

D5.5

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Abbreviation List

ATEX : Atmosphères Explosibles (EU Directive on explosive atmospheres)

BAU: Business As Usual

CAPEX: Capital Expenditure

CEPI: Confederation of European Paper Industries

CHP: Combined Heat and Power

CID: Clean Industrial Deal

CINEA: European Climate, Infrastructure and Environment Executive Agency

CISAF: Clean Industrial Deal State Aid Framework

EAP: Electrification Action Plan

EED: Energy Efficiency Directive

EHPA: European Heat Pump Association

EIB: European Investment Bank

EPBD: Energy Performance of Buildings Directive

EPC: Engineering, Procurement and Construction

ERDF: European Regional Development Fund

ESCO: Energy Service Company

ESG: Environmental, Social and Governance

ETS: Emissions Trading System

ETS2: Emissions Trading System 2

GHG: Greenhouse Gas

HaaS: Heat-as-a-Service

HP: Heat Pump

HTHP: High Temperature Heat Pump

HUT: Heat Upgrade Technology

IEA: International Energy Agency

IF25: Innovation Fund 2025 Heat Auction



IF26: Innovation Fund 2026 Heat Auction

JRC: Joint Research Centre (European Commission)

LCA: Life Cycle Assessment

NZBISC: Net Zero Basque Industrial Super Cluster

NZIA: Net-Zero Industry Act

OPEX: Operational Expenditure

PESTEL: Political, Economic, Social, Technical, Environmental, Legal

PFAS: Per- and Polyfluoroalkyl Substances

PNIEC: Piano Nazionale Integrato Energia e Clima (Italy)

RES: Renewable Energy Sources

ROI: Return on Investment

tCO₂eq: Tonnes of CO₂ equivalent

VHHP: Very High Temperature Heat Pump

WHR: Waste Heat Recovery



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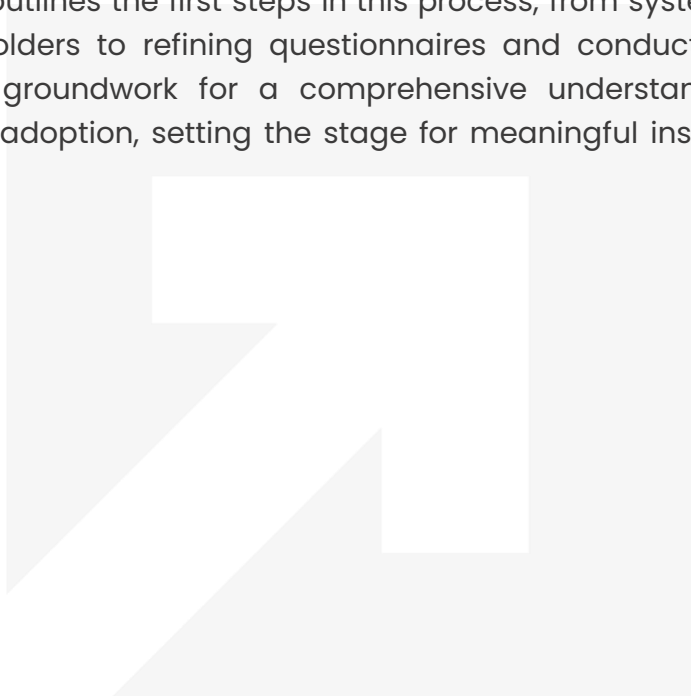
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1. Introduction

The Push2Heat project, under WP5: Heat Upgrade Systems Exploitation, Life Cycle & Impact Assessment, is conducting a detailed questionnaire (political, economic, social, technical, environmental, legal) analysis to identify the barriers and opportunities for Heat Upgrade Technologies (HUTs) across Europe. The analysis is essential for shaping strategies and policies that will encourage the widespread adoption of HUTs and will culminate in the project's final deliverable D5.6 the Heat Upgrade Technologies Exploitation Roadmap.

This document outlines the first steps in this process, from systematically identifying relevant stakeholders to refining questionnaires and conducting outreach. These efforts lay the groundwork for a comprehensive understanding of the factors influencing HUT adoption, setting the stage for meaningful insights and actionable conclusions.



2. Background

2.1 The role of industrial heat in Europe's energy system

A sector resistant to change

Industrial process heat represents one of the most significant and most structurally resistant components of Europe's decarbonisation challenge. Heating and cooling together account for approximately half¹ of the EU's total final energy consumption, and within the industrial sector specifically, process heating dominates it accounts for nearly half of all industrial energy use and is responsible for approximately three quarters of the CO₂ emissions generated by industry². Yet despite decades of climate policy ambition at both the EU and national levels, progress in decarbonizing industrial heat has been remarkably limited. EU industrial greenhouse gas emissions fell by only 8% over the last decade,³ and this modest reduction was driven primarily by energy savings and output changes rather than by any structural shift away from fossil fuels.

The share of electricity in industrial final energy use increased only marginally, from 31% in 2000 to 34% in 2021, and today only 3% of industrial process heat in the EU is supplied by electricity.⁴

As illustrated in Figure 1, process heating accounts for 66% of total industrial energy demand in Europe, equivalent to 1,952 TWh per year out of a total of 2,950 TWh per year. A critical finding for Heat Upgrade Technology deployment is that 37% of this process heating demand falls below 200°C, the temperature range directly addressable by current heat pump technology. This sub-200°C segment is currently supplied predominantly by fossil fuels, with gas alone accounting for 36% of fuel sources, followed by coal at 20% and oil at 8%. Renewables and electricity together represent a small fraction of current supply. Despite this large addressable market, current installed heat pump capacity for industrial process heat stands at only 7 TWh⁵,

indicating a potential for growth of approximately 100 times relative to today's deployment levels.

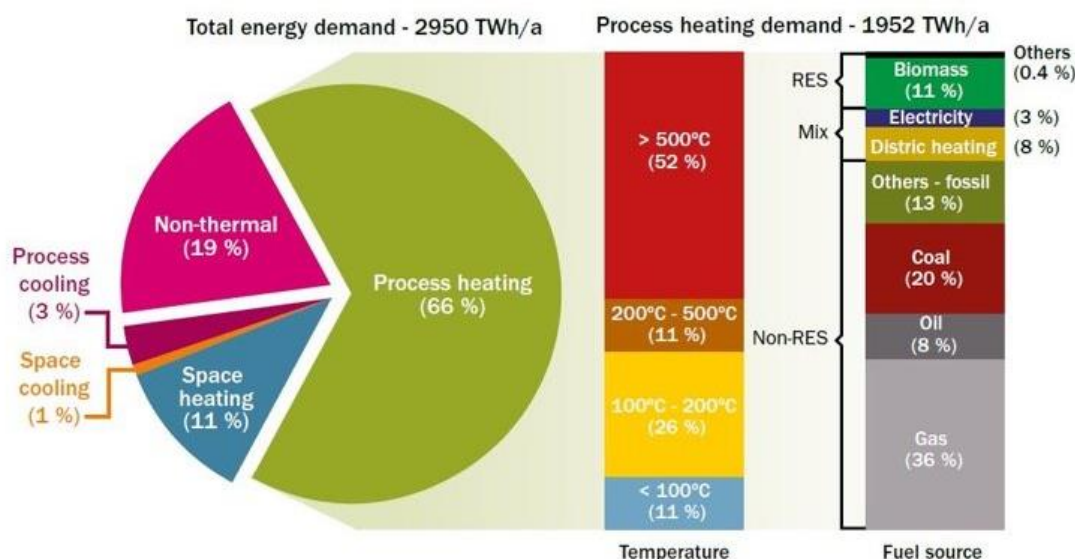


Figure 1. Breakdown of the final energy demand in European industry by broad application (left) and process heating demand by temperature level (centre) and energy source (right) (RES = renewable energy sources) (Source: De Boer et al., 2020)

This structural inertia stands in sharp contrast to the scale of ambition embedded in EU and national climate targets, and reflects the multiple and mutually reinforcing barriers, like economic, technical, regulatory, social, and infrastructural, that prevent industrial operators from making the transition to electrified process heat. It is this gap between potential and reality that the present report systematically examines.

A strategic vulnerability: Fossil fuel dependence and energy security

The fossil fuel dependence embedded in Europe's industrial heat system carries consequences that extend well beyond climate policy. Heating and cooling across the EU remain overwhelmingly dependent on imported fossil fuels, generating an annual import bill of approximately €340 billion in 2025.⁶ The geopolitical and economic risks inherent in this dependence are directly transmitted to industrial energy costs: price volatility in fossil fuel markets. This pattern of repeated exposure demonstrates that

Europe's fossil fuel import dependence is not a temporary condition but a structural vulnerability that electrification can systematically address. Heat pump deployment offers a measurable contribution to reducing this dependence: in 2025 alone, heat pumps across the EU are estimated to have avoided approximately 20 billion⁷ cubic metres of gas consumption, a volume equivalent to the combined annual gas consumption of Belgium and Spain.

In April 2026, the European Commission has formally recognised this strategic dimension, identifying industrial heat pumps as a key instrument for reducing gas imports and enhancing industrial competitiveness. According to the Accelerate EU communication, electrification of industry is now framed as both a geopolitical and economic necessity, with industrial heat pumps identified as a cornerstone of Europe's energy sovereignty strategy⁸.

The electrification potential: efficiency, emissions and scale

The technical potential for industrial electrification through heat pump deployment is substantial and well-documented in scientific literature. Analysis of the potential to electrify industrial processes suggests that 78% of industrial process heat could be electrified with technologies already commercially available today, rising to more than 90% when technologies currently under development are also considered⁹.

According to the IEA analysis¹⁰, the efficiency advantages of heat pump systems over fossil-based alternatives are particularly significant: replacing fossil boilers with (electrically driven) industrial heat pumps can reduce final energy use by 15% to 35%, depending on the temperature level and degree of system integration achieved. This efficiency gain is not incidental but structural; electrification through heat pumps is itself a form of energy efficiency, as it converts electricity into useful heat at multiples of the input energy rather than simply substituting one fuel for another.

At a broader system level, scenario analysis indicates that electrification via industrial heat pumps could increase the utilisation of currently unused waste heat and ambient

heat to 600 TWh in the EU27 by 2050, which alone would increase the efficiency of industrial energy use by 20%.¹¹

The full decarbonisation potential is striking: across the EU27, under advanced electrification scenarios, complete electrification of industrial processes has been estimated to hold the potential to reduce CO₂ emissions by 117 million tonnes per year by 2050¹², making industrial electrification one of the highest-impact levers available to European climate policy.

This heat-pump-specific evidence is reinforced by a broader, cross-technology assessment: Fraunhofer ISI (2024), on behalf of Agora Industry¹³, estimates that direct electrification technologies expected to be available by 2035, including heat pumps, could meet 90% of the final energy demand not yet electrified across EU-27 industry. Critically, 62% of this potential is already achievable with technologies commercially available today, with a further 20% unlocked by 2030 and the remaining 8% by 2035, confirming that the barrier to industrial electrification is predominantly economic and organisational rather than technical.

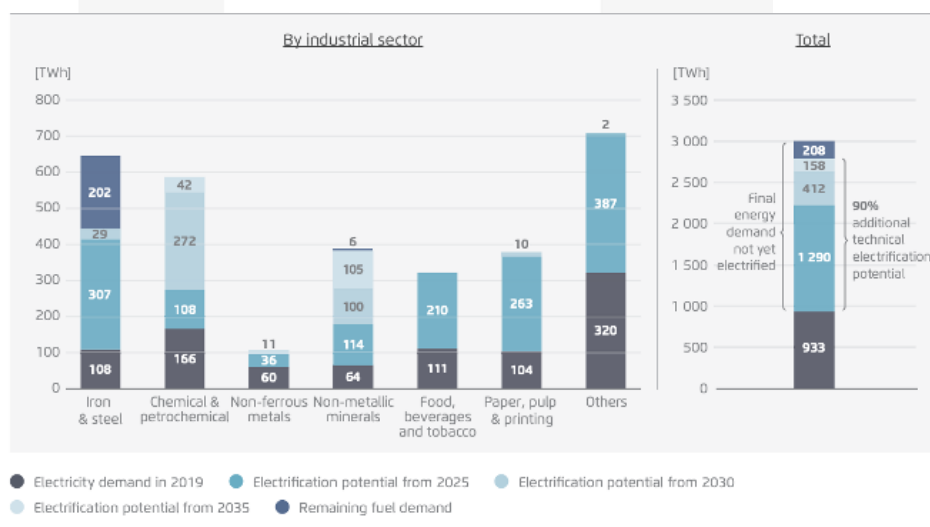


Figure 2: Technical potential for direct electrification in the EU-27 based on 2019 energy demands. Fraunhofer ISI (2024).

Where the opportunity lies: temperature profiles and target sectors

The temperature structure of industrial heat demand determines the practical deployment landscape for heat pump technologies and defines the sectors where near-term action is most feasible. According to Eurostat data for 2022, total industrial energy consumption across the EU reached approximately 2,790 TWh per year, with demand strongly concentrated in a small number of sectors: the chemical and petrochemical industry alone accounts for 598 TWh/year, followed by non-metallic minerals at 395 TWh/year, paper, pulp and printing at 378 TWh/year, and food, beverages and tobacco at 324 TWh/year (Figure 3). Together, these four sectors represent more than 60% of total EU industrial energy use.

