notes that very few funded projects focus on industrial electrification. • Overall uptake has been limited
	High electricity to fossil fuel price ratio	• Carbon pricing • Dedicated electricity tariffs • Operating subsidies	• Gap in effectiveness: The EU-ETS (Emissions Trading System) incentive is weakened by free allowances for industries at risk of carbon leakage. • Only a few countries, like Finland, have systematically reformed electricity taxes to address the price ratio. • Most countries rely on piecemeal measures.
	Expectation of short payback periods	• Carbon Contracts for Difference • Operating subsidies • Grants	• Gap in availability: Carbon Contracts for Difference provide long-term certainty but are not widespread. • Germany's scheme was launched in 2024. • The Netherlands' SDE++ (Stimulation of Sustainable Energy Production and Climate Transition) is one of the few established examples.
Technological	Limited demonstration examples & perceived risks	• Funding for R&D programs • Information provision	• Gap in focus & scale: There is no dedicated EU R&D strategy for industrial electrification. • While EU R&D programs have funded some demonstrations (e.g., Push2Heat, SPIRIT), there isn't a large-scale, coordinated program to systematically de-risk technologies.
	Custom-made designs instead of standardization	• R&D programs • Value chain cooperation	• Gap in policy focus: Implemented policies show little focus on promoting standardization. • Instruments like “sectoral decarbonisation dialogues” in Austria or “climate agreements” in the Netherlands are general and not specifically targeted at this technical barrier.
Knowledge	Lack of awareness and skills in the supply chain & companies	• Information provision • Value chain cooperation	• Gap in coherence: Information policies are ad hoc. • Survey results indicate low policymaker awareness of industrial electrification, suggesting that existing information channels are insufficient to build the necessary knowledge and capacity.
Infrastructure	Potential requirement for upgraded electrical grid connection & (perceived) limits on supply	• Electrical grid planning & optimization	• Gap in timeliness: Infrastructure barriers are now recognized at the EU level, as evidenced by the recent ‘EU grid action plan’. • This indicates the policy response is nascent and lagging behind the need, with electrical grid access often not a given.

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