Industrial sector	Energy consumption (TWh/year, 2022)	Share on total
Chemical & petrochemical	598	21%
Non-metallic minerals	395	14%
Paper, pulp & printing	378	14%
Food, beverages & tobacco	324	12%
Iron & steel	285	10%
Machinery	186	7%
Not elsewhere specified (industry)	125	4%
Construction	119	4%
Non-ferrous metals	108	4%
Wood & wood products	108	4%
Transport equipment	84	3%
Mining & quarrying	43	2%
Textile & leather	36	1%

Figure 3. Industrial sectors energy consumption in the EU (TWh/yr), (SPIRIT project, 2022)

As reported in a recent market analysis of the SPIRIT¹⁴ project, this demand falls within a temperature range that is technically addressable by current heat pump technology. Industrial process heat below 200°C, the principal applicability window for near and mid-term high-temperature heat pump deployment, is concentrated in specific sectors. Paper, pulp and printing is the largest consumer of sub-200°C process heat, requiring 260 TWh/year; food and beverage follows at 149 TWh/year;

chemicals at 82 TWh/year; non-metallic minerals at 47 TWh/year; machinery at 31 TWh/year; transport equipment at 24 TWh/year; and textiles at 11 TWh/year. The chemical and pulp & paper sector, which together account for a substantial share of technically addressable industrial heat demand in Europe, are directly targeted by the Push2Heat demonstration activities, confirming the strategic focus of the project on the industrial segments where heat pump deployment can deliver the most significant and immediate decarbonisation impact.

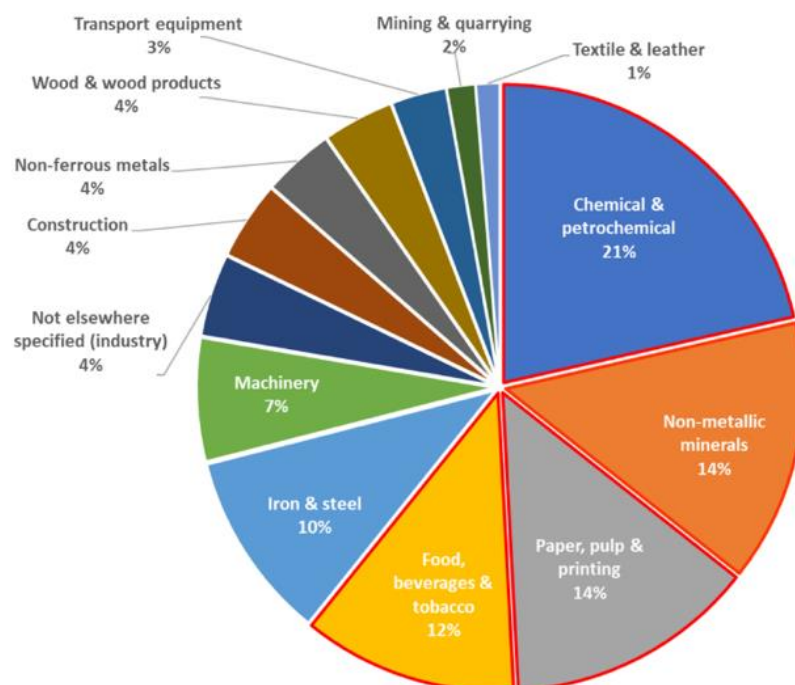


Figure 4. Industrial sectors energy consumption in the EU (shares), (SPIRIT project, 2022)

The untapped resource: industrial waste heat

A particularly significant and systematically underexploited dimension of this potential is industrial waste heat recovery. On-site waste heat, the thermal energy generated as an unavoidable by-product of industrial, commercial, and tertiary sector processes, represents one of the EU's most underutilized energy resources, largely because the regulatory and economic framework does not yet incentivize its recovery and reuse at scale.

Industrial heat pumps are uniquely suited to capture and upgrade this resource: capable of reaching temperatures up to 200°C, they can recover low-temperature waste heat from diverse industrial sources, including cooling processes, exhaust air streams, wastewater, and process condensates, and upgrade it for productive use in heating applications, typically operating at two to four times the efficiency of conventional fossil-based heating systems.

When both heating and cooling needs can be addressed simultaneously within the same facility or across connected sites, the efficiency gains are even greater: one unit of electricity can provide five to nine units of useful heating and cooling energy. This integrated approach, connecting buildings or industrial sites with complementary heating and cooling needs through thermal energy networks, allows heat from one process's cooling system to be reused as heat input for another, creating a circular energy economy within industrial clusters that substantially reduces total primary energy demand. The scale of this untapped resource is extraordinary: the industrial waste heat potential available across the EU27 is estimated to match the total energy demand for heating and hot water in all residential and service sector buildings combined, approximately 917.6 TWh per year¹⁵.

Fully enabling waste heat recovery through an integrated approach, encompassing on-site recovery, inter-site thermal networks, and district heating integration, has the potential to save €67.4 billion per year across the EU by 2050, equivalent to the current GDP of Slovenia¹⁶. This figure alone illustrates the scale of economic value currently

being left unrealized due to the absence of adequate policy frameworks, investment incentives, and regulatory obligations for waste heat recovery.

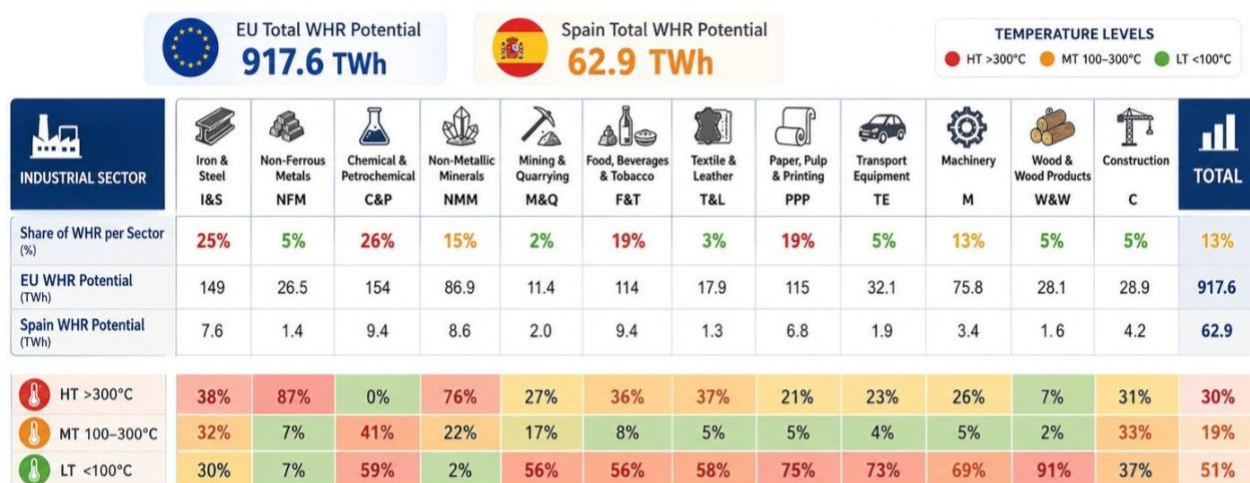


Figure 5. Waste heat recovery factor by sector and temperature

The deployment gap: potential versus reality

Despite this documented potential across multiple dimensions, electrification potential, efficiency gains, CO₂ reduction, and waste heat recovery, actual deployment of industrial heat pumps in Europe today remains marginal. Current installations represent less than 1% ¹⁷ of total industrial heating capacity in the EU, and early deployment is primarily concentrated in applications with low-to-medium temperature requirements (food and beverage processing, papermaking, and selected chemical processes where technical feasibility and economic robustness are already well established).

Higher-temperature applications remain largely limited to demonstration and early commercial projects, reflecting the compound effect of high upfront costs, process integration complexity, limited high-temperature references, and an energy pricing environment that systematically favours fossil fuels over electrified alternatives.

While a recent survey of 850 electrification purchase decision-makers from industry and utilities across France, Germany, Italy, Norway, and the UK found that 71% prioritise shifting from fossil fuels, 51% acknowledge that their organisations lack the resources to meet their commitments in the energy transition, indicating a fundamental gap between stated ambition and practical capacity that cannot be bridged without structural policy intervention¹⁸. It is this gap, and the policy instruments available to close it, that the analysis developed in this deliverable directly addresses.

2.2 EU regulatory and policy landscape

The deployment of Heat Upgrade Technologies in Europe does not take place in a regulatory vacuum. Over the past decade, the EU has progressively built a legislative and policy framework aimed at accelerating the decarbonisation of industry, improving energy efficiency, and reducing dependence on fossil fuels. This framework, spanning binding directives, carbon pricing mechanisms, industrial strategy instruments, and dedicated financing tools, defines the conditions under which industrial heat pump technologies are developed, financed, deployed, and operated across Member States.

Understanding this regulatory landscape is essential for identifying both the opportunities and the constraints that shape HUT deployment at scale. The instruments examined in this chapter include:

Foundational energy legislation:

- Renewable Energy Directive (RED III) — Directive (EU) 2023/2413
- Energy Efficiency Directive (EED) — Directive (EU) 2023/1791

Industrial decarbonisation and competitiveness:

- EU Clean Industrial Deal — COM(2025) 85
- Clean Industrial Deal State Aid Framework (CISAF) — in force from 25 June 2025
- Net-Zero Industry Act (NZIA) — Regulation (EU) 2024/1735
- Industrial Accelerator Act — COM(2026) 100, under negotiation

Energy affordability and grid infrastructure:

- Affordable Energy Action Plan — COM(2025) 88
- European Grids Package — COM(2025) 1005

- AccelerateEU — COM(2026) 370
- EU Electrification Action Plan — published 17 July 2026

Carbon pricing and financing:

- EU Emissions Trading System (ETS and ETS2) — Directive (EU) 2023/959
- Innovation Fund — IF26 Heat Auction

The following sections provide an overview of each instrument, with particular attention to the provisions most directly relevant to industrial heat pump deployment and waste heat recovery. This analysis serves as a reference framework for the PESTEL and SWOT analyses developed in subsequent chapters, which examine in greater depth the extent to which the current regulatory environment supports or hinders the widespread adoption of HUTs across European industry.

2.2.1 Renewable Energy Directive (RED III)

The Renewable Energy Directive III¹⁹ (Directive EU 2023/2413) is the EU's primary legislative instrument for promoting renewable energy across Member States. It sets the overall direction for renewable energy deployment in industry, heating and cooling, and district energy systems, with several provisions directly relevant to Heat Upgrade Technologies and waste heat recovery.

Key targets and obligations

- Overall renewable energy target of 42.5% of final energy consumption by 2030, rising to 43.5% when waste heat sources are included
- Industrial sector: indicative increase of 1.6% per year in the share of renewable energy, for the periods 2021 to 2025 and 2026 to 2030
- Heating and cooling sector: annual increase of at least 0.8% per year until 2025, rising to 1.1% per year from 2026 to 2030, with waste heat allowed to cover a maximum of 0.4% of this increase
- District heating and cooling: indicative increase of 2.2% per year in the share of renewables and waste heat

Waste heat under the Renewable Energy Directive (RED III)

The directive's definition of waste heat is particularly relevant for HUT deployment. Article 2 defines waste heat as unavoidable thermal energy generated as a by-

product of industrial or power generation processes that would otherwise be dissipated unused. To qualify, four cumulative criteria must be met: the heat must be unavoidable, a by-product of the process, generated in an industrial or tertiary sector installation, and destined for delivery to a district heating or cooling system. on-site waste heat recovery and single-building applications do not qualify, substantially narrowing the scope of what counts towards national renewable energy targets.

The scale of what this definition leaves out is considerable. Across the EU, excess heat is estimated at around 245 Mtoe per year, equivalent to the total energy demand for space heating and hot water in all residential and service sector buildings.²⁰

As illustrated in Figure 6, industrial processes account for a major share of this potential, with significant contributions from the chemical, food and beverage, paper, and steel sectors.

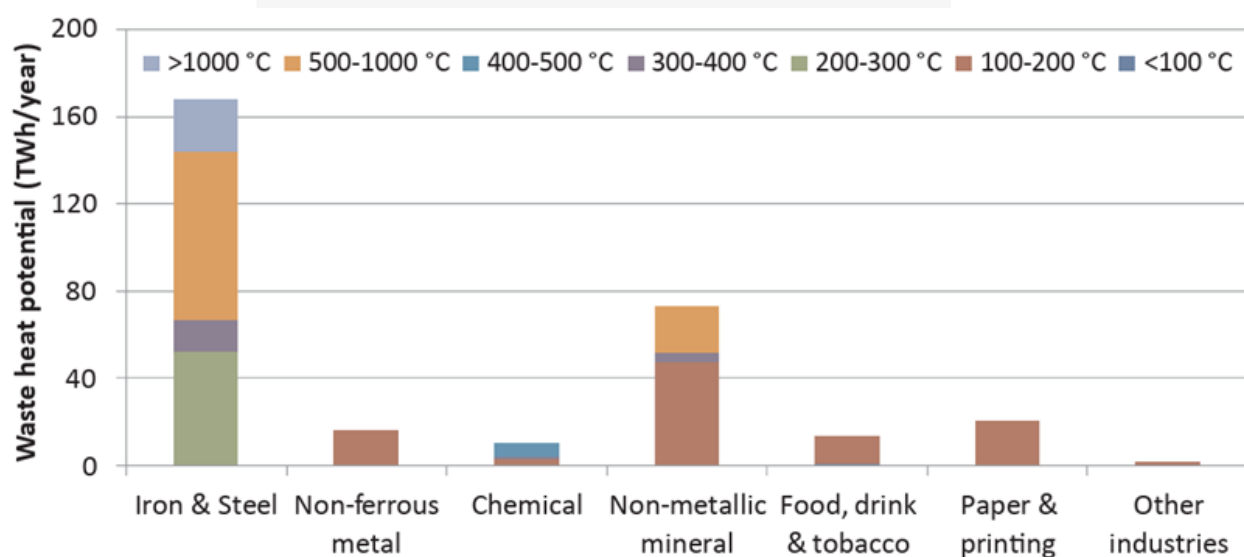


Figure 6. Estimation of technically available resources in EU, per industrial sector.

(Source: Papapetrou, M., Kosmadakis, G., Cipollina, A., La Commare, U., Micale, G., (2018). Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country. *Applied Thermal Engineering* 138, 207–216.)

While RED III provides an important directional framework, its provisions for industrial heat pump adoption and waste heat recovery remain largely indicative rather than binding. The absence of concrete obligations, combined with the narrow definition of waste heat that excludes on-site recovery, limits the directive's effectiveness as a direct driver of HUT deployment at scale.

2.2.2 Energy Efficiency Directive (EED)

The revised Energy Efficiency Directive ²¹ (Directive EU 2023/1791) establishes a comprehensive framework for improving energy efficiency across the EU economy. Its foundational principle, the Energy Efficiency First principle, requires Member States to assess available energy efficiency solutions before committing to new infrastructure investments. For industrial heat pump deployment and waste heat recovery, the directive introduces a set of planning obligations, assessment requirements, and sector-specific mandates that are directly relevant to the HUT deployment landscape.

Key obligations and thresholds

- Energy Efficiency First principle (Article 3): waste heat recovery must be assessed as an alternative or complementary solution in planning, policy and major investment decisions in the heat, industry, and ICT sectors.
- Industrial installations above 8 MW and service facilities above 7 MW must conduct a Cost-Benefit Analysis assessing on-site and off-site waste heat utilisation utilization when planning new facilities or major refurbishments (Article 26).
- Thermal electricity generation installations above 10 MW must assess the costs and benefits of high-efficiency cogeneration (Article 26).
- Data centres above 1 MW must assess waste heat recovery potential and possible connections to district heating or cooling systems (Article 26).

Waste heat in the EED

The mandatory waste heat requirement for data centres above 1 MW represents a significant regulatory precedent: it is the first binding EU-level obligation for waste heat

recovery in a specific sector, and it establishes a model that could in principle be extended to other energy-intensive industries in future legislative revisions.

While the EED introduces meaningful planning and assessment obligations, its provisions for broader industrial waste heat recovery beyond the data centre sector remain based on assessment rather than binding recovery targets, leaving the ultimate decision to individual operators and Member States²².

2.2.3 Net-Zero Industry Act (NZIA)

The Net-Zero Industry Act²³, adopted as part of the Green Deal Industrial Plan, aims to ensure that at least 40% of the EU's annual deployment needs for strategic net-zero technologies are met by domestic production by 2030. Heat pumps are explicitly included among the strategic technologies covered by the Act. While the NZIA does not distinguish between residential and industrial applications, the manufacturing scale-up and supply chain development it supports benefit the entire heat pump sector, including industrial systems.

Key provisions relevant to HUTs

- Heat pumps recognised as a strategic net-zero technology supporting European manufacturing scale-up.
- 40% domestic production target by 2030 for strategic clean technologies.
- Recital 67 (a non-binding explanatory clause in the legislative text) recognises waste heat and cold recovery as a relevant contribution to energy system integration, alongside energy storage and renewable hydrogen.

The NZIA's focus is primarily on the supply side of the market rather than on driving adoption within industry. It does not introduce obligations or incentives for industrial end-users to adopt heat pumps or implement waste heat recovery, and the reference to waste heat in Recital 67 remains a general principle rather than a binding provision.

2.2.4 EU Emissions Trading System (ETS and ETS2)

The EU Emissions Trading System²⁴ is the EU's primary carbon pricing mechanism, setting a cap on greenhouse gas emissions from large industrial installations and incentivising the shift to lower-carbon alternatives. Following revisions and expansion in 2023, a second trading system, EU ETS2, will enter into force from 2027 onwards, or from 2028 in the event of extreme gas prices.

Key provisions relevant to HUTs

- ETS2 will cover fossil fuel use in buildings, transport, and small industrial systems from 2027
- An estimated 8,000 to 11,000 small industrial installations across Europe will be covered, with approximately 56% currently using gas, 24% coal, and 20% oil²⁵.
- Industrial sectors covered include food processing and beverages, pulp and paper, chemicals, textiles, non-metallic minerals, machinery, and transport equipment, among others.
- The European Commission specified in the ETS directive that if the average price of allowances exceeds 45 euro/ton for a period of two consecutive months it would release allowances from the market reserve, a price of 45 euro/ton would lead to an increase in gasoline prices of around 12 ct. per liter and 0.9 ct per kWh for natural gas (both before taxes). At this price level, the additional incentive to electrify will likely be limited.

Relevance for industrial electrification

ETS2 is significant for HUT deployment because it extends carbon pricing to smaller industrial consumers that have so far operated outside the existing ETS framework, creating a financial incentive to shift away from fossil-based process heat. However, the price stabilisation mechanism represents an important limitation: at the €45 per tonne threshold, the additional incentive to electrify industrial processes is likely to remain limited, as the resulting increase in fossil fuel costs would be modest relative to the investment required for heat pump adoption.

2.2.5 EU Clean Industrial Deal

- The EU Clean Industrial Deal ²⁶, launched in February 2025, presents a comprehensive set of measures to strengthen decarbonisation in EU industry while enhancing its global competitiveness. For the industrial heat pump sector, the Deal is relevant across several dimensions.

Key provisions relevant to HUTs

- Mobilisation of over €100 billion for clean manufacturing and decarbonisation, including a simplified state aid framework (CISAF – a set of rules that allows EU Member States to more easily provide financial support to companies investing in clean technologies, without requiring lengthy case-by-case approval from the European Commission) for clean technologies
- Reduction of electricity costs through the Action Plan for Affordable Energy
- Industrial Decarbonisation Accelerator Act (proposed on March 2026, currently under negotiation between the European Parliament and the Council – entry into force expected no earlier than 2027) introducing sustainability and made-in-Europe criteria in public procurement
- Simplification of administrative and permitting procedures and support for workforce development

By simultaneously addressing energy costs, financing barriers, manufacturing competitiveness, and administrative complexity, the Clean Industrial Deal targets several of the structural conditions that currently prevent HUT deployment at scale.

2.2.6 EU Action Plan for Affordable Energy

The Action Plan for Affordable Energy²⁷, a key component of the Clean Industrial Deal launched in February 2025, focuses on reducing energy costs for citizens, businesses, and industry. Several of its measures directly address the structural economic barriers that currently limit industrial heat pump deployment.

Key provisions relevant to HUTs

- Lowering electricity taxation at national level and removing non-energy cost components from bills, through the revision of the Energy Taxation Directive and guidance to Member States²⁸
- Reducing network charges by designing tariff methodologies that reward flexibility and demand-shifting
- Accelerating grid expansion and modernisation, including faster permitting for renewables and infrastructure through the European Grid Package
- Promoting long-term Power Purchase Agreements and other supply contracts to decouple retail electricity bills from volatile fossil gas prices
- Improving demand-side flexibility by encouraging retail contracts and tariffs that reward consumers for shifting consumption to lower-cost periods
- Scaling up waste heat recovery and heat pump deployment in industrial and district heating applications
- Accelerating electrification of industry, heating, and cooling, with explicit reference to large-scale industrial heat pump investments

The Action Plan is particularly significant for HUT deployment because it directly targets the electricity-to-gas price ratio, identified in the PESTEL analysis as the single most critical economic barrier. By addressing electricity costs, grid access, and long-term price predictability simultaneously, it creates economic conditions under which the business case for industrial heat pumps can be realised.

2.2.7 European Grids Package

Europe's electricity network is one of the most extensive in the world, spanning over 11 million kilometres across the internal market. However, this infrastructure faces significant and growing challenges: insufficient grid capacity to meet rising connection requests on both the supply and demand side, delays in project implementation, and increasing security threats. These challenges are directly relevant to industrial heat pump deployment, where grid access delays and insufficient on-site electricity capacity have been consistently identified as a primary operational barrier.

In response, the European Commission presented the European Grids Package on 10 December 2025, following the EU Action Plan for Grids adopted in November 2023²⁹. The package consists of a proposal to accelerate permit granting procedures by amending the Renewable Energy Directive, the Electricity Market Design, and the Gas Directive. On 3 July 2026, the European Parliament voted in favour of the package, with final negotiations with the Council expected to conclude before the end of 2026.

Key provisions relevant to HUTs

- Electricity grids and renewables granted overriding public interest status, supporting accelerated build-out
- Streamlined and accelerated permitting processes for grids, renewables, and storage
- Tacit approval introduced to prevent administrative delays from holding up grid connections
- Better coordination at EU level for mapping and planning grid infrastructure
- Enhanced cost-sharing tools and measures to improve efficiency of existing infrastructure

2.2.8 Accelerate EU

AccelerateEU³⁰ (COM/2026/370), presented by the European Commission on 22 April 2026, is a comprehensive set of actions aimed at addressing rising energy costs and accelerating the EU's transition to clean, homegrown energy. Developed in response to mounting geopolitical pressures, including the escalation of the Middle East conflict in March 2026, the initiative underscores the urgency of reducing Europe's dependence on imported fossil fuels, which in 2025 alone cost the EU approximately €340 billion and represent 57% of total EU energy consumption.

Key provisions relevant to HUTs

- Electrification target introduced to accelerate the shift to homegrown clean energy, with explicit removal of barriers to electrification in the industrial, transport, and building sectors

- Acceleration of the European Grids Package negotiations and support for Energy Highways infrastructure projects
- Mobilisation of public and private investment at EU and national level for the clean energy transition, including a temporary State aid framework adopted in April 2026
- Closer EU coordination through the Energy Union Task Force, launched in 2025, to support Member States in filling gas storage and managing energy price spikes
- Consumer protection measures including targeted income support, energy vouchers, and reduced excise duties on electricity for vulnerable households.

2.2.9 Innovation Fund: Heat Auction for Industrial Process Heat Decarbonisation

The Innovation Fund³¹ is one of the EU's largest funding programmes for innovative low-carbon technologies, financed through revenues from the EU Emissions Trading System. Within this broader framework, the European Commission has established a dedicated auction mechanism specifically targeting the decarbonisation of industrial process heat, representing one of the most directly applicable financing instruments for Heat Upgrade Technologies currently available at EU level.

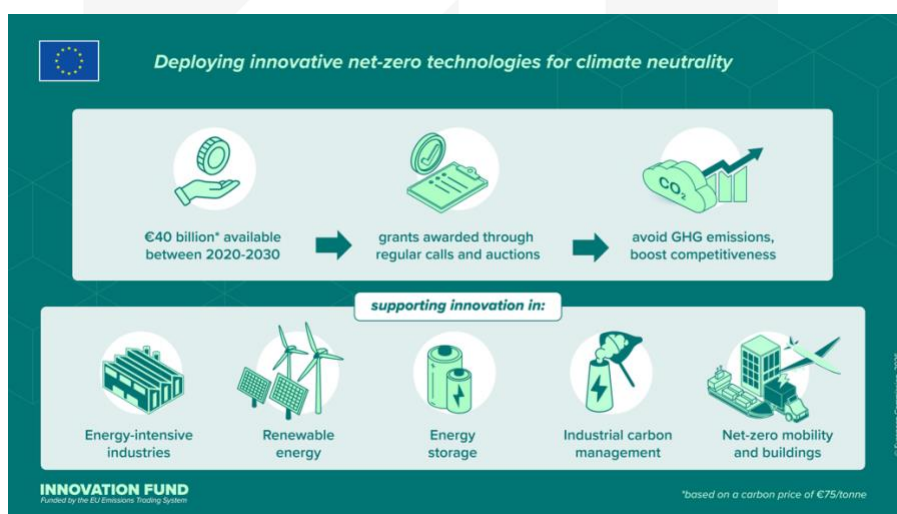


Figure 7. Deploying innovative net-zero technologies for climate neutrality

Key features of the instrument

- Fixed-premium auction structure: projects compete on the lowest subsidy required per tonne of CO₂ avoided, expressed in €/tCO₂
- Premium paid only after the plant becomes operational, based on verified decarbonised heat production
- Eligible technologies include heat pumps, electric boilers, resistance heating, induction heating, plasma heating, solar thermal, and geothermal, with nuclear heat added in the 2026 round
- Projects can cover all cost components including CAPEX, OPEX, development expenditure, and thermal storage

Market signal: results of the first round (IF25)

The first round of the Heat Auction, launched in 2025, attracted 85 bids from 10 countries, with €1.4 billion in funding requested against a €1 billion budget. Of the 65 selected projects, €400 million was awarded, with the leading sectors being pulp and paper (16 projects), food and beverage, and chemicals. Spain was the most successful country, recording the highest number of bids, selections, and funding awarded. Notably, only 7 heat pump projects were accepted, with electric boilers dominating due to higher COP assumptions used in the evaluation methodology. This outcome signals that while the auction mechanism is well-suited to HUT projects in principle, the current evaluation framework may not yet fully capture the long-term performance advantages of heat pumps over simpler electrification technologies.

The strong participation led the European Commission to confirm a second round (IF26) with a budget of up to €1 billion, largely preserving the 2025 design while introducing significant simplifications. Draft Terms and Conditions for IF26 were published in June 2026, with final terms expected in September 2026 and the call opening towards the end of the year.

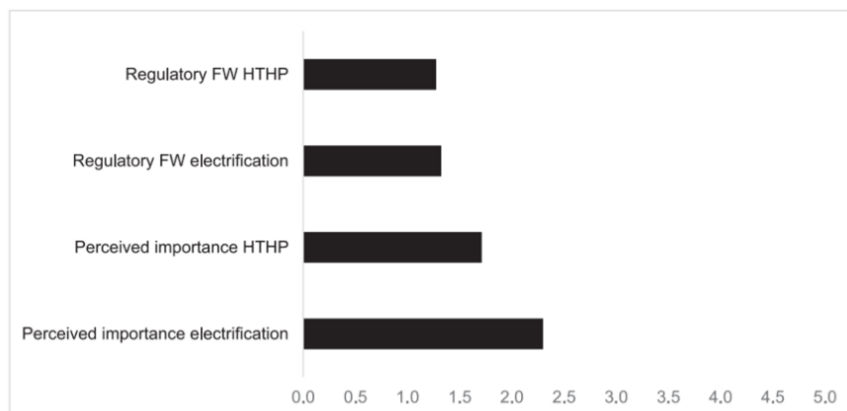


Figure 8. Scoring of the regulatory framework (FW) and perception of industrial electrification by policymakers

Source: (Rosenow et al. 2025, "The Heat Is On: Policy Solutions for Industrial Electrification)

2.3 National regulatory context in demo-site countries

2.3.1 BELGIUM

Belgium's approach to industrial electrification is shaped by its federal structure, with energy policy distributed across the federal government and three regional authorities: Flanders, Wallonia, and Brussels. The updated National Energy and Climate Plan³² provides the overarching national framework, while regional governments have developed their own complementary instruments.

References to industrial heat pumps: yes

- ✓ Flanders leads with the most concrete national support: 2024 pilot call of the Climate Leap Transition³³ awarded support to nine industrial projects investing in large-scale

electric boilers and heat pumps through a contracts for difference mechanism, collectively cutting over 82,000 tonnes of CO₂ per year.

- ✓ Projects span chemicals, food, and pharmaceuticals sectors and include companies such as INEOS, TotalEnergies Antwerp, and Pfizer Manufacturing Belgium.
- ✓ The Flemish Government Agreement 2024–2029 paved the way for an experimental Contract for Difference (CfD) instrument to support industrial decarbonisation. The subsequent *Transitiecontract Klimaatsprong* ³⁴ pilot call provides support for investments in large-scale industrial electric boilers and heat pumps, including coverage of both investment and operational costs.

References to industrial waste heat recovery: yes

- ✓ Mentioned in the NECP primarily in the context of district heating networks
- ✓ In Wallonia, cited as a potential contributor to energy cost reduction in voluntary company agreements toward carbon neutrality by 2050
- ✗ No binding obligations or dedicated support mechanisms for on-site industrial waste heat recovery at national or regional level.

References to industrial electrification: yes

- ✓ NECP identifies electrification of industrial processes as a key decarbonisation instrument, with a national target of 42.6% reduction in effort-sharing sector emissions by 2030
- ✓ Flemish Government Agreement 2024 to 2029 commits to lowering electricity costs for non-residential consumers and accelerating industrial electrification
- ✗ A 2024 Federal Planning Bureau assessment concluded Belgium is not currently on track to meet its 2030 climate targets, pointing to a gap between policy ambition and implementation

2.3.2 GERMANY

Germany's industrial electrification policy is shaped by its ambitious climate neutrality target of 2045, set one year ahead of the EU's 2050 goal. The updated National Energy and Climate Plan provides the overarching framework, while a range of federal funding instruments and regulatory measures support the transition at sector level.

References to industrial heat pumps: yes

- ✗ Not explicitly referenced as a standalone technology category in the NECP
- ✓ Large-scale heat pumps mentioned in district heating context: 4 GW/year expansion needed by 2045, 86 TWh/year target in heating networks by 2030. Until September 2022, funding was only possible as part of an innovative CHP system (KWKG) under the CHP Act³⁵, requiring at least 30% of total heat provision to be generated as innovative renewable heat, and explicitly excluding the use of waste heat. The Federal Funding Programme for Efficient Heat Networks³⁶ (BEW), significantly expanded this framework through four modules:

Module 1: feasibility studies and transformation plans, up to 50% or €2 million.
Module 2: systemic funding for heating and cooling networks, up to 40% or €100 million.
Module 3: individual measures for generating technology, up to 40% or €100 million.
Module 4: operating cost support for large-scale heat pumps, up to €0.092/kWh.
- ✓ The Federal Support for Energy and Resource Efficiency in Industry (EEW) provides additional support options for industrial applications beyond district heating³⁷

References to industrial waste heat recovery

- ✓ Explicitly recognised in the NECP: estimated waste heat and cooling volume of 7 TWh/year by 2030, of which 4.8 TWh from manufacturing industry and 2 TWh from data centres.
- ✓ Buildings Energy Act (GEG) requires new district heating systems to use at least 65% renewable energy and waste heat from April 2024.

- ✓ Transformation plans mandated for existing district heating systems: at least 50% renewable energy and waste heat by 2030, full decarbonisation by 2044.
- ✗ References remain focused on district heating — no binding obligations for on-site industrial waste heat recovery³⁸.

References to industrial electrification

- ✓ NECP explicitly recognises industrial electrification as essential to achieving net-zero targets.
- ✓ EEG levy eliminated and exemptions from CHP and offshore grid levies introduced, reducing operating costs for large-scale HP operators.
- ✗ Investment and operating cost support still necessary — industrial HP applications differ from district heating due to higher sink temperatures and utilisation rates averaging 6,000 full load hours/year.

2.3.4 ITALY

Italy's approach to industrial electrification is guided by its National Integrated Energy and Climate Plan³⁹ (PNIEC), which sets out the country's strategy for the energy and climate transition to 2030. The PNIEC identifies the replacement of fossil fuels through electrification and hydrogen as a priority for the industrial sector, while also acknowledging the risks associated with high industrial electrification, particularly vulnerability to blackouts.

References to industrial heat pumps

- ✗ Not explicitly referenced in the PNIEC as a standalone technology category.
- ✗ No specific targets or dedicated support mechanisms for industrial HP deployment.

References to industrial waste heat recovery

- ✓ Explicitly recognised in the PNIEC as a priority action to reduce emissions and energy consumption in hard-to-abate industrial sectors ⁴⁰.
- ✓ References remain focused on district heating and cooling — limited mention of direct industrial process applications.
- ✗ No binding obligations or dedicated support mechanisms for on-site industrial waste heat recovery at national level.

References to industrial electrification

- ✓ PNIEC explicitly identifies electrification and hydrogen as core industrial decarbonisation strategies
- ✓ Italy approved a €6.3 billion package known as Transition 5.0⁴¹ providing tax rebates for energy efficiency investments including heat pumps and thermal storage, targeting energy savings above 15% in installations with investment costs below €2.5 million.
- ✓ Conto Termico 2.0⁴² an additional support instrument, provides incentives for thermal energy production from renewable sources including heat pumps.
- ✓ Certificati Bianchi scheme⁴³ grants proportional to energy savings from industrial efficiency improvements.
- ✗ Grid vulnerability explicitly flagged in the PNIEC as a risk associated with high industrial electrification — increased electricity demand makes industry particularly exposed to supply disruptions.

Table 1. Summary of policy instruments in demo-site countries

Policy instrument	Belgium	Germany	Italy
Energy savings obligation for industry	Yes	Yes	Yes
National carbon pricing	No	Yes (fossil fuel carbon pricing in non-ETS sectors)	No
Contracts for difference (federal level)	No	No	No
Investment support	Yes (Flanders region only)	Yes (BEW, EEW programmes)	Yes (Transition 5.0, Conto Termico 2.0)
Fiscal incentives (national level)	No	Yes (EEG levy elimination, CHP and offshore grid levy exemptions)	Yes (Tax rebates under Transition 5.0)
Sectoral decarbonisation agreements	Yes	No	No
Value chain cooperation	Yes	Yes	No
Dedicated R&D programmes	No	Yes	Yes

3. Methodology

3.1 Overview of the research approach

The findings presented in this deliverable are based on a three-phase research process.

- 1) structured stakeholder survey
- 2) internal pre-analysis of the collected responses
- 3) validation through two roundtables held with policymakers, researchers, manufacturers, and industrial end-users.

This approach was chosen to ensure that the analysis reflects the perspectives of a wide range of stakeholders involved in the deployment of Heat Upgrade Technologies across Europe, and that the results are both empirically grounded and practically validated.

The process started with a structured stakeholder survey, designed to collect systematic input across all six PESTEL dimensions from four different types of organisations. The survey responses were then analysed internally by the Push2Heat consortium to identify the main patterns and themes emerging from the data. Finally, the preliminary findings were presented and discussed during two roundtables, bringing together policymakers, researchers, manufacturers, and industrial end-users. The roundtables allowed for validation of the survey conclusions and added qualitative insights that the quantitative data alone could not provide.

Each phase is described in more detail in the sections below.

3.2 Stakeholder mapping and questionnaire design

To identify relevant stakeholders for evaluating barriers and opportunities associated with the deployment of heat upgrade technologies in Europe, a systematic stakeholder mapping process was conducted. This step was critical to support the subsequent PESTEL analysis, which focused on political, economic, social, environmental, technical, and legal dimensions.

The stakeholder mapping began with the definition of target groups whose expertise and experiences aligned with the objectives of the study. The following categories of stakeholders were identified as most relevant:

- **Energy and industrial process engineers** with experience in installing and operating heat upgrade technologies.
- **Environmental and sustainability managers** in industrial companies, particularly those involved in decision-making processes for heat recovery systems.
- **Legal professionals specialising in energy and environmental regulations**, providing advisory services on the legal aspects of implementing heat recovery technologies.
- **Experts in energy and environmental regulations** with experience in advising companies with varying levels of success in deploying heat recovery systems.
- **Energy efficiency consultants** who have recommended and implemented heat recovery systems in industrial contexts.
- **Plant operators** using heat recovery systems in daily operations, offering practical insights into their performance and challenges.
- **Maintenance engineers or technical service personnel** responsible for maintaining and optimising heat recovery equipment.
- **Researchers or technical experts** investigating the potential and application of heat recovery technologies, contributing knowledge on advancements and trends.
- **Energy service company professionals** involved in assessing feasibility and providing recommendations for heat recovery projects.
- **Representatives of industrial associations** advocating for the adoption of heat recovery technologies.
- **Government officials or public servants** knowledgeable about regulatory systems and social aspects, particularly those demonstrating proactive engagement in the field.

To facilitate engagement with these stakeholders, a targeted approach was implemented. Partners were provided with a detailed PDF document to share within their networks, which outlined the purpose and background of the questionnaire, the role of respondents, descriptions of target profiles, and an overview of the project. Stakeholders were also encouraged to suggest additional relevant contacts within their networks who met the criteria.

An Excel file was created to streamline the collection and tracking of stakeholder data. This file included fields for the main area of expertise (aligned with the six PESTEL dimensions), additional areas of relevance, the profile of potential respondents, and contact details. This tool also served to monitor the distribution of the questionnaire and track responses, enabling efficient follow-up with non-respondents.



3.3 Media actions

To increase the number of respondents beyond the contacts provided by project partners, a LinkedIn campaign was launched using the Push2Heat LinkedIn page, which has approximately 900 followers. The campaign included a series of engaging posts aimed at attracting potential respondents to participate in the questionnaire. These posts featured interactive elements, such as small polls with sample questions from the questionnaires, and visually appealing images encouraging participation. This approach helped raise awareness of the project and expand outreach to a broader audience within the professional network, increasing the likelihood of gathering diverse and valuable insights.

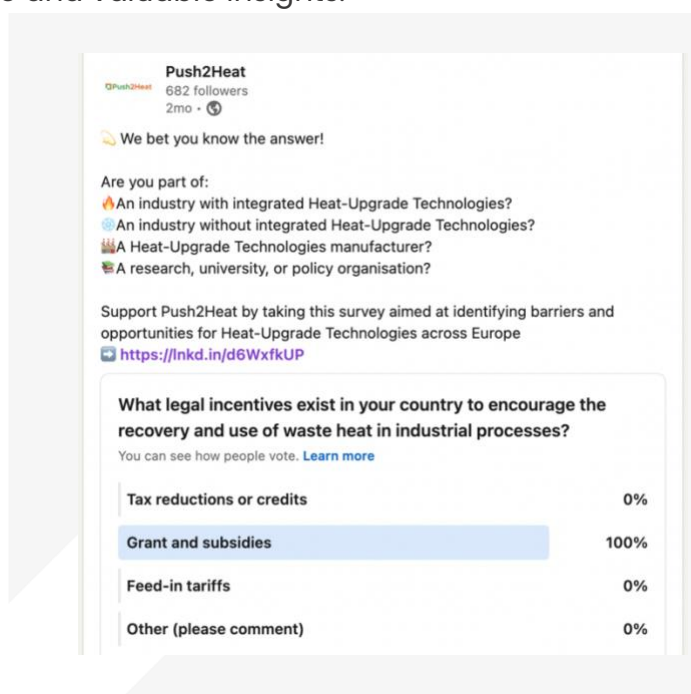


Figure 9. LinkedIn survey assessing barriers to the deployment of HUTs

3.4 Survey results overview

Limitations

Before presenting the findings of this survey, it is important to acknowledge two main limitations of this methodology.

The first concerns the response rate. Despite reaching out to a significant number of stakeholders across Europe, only a limited number completed the survey. This was partly due to the indirect communication channels used to reach companies in the pulp and paper and chemical sectors, where EHPA had to engage through EU and

national industry associations rather than through direct company contacts, which made it harder to secure responses.

The second limitation relates to the profile of the industrial respondents. The results from food and beverage, paper and pulp, and chemical companies may reflect a selection bias, as it is likely that only companies already aware of industrial heat pumps and actively considering electrification took the time to participate. This means that the survey may not fully capture the perspective of industries with little or no prior exposure to Heat Upgrade Technologies.

To help address these limitations, the survey findings were complemented by three additional sources of evidence.

- First, the two roundtables provided qualitative depth through targeted discussions with a diverse group of researchers, manufacturers, policymakers, and industrial end-users.
- Second, the live poll conducted during the “The Road to Sustainable Industrial Heat: A Roundtable on the Future of Industrial Heat Pumps” events engaged an audience of over 30 industrial stakeholders, broadening the evidence base beyond the survey respondents.
- Third, the findings were triangulated with existing scientific literature and EHPA position papers, reducing the risk that the survey's inherent biases influence the overall conclusions of the analysis.

For the purposes of this research, these responses are broadly consistent with the findings of the surveys and interviews conducted in the project, which are presented in the following sections. Together, these complementary sources of evidence strengthen the robustness of the analytical framework underpinning the PESTEL and SWOT analyses presented in this deliverable.

Survey key findings

The survey collected 39 validated responses from stakeholders across 12 countries, distributed across the four organisational profiles as follows:

- Research, University, and Policy organisations: 20 responses (51%)
- Industries with Heat Upgrade Technologies integrated: 7 responses (18%)
- Heat Upgrade Technology manufacturers: 7 responses (18%)
- Industries without Heat Upgrade Technologies: 5 responses (13%)

While the respondent pool reflects the composition of the Push2Heat consortium and its networks, with research, university, and policy institutions accounting for just over 50% of responses, the dataset benefits from a notable diversity of industrial sectors, countries, and professional backgrounds across all four profiles. This breadth ensures that the findings capture a wide range of perspectives on HUT deployment, from hands-on operational experience to regulatory and academic insight. Key thematic findings from the pre-analysis confirmed that political, social, and economic factors were the most consistently cited dimensions across all respondent profiles. Technical barriers were particularly prominent among industries with HUT experience, while environmental and legal factors were most frequently raised by research and policy respondents.

Which of the following groups does your organization most closely resemble?

39 respuestas

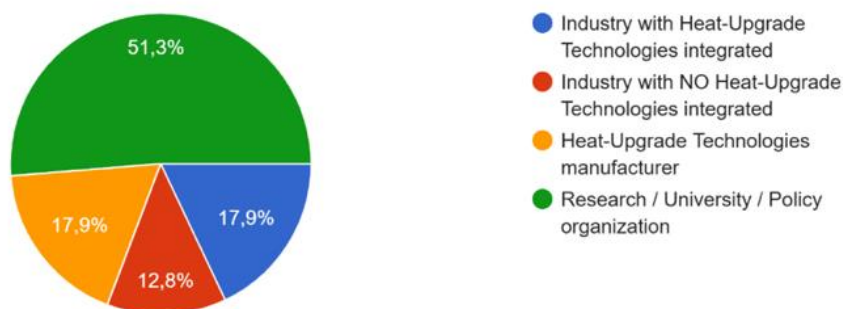


Figure 10. Final graph of respondent's profile by type

Among industries already operating HUTs, the most critical technical barriers identified were high initial investment and installation costs, maintenance and operational challenges, and inadequate supply chain or manufacturer support.

Rank the main technical challenges you have faced when implementing waste heat recovery technologies.

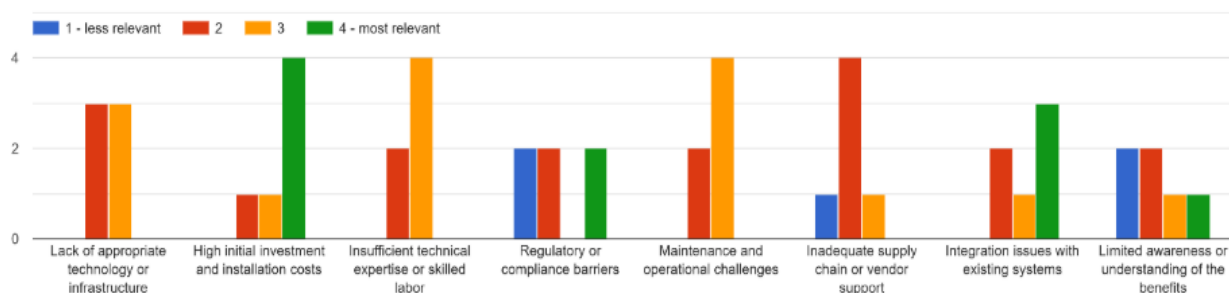


Figure 11. Main technical challenges when implementing waste heat recovery technologies (from technical perspective)

The survey also collected data on the actual waste heat sources and temperature ranges currently present in the facilities of respondents with HUT experience, providing a concrete empirical picture of the deployment context. Most respondents provided information on the annual waste energy generated by their processes, reflecting a clear interest in quantifying and optimising energy recovery potential. The data confirm that waste heat sources span a wide range of temperatures and industrial applications, from ammonia condensers and CIP waters at 70 to 80°C to exhaust air from dryers at up to 90°C, feeding into sink processes requiring temperatures between 80°C and 130°C. This temperature mapping, summarised in Table 1, confirms strong technical compatibility between the waste heat profiles identified in the survey and the operating range of the Heat Upgrade Technologies demonstrated in the Push2Heat project:

Table 2. Waste heat sources and sink processes identified in the stakeholder survey

Source Process (Waste Heat)	Temperature Range	Sink Process (Heat Demand)	Temperature Range
Ammonia condensers from cooling facilities	70–80°C	Hot water for scalding (food industry)	80–90°C
Stack heat from frying vapors	70–80°C	Industrial frying and cooking	80–90°C
CIP waters, waste pasteurization water	70–80°C	Pasteurization	90–110°C
Wastewater from steel mill process	20°C	District heating	~90°C
Exhaust air from dryers	50–90°C	Steam for drying process	110–130°C

Beyond technical data, the survey also captured the policy and support landscape as experienced directly by industrial respondents. Even among industries that have already integrated HUT systems, the majority highlighted political opportunities as important enablers of broader deployment, pointing to government incentives, public-private partnerships, and regulatory support as factors that remain relevant even for early adopters. This suggests that policy support is not only a barrier for those yet to adopt but a continued enabler for scaling up existing installations.

Responses regarding the availability of financial support and guidance were varied, reflecting the fragmented nature of the policy landscape across EU Member States. Some respondents reported benefiting from specific financial instruments such as Energy Saving Certificates (CAEs), subsidies, and tax reductions, which had helped make heat pump solutions more economically competitive. Others relied primarily on support from research institutes rather than government bodies. The European Regional Development Fund (ERDF) was also mentioned as a source of financial aid by some participants. However, a number of respondents reported receiving no government support at all, highlighting the uneven distribution of incentives across countries and the extent to which access to financial mechanisms depends on the specific Member State and the availability of local energy agencies and sector associations to facilitate guidance and application processes.

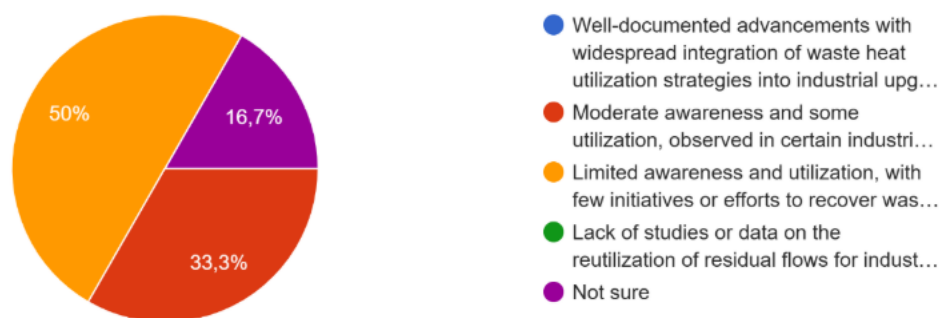


Figure 12. Stakeholder perception of the role and characterisation of HUTs for industrial applications by country

3.5 Roundtables

The survey findings were validated and enriched through two national roundtables. Prior to each event, speakers were provided with a document summarising the preliminary findings of the PESTEL analysis derived from the survey data. They were invited to reflect on these results from their own professional perspective, validate the barriers and opportunities identified, and highlight any dimensions they felt had not been sufficiently addressed. To ensure that all six PESTEL dimensions were covered, participants were selected to represent a broad range of profiles, including policymakers, researchers, manufacturers, and industrial end-users, ensuring that both the audience and the speakers could contribute meaningfully to the discussion from their respective areas of expertise. This approach allowed the roundtables to go beyond simple confirmation of the survey findings, generating new insights and adding the qualitative depth that a quantitative survey alone cannot provide.

Roundtable 1 — The Road to Sustainable Industrial Heat: A Roundtable on the Future of Industrial Heat Pumps

Online event, 22 May 2025, organised jointly by Push2Heat and SPIRIT projects

The first roundtable was held as an online webinar under the title "The Road to Sustainable Industrial Heat: A Roundtable on the Future of Industrial Heat Pumps". It brought together speakers from academia, industry, and the policy sector to present and discuss the preliminary findings of the Push2Heat PESTEL analysis. The event was

structured around four thematic presentations followed by a moderated panel discussion.

Speaker	Organization/company	Role
Paola Maio	EHPA	Welcome, introduction and overview of PESTEL findings
Jozefien Vanbecelaere	EHPA	EU policy and regulatory landscape on industrial heat pumps
Cordin Arpagaus	OST – University of Applied Sciences Eastern Switzerland	Perspectives on the Technical and Economic Factors of Industrial Heat Pumps through the PESTEL lens
Milen Perez Camman	CARTIF	Reflections from the Field on the Future of Heat Upgrade Technologies: An Academic Perspective
Tor Hodne	SPH (Sustainable Process Heat)	Perspectives from an industrial heat pump manufacturer
Bart Aerts	Tiense Suikerraffinaderaij	Insights from an industrial heat pump end-user

Roundtable-validated findings

High CAPEX and limited financing confirmed as the primary economic barrier across all stakeholder profiles

Integration complexity and skills shortage confirmed as the leading technical obstacles to deployment

Unfavourable electricity-to-gas price ratio confirmed as the dominant structural economic barrier

Low awareness among industrial decision-makers confirmed, particularly in food, chemicals, and pharma

Additional insights from the roundtable

Trust-confidence cycle: the absence of high-temperature reference installations creates a self-reinforcing barrier that financial incentives alone cannot resolve

Total project cost underestimation: the HP unit represents only ~50% of total investment – remaining costs are systematically overlooked at the project assessment stage

Economy of scale: specific investment cost per unit of thermal output declines as system capacity increases – an underexplored market development lever

Food industry compliance cascade: ATEX zoning and mandatory food risk analyses add layers of safety costs specific to food sector end-users

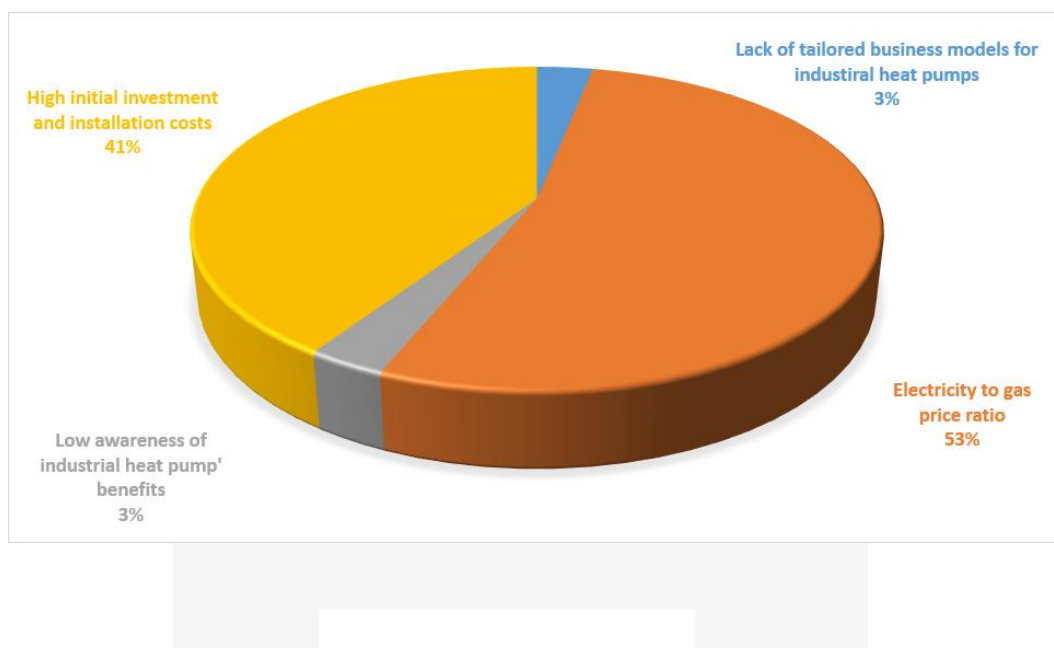


Figure 13. Result from the live poll survey on “What is the primary non-technical challenge preventing a stronger uptake of heat pumps in industry?”, launched during the event “The Road to Sustainable Industrial Heat: A Roundtable on the Future of Industrial Heat Pumps”

Roundtable 2 — Challenges and Opportunities for Industrial Adoption

Madrid, 22 October 2025 - Held within the Tecnalía Workshop: “High Temperature Heat Pumps for Industrial Decarbonisation”

The second roundtable was held in person in Madrid as part of the Tecnalía workshop on high-temperature heat pumps for industrial decarbonisation, focusing on the Spanish and Basque Country context. It brought together five participants representing a policy agency, a research centre, a university, an HTHP manufacturer, and an energy utility, providing a cross-sectoral perspective on the conditions for industrial heat pump deployment in Spain.

Speaker	Organization/company	Role
Cristina Oyón	SPRI – Basque Agency for Industrial Strategy	Policy / public authority
Miguel Ramirez	TNO	Research center
José Ignacio Linares	ICAI	University
Jose Pascual Martí	RANK	HTHP manufacturer
Ignacio Flores	ENGIE	Energy utility

The roundtable was structured around three thematic blocks: **economy and trust; scale and industrial policy**; and **energy flexibility and future vision**. The Basque Country Net Zero Basque Industrial Super Cluster (NZBISC) was discussed as a leading regional initiative, with initial estimates suggesting that electrification with heat pumps could reduce the region's annual industrial CO₂ emissions – currently approximately 5.7 million tonnes – by up to 15%. The role of EU projects in building trust through demonstration, fostering knowledge exchange, and reducing technological risk was consistently emphasised across all participants.

Roundtable-validated findings

- Electricity-to-gas price ratio as the dominant economic barrier
- Regulatory uncertainty deterring long-term industrial investment
- Need for real-world demonstrations to build trust and confidence
- Role of EU projects in reducing technological risk through early pilots
- Importance of collaboration across the full value chain

Additional insights from the roundtable

- Electrification with HPs could reduce Basque Country industrial CO₂ by up to 15% from a baseline of 5.7 Mt/yr (NZBISC)
- Energy flexibility as a value layer: combining thermal storage with HPs enables price arbitrage, ancillary services, and capacity market participation – an economic dimension beyond heat supply cost reduction not identified in the survey
- Public authority constraints: regional bodies such as SPRI are limited by national and EU regulatory frameworks in their ability to provide direct CAPEX or OPEX support – a critical nuance for the design of regional financial support mechanisms

4. PESTEL Analysis

The analysis examines the macro-environmental factors affecting the deployment of industrial Heat Upgrade Technologies (HUTs), specifically heat pump systems capable of supplying process heat in the temperature range of 90°C to 160°C, across Europe. The analytical framework follows the PESTEL methodology (Political, Economic, Social, Technical, Environmental, Legal), used as a structured tool to identify and assess external drivers shaping the conditions for HUT deployment at scale.

The findings are derived from four complementary sources, which together ensure that the analysis is grounded in both empirical data and expert knowledge:

- **Regulatory and policy analysis:** a review of the relevant EU legislative framework and national policy landscape in the Push2Heat demonstration countries (Belgium, Italy, and Germany), covering the most relevant instruments addressing industrial electrification and large-scale heat pump deployment.
- **Stakeholder survey:** an online questionnaire collecting 39 validated responses from 12 countries, distributed across four organisational profiles: research, university and policy organisations (20 responses); industries with HUTs integrated (7); HUT manufacturers (7); and industries without HUTs (5).
- **National roundtables:** two structured events bringing together policymakers, researchers, manufacturers, and industrial end-users from Push2Heat demonstration countries. Prior to each event, speakers were provided with a summary of the preliminary PESTEL findings derived from the survey data and invited to validate, challenge, and enrich these results from their own professional experience. The roundtables confirmed the main barriers and opportunities identified in the survey while adding new qualitative insights that the quantitative data alone had not fully captured.
- **Literature review and position papers:** a review of relevant scientific publications, consortium reports, SPIRIT project deliverables, and EHPA position papers, which provided additional quantitative evidence, sectoral data, and policy context to complement and strengthen the empirical findings.

Key factors identified for each PESTEL dimension were rated High or Medium based on two combined criteria: (1) the frequency with which the factor was identified across the empirical sources consulted, including the stakeholder survey, two national roundtables, and the scientific and policy literature reviewed; and (2) its assessed direct impact on HUT deployment decisions, defined as whether a change in that factor would directly influence an industrial operator's decision to invest in or proceed

with a heat pump project. Factors meeting both criteria, identified across multiple sources and with a direct, determinant influence on investment decisions, were rated High. Factors meeting only one criterion, either identified in fewer sources or with an indirect or contextual rather than determinant influence, were rated Medium.

4.1 Political

The political dimension assesses the extent to which EU and national governance frameworks, regulatory mandates, and policy instruments shape the macro-environment for industrial HUT deployment. Despite growing political ambition at EU level, reflected in the Clean Industrial Deal and the Affordable Energy Action Plan, significant structural gaps persist at both EU and national level, creating an uncertain and often unsupportive environment for industrial electrification investment.

Key factors

Long-term regulatory certainty	Major barrier	Without stable policy frameworks, industrial operators delay or avoid long-term investment decisions
Subsidies still favouring fossil fuels	Major barrier	Existing support mechanisms in many MS reward fossil fuel-based heating over decarbonised alternatives
No electrification requirements in industrial permits	Minor barrier	New and renovated industrial facilities are not required to assess or adopt electrification at the permitting stage
Fragmented policies across Member States	Minor barrier	HUTs absent from most national decarbonisation strategies; no EU-wide framework for excess heat recovery

Poor grid access for new installations	Minor barrier	Long delays or refusals for grid connection upgrades block otherwise viable industrial HP projects
Regional policy leadership	Minor opportunity	Initiatives like Flemish Climate Leap Contracts and Basque NZBISC demonstrate replicable models for regional industrial decarbonisation
EU Clean Industrial Deal & policy mandates	Major opportunity	Emerging EU framework explicitly supports industrial heat decarbonisation
EU Electrification Action Plan (July 2026)	Major opportunity	First-ever binding KPIs: electricity-to-gas ratio max 2.0 for industry by 2030, waste heat KPI of 11% by 2050
Mandatory waste heat recovery plans	Major opportunity	Requiring recovery plans as a permit condition would generate a large policy-driven pipeline of HUT projects
ETS2 expansion from 2027	Major opportunity	Extends carbon pricing to 8,000–11,000 smaller industrial consumers, strengthening the case for electrification when combined with energy taxation reform

Barriers

Lack of long-term regulatory certainty. Industrial decision-makers require confidence that electrification will remain a strategic political priority over multi-decade investment horizons. Survey respondents and roundtable participants consistently identified regulatory uncertainty as one of the most critical barriers to HUT deployment. This finding is reinforced by the broader literature: Aydemir et al. (2026), in a survey of industrial companies across Germany, confirm that the current policy environment is perceived as insufficiently predictable, actively discouraging firms from transitioning to heat pump solutions. **The challenge is no longer technology readiness but a coherent policy framework creating the policy, market, and infrastructure conditions that allow industrial heat pumps to scale across European industry.**

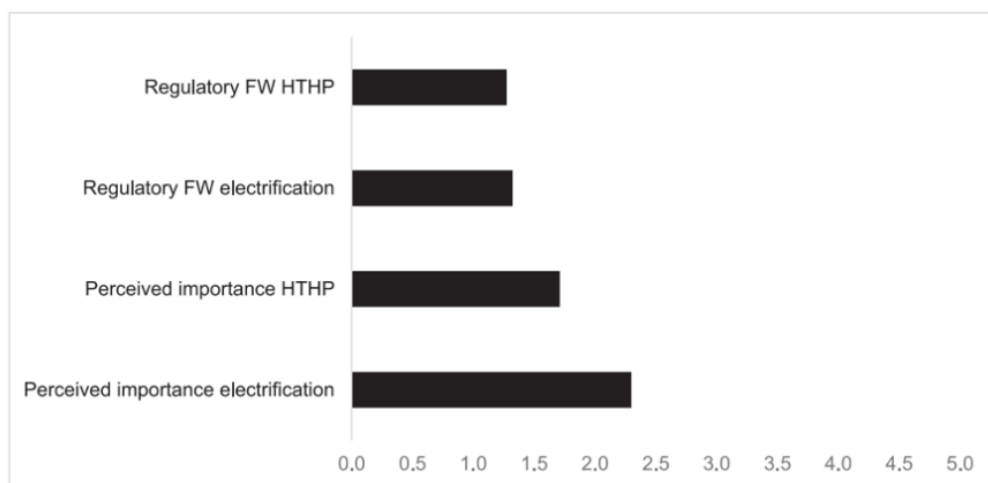


Figure 14. Scoring of the regulatory framework (FW) and perception of industrial electrification by policymakers (Rosenow et al. (2025): The Heat Is On: Policy Solutions for Industrial Electrification)

Subsidies still favouring fossil fuels in many Member States. Existing support mechanisms in many Member States continue to reward fossil fuel-based industrial heating rather than decarbonised alternatives. This misalignment makes the policy environment not only uncertain but actively contradictory for industrial operators trying to justify electrification investments, undermining the stated goals of the European Green Deal.

No electrification requirements in industrial permits. Current permitting and licensing procedures do not require industrial operators to consider or adopt electrification when building new facilities or renovating existing ones. Both roundtables proposed that new or renovated industrial plants should be required to demonstrate that electrification has been assessed and adopted wherever technically and economically feasible. This represents a significant missed regulatory opportunity to drive technology uptake at a critical decision point in the industrial investment cycle.

Fragmented policies across Member States. HUTs are frequently absent from national decarbonisation strategies, and there is no EU-wide framework specifically addressing excess heat recovery as a strategic energy resource. The analysis of the NECPs of the three Push2Heat demonstration countries confirms that references to industrial heat pumps remain largely non-binding and disconnected from concrete deployment targets, with significant variation in the availability and design of support instruments across Belgium, Germany, and Italy.

Poor grid access for new installations. Many factories willing to install heat pumps face long delays or outright refusals for grid connection upgrades, a concrete operational barrier that no financial incentive can compensate for on its own.

Opportunities

EU Clean Industrial Deal and CISAF. The Clean Industrial Deal and the Clean Industrial Deal State Aid Framework, which entered into force on 25 June 2025 and applies until 31 December 2030, represent the most comprehensive EU policy package directly relevant to industrial heat pump deployment to date. CISAF mobilises over €100 billion for EU-based clean manufacturing, with explicit coverage of industrial heat decarbonisation and waste heat reuse below 400°C.

Mandatory waste heat recovery plans. Requiring industrial facilities to develop waste heat recovery plans as a condition of new permits or licence renewals was identified consistently across both roundtables and by EHPA's position as one of the most impactful political levers available. The precedent set by the EED for data centres above 1 MW demonstrates that this type of obligation is legally and administratively feasible.

EU Electrification Action Plan — a milestone for industrial heat pump deployment.

On 17 July 2026, the European Commission published the Electrification Action Plan⁴⁴, representing a landmark moment for the industrial heat pump sector. For the first time, the EU has set quantitative targets directly relevant to HUT deployment: **a maximum electricity-to-gas price ratio of 2.0 for industry by 2030, a waste heat recovery KPI of 11% of EU heat demand by 2050, and a target of 4 million heat pump installations per year by 2030**. The plan explicitly recognises that around 60% of industrial fuel-based energy demand can be electrified using heat pumps, and backs this with concrete support measures including the Industrial Decarbonisation Bank, a second Innovation Fund industrial heat auction, sector-specific electrification roadmaps, and investment in grid connections, thermal storage, and energy management systems. The EU Waste Heat Initiative, expected by Q2 2027, and the introduction of a clean heat market mechanism by 2027 further reinforce the regulatory and financial framework for HUT deployment. A legislative proposal to rebalance electricity-to-gas price ratios through reforms to taxation and network charges has been published alongside the plan.

ETS2 expansion from 2027. The extension of the Emissions Trading System to smaller industrial consumers, estimated to cover between 8,000 and 11,000 installations across Europe⁴⁵, represents a significant political step toward making fossil-based industrial heating progressively more expensive and strengthening the relative competitiveness of heat pump technologies. For many industrial operators that have so far operated outside any carbon pricing framework, ETS2 will introduce for the first time a direct financial incentive to reduce emissions, creating new market conditions that favour electrification. The effectiveness of this instrument will however depend on how it is designed and implemented alongside complementary measures. Carbon pricing works best as an enabler of HUT deployment when the electricity-to-gas price ratio is already at a level where electrification is economically viable, meaning that ETS2 is most powerful when combined with parallel action on energy taxation and electricity costs⁴⁶. If these conditions are in place, ETS2 has the potential to be a structural game-changer for industrial heat pump markets across Europe.



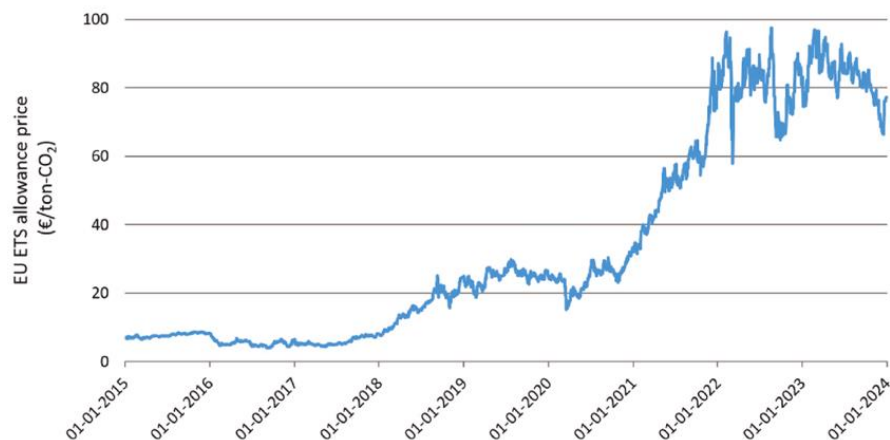


Figure 15. Price evolution of the EU ETS allowances between January 1st, 2015 and December 31st, 2023 (Source Högnabba et al., 2024).

Regional policy leadership. Proactive regional initiatives such as the Flemish Climate Leap Transition Contracts and the Basque Country NZBISC demonstrate the impact achievable when political leadership at regional level is aligned with industrial decarbonisation strategy. Initial estimates from the NZBISC suggest that electrification with heat pumps could reduce the region's annual industrial CO₂ emissions by up to 15%, providing a replicable model for other EU regions.

4.2 Economic

The economic dimension examines the financial conditions, cost structures, and business model frameworks that determine investment viability for HUTs. Economic barriers were the most consistently reported findings across all sources. A key insight is that HUT projects are frequently technically sound and economically viable over their lifetime, yet fail to progress due to structural mismatches between financing mechanisms and investment profiles.

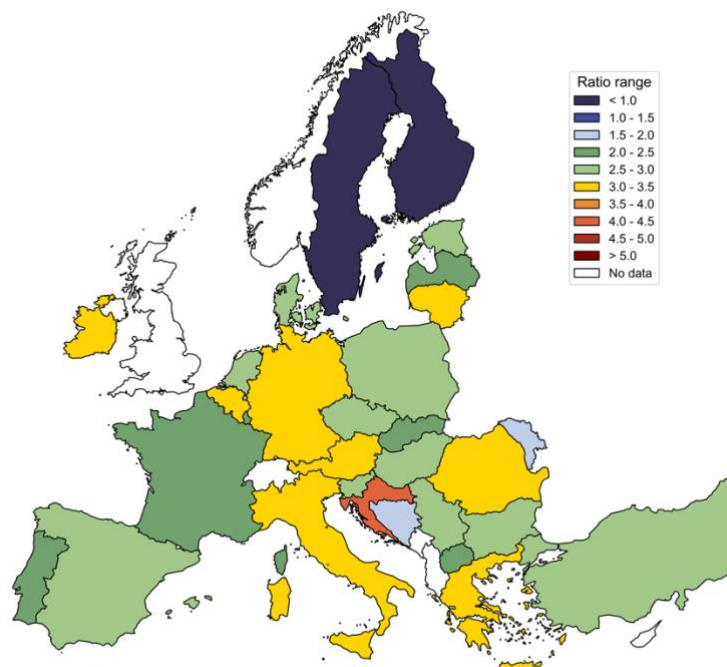
Electricity-to-gas price ratio	Major barrier	High electricity costs make fossil fuels cheaper for most industrial operators
CAPEX and access to finance	Major barrier	High upfront costs and complex subsidy processes prevent many industries from investing
Payback period expectations	Major barrier	Short payback expectations make HUT investments hard to justify internally
Lack of tailored business models	Major barrier	Generic financing structures do not match HUT deployment needs
Strong European industrial value chain	Major opportunity	Robust European HP manufacturing base and local value chain ready to scale
EU Innovation Fund & CISAF	Major opportunity	Fixed-premium structure covers CAPEX, OPEX and thermal storage up to €1bn for a second round (2026)

Economy of scale in HP manufacturing	Minor opportunity	Scaling up system size and market volume reduces investment costs
Heat-as-a-Service and innovative financing	Minor opportunity	HaaS, ESCO, and leasing models reduce upfront barriers; identified as top emerging models

Barriers

Electricity more expensive than gas across most EU countries. The price ratio between electricity and natural gas is the single most critical economic determinant of heat pump competitiveness. Heat pumps are most competitive when electricity costs no more than twice the price of gas — yet in many EU Member States this threshold is significantly exceeded, with electricity taxed three to seven times more than gas in some countries.

Electricity to gas price ratio for industry - first half 2024



Source: Eurostat (nrg_pc_203 ; nrg_pc_205). These electricity to gas prices apply to the industrial and commercial sectors, consumption bands are 2 GWh/a to 20 GWh/a of electricity, 3 GWh/a to 28 GWh/a of gas.

Figure 16. Electricity to price gas ratio for industry– first half 2024

Empirical evidence confirms a direct correlation between this price gap and market size: the eight countries in Europe that tax electricity at least three times more than gas were all among the smallest heat pump markets relative to their population in 2024⁴⁷. This price gap is not a market outcome but a policy-driven distortion, largely the result of taxes, levies, and grid charges being disproportionately concentrated on electricity bills rather than on fossil fuel consumption.

High upfront investment costs: High CAPEX remains a primary obstacle, particularly for SMEs and industries with tight margins. An important nuance emerging from the roundtables is that the heat pump unit itself represents only approximately 50% of total project cost, with the remaining expenditure required for heat source connection, grid connection, planning, and construction. This systematic underestimation of total project costs distorts ROI assessments and contributes to investment hesitation even in projects that are economically sound when properly evaluated on a lifecycle basis. Financial support to reduce the initial investment barrier is therefore essential, and without it, even industries that are aware of the long-term benefits are unlikely to proceed.

Short payback expectations: Industrial decision-makers typically expect payback periods of two to three years, which are structurally misaligned with HUT investment profiles that generate value over 15 to 25 year asset lifetimes. The absence of lifecycle cost analysis in industrial procurement practices leads to systematic undervaluation of long-term economic benefits. Economic analysis across European countries confirms that discounted payback periods for industrial heat pumps vary widely depending on the electricity-to-gas price ratio: in Finland and Sweden, payback periods of under two years are achievable, while in Germany and the United Kingdom the investment remains unprofitable under current price conditions.⁴⁸

Limited access to finance: Access to financing remains restricted, and subsidy application processes are frequently perceived as overly complex and administratively burdensome. A fundamental mismatch exists between available financing structures and HUT business models: funding mechanisms do not align with the investment timelines and cash flow profiles of industrial HUT installations. Specific support should be directed toward SMEs and energy-intensive industries that could

benefit from heat pump technologies but are often discouraged by high upfront costs and limited technical knowledge.

Lack of tailored business models: Heat-as-a-Service, ESCO-based approaches, and leasing models, which could substantially reduce upfront cost barriers, are not yet widely deployed. The market remains dominated by direct purchase arrangements that concentrate the full financial burden on the industrial end-user, limiting access particularly for SMEs and industries with constrained capital. This is compounded by the fact that operating expenses for industrial processes are often not eligible for EU funding, meaning that even where CAPEX support is available, the ongoing cost of electricity at current prices can still make projects financially unattractive.

Opportunities

EU Innovation Fund Auction for industrial heat: The Innovation Fund Heat Auction represents one of the most directly applicable financial instruments for HUT projects currently available at EU level. Its fixed-premium structure, covering CAPEX, OPEX, and thermal storage costs, directly addresses the investment viability gap. The strong participation in the first round – 85 bids from 10 countries with €1.4 billion requested against a €1 billion budget – confirms significant market interest, and the confirmed second round with a budget of up to €1 billion signals growing institutional commitment to this instrument.

Table 3. Innovation Fund Auction on Industrial Process Heat Decarbonisation – Results first auction

Country	Proposals	Selected	Budget
Spain	27	24	135.6 M
France	27	21	100.6 M
Belgium	8	6	18.3 M
Germany	9	4	26.7 M
Portugal	3	3	7.4 M
Denmark	2	2	32.2 M
Czechia	2	2	17.2 M
Austria	1	1	37.1 M
Hungary	1	1	17.9 M
Slovenia	1	1	3.5 M

Technology	High-Temp	Mid-Temp >5 MW	Mid-Temp 3 to 5 MW
Direct resistance	3	18	7
Indirect resistance	0	15	7
Heat Pump	0	5	2
Solar thermal	0	2	0
Other	2	4	0
Geothermal	0	0	0

Strong European industrial value chain. Europe manufactures 60–73%⁴⁹ of the heat pumps installed on its territory, with around 300 production sites and 170,000 direct jobs. The industrial heat pump segment benefits from a complete local supply chain covering all key components, confirmed by the JRC, giving Europe a strong foundation to scale HUT deployment rapidly if the right market and policy conditions are in place.

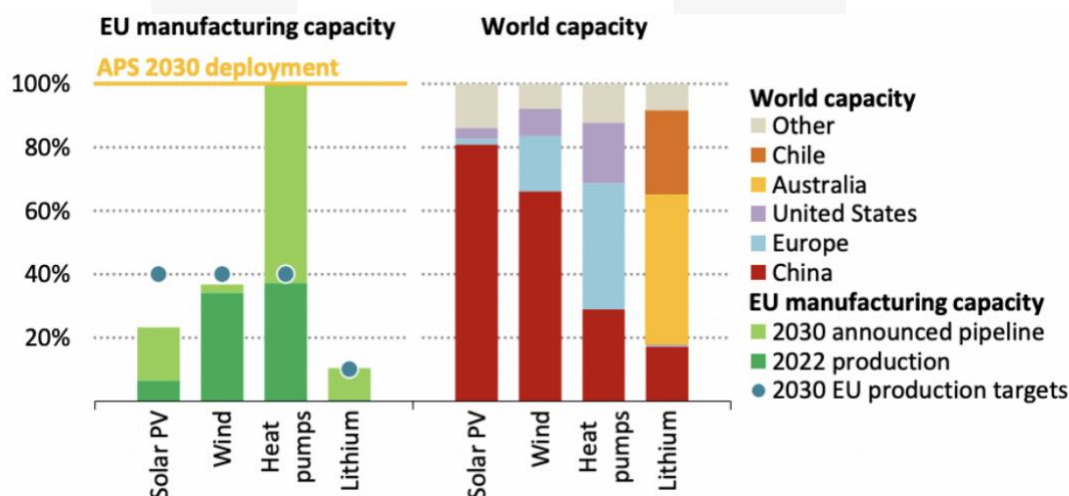


Figure 17. Manufacturing capacity in the European Union as share of APS(announced pledges scenario) development levels and global capacity by regions by 2030

(Source: IEA energy outlook 2023)

Europe's strength lies not only in manufacturing but particularly in **system engineering and system integration**; large heat pump projects are highly application-specific and require close integration with industrial processes, and European system integrators, engineering consultancies, and EPC contractors play a central role in project development and optimisation. This combination of manufacturing capacity and engineering expertise provides a solid foundation for scaling industrial heat pump deployment, provided that demand signals are sufficiently stable and predictable to justify investment in expanded production capacity

CISAF and national state aid schemes: CISAF provides Member States with a clear legal basis to support industrial decarbonisation investments through grants, loans, guarantees, and tax advantages. The European Commission should coordinate qualitative support schemes at EU level, similar to the auctions-as-a-service system, to ensure that national subsidy schemes are well-designed and effective. At national level, instruments such as Energy Saving Certificates in Spain, the Basque Country's 35% tax relief for clean technology investments, Italy's Transition 5.0 package, and the Flemish Climate Leap Transition Contracts demonstrate that targeted fiscal policy can meaningfully shift the economic case for HUT adoption.

Rebalancing energy taxation. The most powerful economic enabler available to policymakers is the correction of the electricity-to-gas price ratio through energy taxation reform. Electricity should not be taxed more heavily than fossil fuels, and the polluter pays principle should be reflected in energy bills so that the true societal and environmental costs of fossil fuels are accounted for. Member States should review their energy taxation policy to ensure electricity prices are no more than twice the price of gas, as recommended by EHPA in its position on the Electrification Action Plan. Countries that have already taken this approach, such as Finland and Sweden, demonstrate significantly higher and more stable heat pump deployment rates. The publication of the EU Electrification Action Plan on 17 July 2026 marks a significant step forward: for the first time, the European Commission has set a binding KPI requiring Member States to reduce the electricity-to-gas price ratio to a maximum of 2.0 for industry by 2030⁵⁰, translating a long-standing EHPA recommendation into a concrete EU-level target.

Heat-as-a-Service and innovative financing: HaaS, ESCO-based approaches, and leasing schemes reduce upfront cost barriers by shifting investment risk away from the industrial end-user. These models are particularly effective for customers who do not wish to commit capital and want performance guarantees and were consistently identified across both roundtables as among the most promising pathways for accelerating adoption. The European Investment Bank should develop targeted financial products, including reduced-rate loans and risk-sharing mechanisms, to further support industrial electrification.

Economy of scale reducing investment costs: As manufacturers increase system capacity and the market grows, specific investment costs per unit of thermal output decline. Early engagement between project developers and HP suppliers for thorough techno-economic analyses is recommended to capture these scale benefits and avoid the systematic underestimation of project costs identified in our survey and roundtables.

Growing organic market demand: Manufacturers report receiving five to ten direct industry inquiries per week without active marketing, indicating strong latent demand that improved economic conditions could rapidly convert into market uptake at scale.

4.3 Social

The social dimension addresses awareness levels, cultural attitudes, trust in emerging technologies, and knowledge-sharing dynamics across industrial sectors. It was consistently identified across all sources as both a major barrier and a key leverage point for accelerating HUT adoption. A particularly striking finding from the survey and roundtables is that many industrial operators are unaware not only of the technology itself, but of the fact that the resources needed to make it work, waste heat from their own processes, are already available within their facilities.

Low awareness of HUT potential	Major barrier	Low awareness among engineers, plant managers and decision-makers in key industrial sectors
Trust and technology maturity perception	Major barrier	Distrust due to limited reference installations; concerns about durability and reliability
Knowledge of internal waste heat potential	Major barrier	Most industrial operators unaware that internal process waste heat can serve as HP source
Knowledge transfer and information sharing	Major opportunity	Systematic sharing of capabilities, design, control and application experience is urgently needed
Demonstration projects as trust-builders	Major opportunity	Real-world demonstrations provide verifiable evidence and replicable blueprints
Training and qualification of personnel	Minor opportunity	Targeted education for energy planners, engineers, installers and consultants

Barriers

Low awareness among engineers and decision-makers: Awareness of HUT potential remains low, particularly in food processing, chemicals, and pharmaceuticals. Many end-users are unaware that waste heat generated within their own processes could serve as a viable heat source for upgrading. This knowledge gap operates at multiple levels: decision-makers lack awareness of the technology's potential, engineers lack the skills to assess and design installations, and procurement teams lack the frameworks to evaluate HUT projects against conventional alternatives. Survey data from Fraunhofer ISI confirm that the specification of performance characteristics and the identification of suitable suppliers are among the most challenging aspects of the purchasing process for industrial heat pumps, reflecting a fundamental gap in practical knowledge across the value chain.⁵¹

Trust deficit and preference for proven systems. Industrial actors systematically favour established fossil-based systems. The limited number of publicly documented reference installations creates a chicken-and-egg problem: customers hesitate without references, but references can only be created by early adopters willing to take on the associated risk. This dynamic is particularly pronounced for high-temperature applications above 150°C, where the evidence base remains thin. Findings from the Fraunhofer ISI survey confirm that concerns about integration into existing production structures and the risk of production downtime are rated as both highly important and highly challenging by industrial respondents, reflecting a deeper cultural resistance to any technology that disrupts established operational routines.

Unawareness of internal waste heat as a source. Most industrial operators do not know that internal process waste heat can serve as a heat pump source, representing a significant missed opportunity for HUT deployment. This unawareness is compounded by the fact that waste heat is often an invisible by-product of cooling processes, not recognised as an energy resource by the engineers and plant managers responsible for energy decisions.

Limited knowledge sharing across sectors. Successful HUT applications in one industrial sector rarely reach decision-makers in others, preventing replication of viable solutions. The food and beverage sector, for example, has accumulated

meaningful experience with heat pump integration, but this knowledge does not systematically flow to the chemicals or paper industries where similar applications are technically feasible.

Opportunities

Demonstration projects as trust-building tools. Real-world demonstrations under industrial conditions are the most effective trust-building mechanism, providing verifiable performance evidence and replicable blueprints for other industries. The Push2Heat project itself contributes directly to this need by demonstrating HUT systems at scale in real industrial environments across five EU countries. As confirmed by both roundtables, building confidence through proven examples is essential to overcoming technological scepticism and driving adoption at scale.

Knowledge transfer and information sharing. Systematic sharing of capabilities, design, control, integration experience, and suitable applications is urgently needed to accelerate market development. This was identified as the first key recommendation by OST at the first roundtable, and is supported by the broader literature, which highlights inter-organisational knowledge exchange as a critical enabler of technology diffusion in industrial markets.

Training programmes for engineers and operators. Targeted education for energy planners, engineers, managers, installers, and consultants would significantly expand the pool of qualified actors capable of designing and implementing HUT projects. Training and reskilling should be integrated into EU industrial, energy, and social policy frameworks, including the Pact for Skills, with harmonised qualification frameworks and mutual recognition of skills across Member States to enable labour mobility.

Collaboration with end-user industry associations. One of the most effective ways to reach industrial decision-makers is through their own sector associations, which have established trust, communication channels, and technical credibility within their industries. A concrete example of this approach is the joint paper published by EHPA and the Confederation of European Paper Industries (CEPI), which demonstrates how collaboration between the heat pump sector and a major energy-intensive industry can generate targeted, sector-specific guidance that is far more likely to reach and influence plant managers and engineers than generic technology promotion. EHPA is committed in replicating this collaboration with other industrial associations in chemicals, food and beverage, and pharmaceuticals.

4.4 Technical

The technical dimension examines the practical barriers and enablers related to the deployment of HUT systems in industrial settings. For a non-technical audience, the most relevant aspects are not the engineering details of heat pump design but the systemic conditions, infrastructure readiness, workforce availability, standardisation, and integration complexity, that determine whether technically viable projects can actually be built and operated at scale.

System integration complexity	Major barrier	HUTs are not plug-and-play; bespoke engineering required, unlike conventional boilers
Grid access and electricity supply	Major barrier	Grid upgrade delays and insufficient on-site electricity capacity block installations
Shortage of skilled engineers and integrators	Major barrier	Structural skills gaps require sustained investment in training and certification across Member States
Lack of standardisation	Major barrier	Absence of common standards increases costs, planning effort and implementation risk
High temperature lifts reducing COP	Minor barrier	Large source-to-sink temperature differentials reduce system efficiency
European Grids Package (voted July 2026)	Major opportunity	Speeds up grid connection approvals and permitting, directly tackling delays for industrial projects

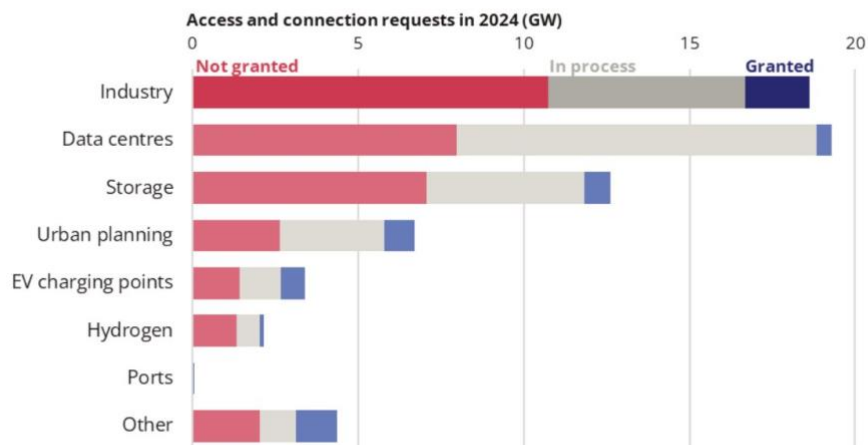
R&D in HTHPs, hybrid systems and AI optimisation	Major opportunity	Active research pipeline addressing efficiency, refrigerants, and integration challenges
Improved standardisation and interoperability	Major opportunity	Standardisation reduces costs, planning effort and multiplies application potential

Barriers

Integration complexity: Unlike conventional boilers, industrial heat pumps cannot be deployed as off-the-shelf replacements. Each installation requires bespoke engineering, tailored to the specific heat sources, temperature requirements, and process configurations of the individual facility. This increases project costs, extends delivery timelines, and demands a level of specialist expertise that is currently in short supply. For industrial operators, the perceived risk of production downtime during integration is one of the most significant deterrents: survey data confirm that integration into existing production structures is rated as both the most important and most challenging aspect of the heat pump purchasing process.

Inadequate grid infrastructure is one of the most concrete and immediate operational barriers to industrial heat pump deployment. Many factories willing to install heat pumps face long delays or outright refusals for grid connection upgrades, reflecting the insufficient priority given to industrial electrification in national grid investment planning. Real-world examples illustrate the scale of this problem: the German Paper Manufacturers Association reports average delays of 5 to 10 years even for projects in the 10 to 50 MW range due to grid congestion, while an anonymous brewery in Belgium faced a 5-year delay because the local distribution grid node does not allow for added capacity until 2030. Requests for connection to the Spanish grid have increased significantly in recent years, totalling over 67 GW of capacity in 2024, a more than tenfold increase from 2022. Industry was one of the most significant sectors requesting connections, along with data centres. Only 10% of the industrial connection capacity requested was awarded a connection.⁵²

Most industrial demand connection requests in Spain get rejected



Source: Spanish distribution system operators; data retrieved from Aelee & Deloitte, September 2025, [Conectando el futuro: Redes eléctricas para una España más competitiva](#)

Figure 18. Access and connection request in Spain (2024)

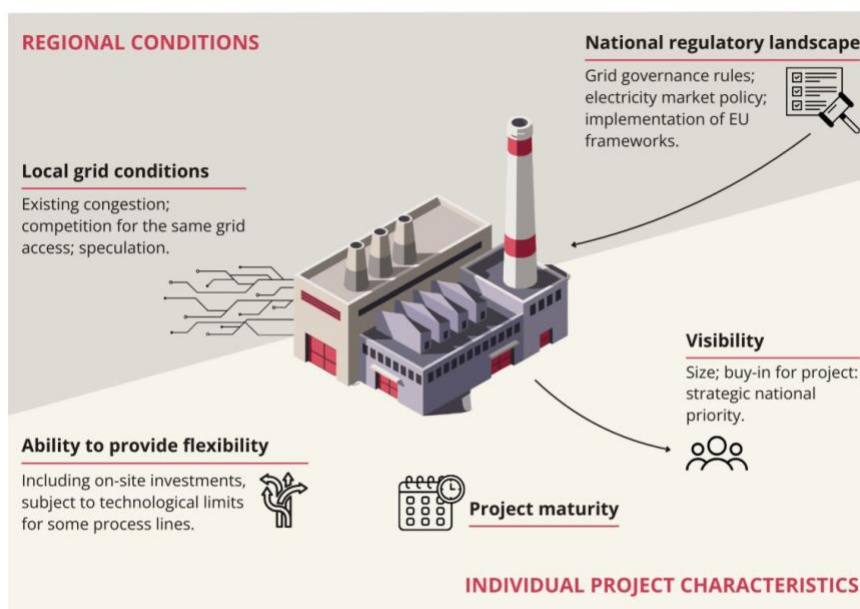


Figure 1: Queues for grid access to electrify industrial projects are increasing, but what determines whether a project secures access? Often, a combination of regional conditions and individual project characteristics is at play.

Figure 19. Factors affecting industrial grid access (Source: E3G, 'Industrial electrification in the EU blocked by the grid')

Shortage of skilled engineers and integrators. The pool of engineers, technicians, and integrators capable of designing, commissioning, and maintaining HUT systems is insufficient relative to growing market demand. This skills gap is structural in nature and cannot be resolved quickly — it requires sustained investment in training, certification programmes, and mutual recognition of qualifications across Member States.

Lack of standardisation and interoperability. The absence of common technical standards for HUT integration increases costs, planning effort, and implementation risk. The degree of standardisation varies significantly depending on system size and temperature requirements: systems below 100°C and 5 MW are relatively standardised, derived from the chiller industry, while modular systems can reach up to 30 MW and 150°C by connecting multiple units in parallel. Above these thresholds, systems become highly customised, requiring bespoke engineering for each installation. A particularly important finding is that the costs of integrating a heat pump into an existing industrial process are at least double and, in some cases, up to four times the cost of the heat pump system itself, making integration complexity one of the most significant cost drivers in industrial HUT projects. Beyond individual projects, lack of standardisation also constrains the ability of heat pump systems to interact with smart grids and broader industrial energy management systems, a growing limitation as demand-side flexibility becomes increasingly important for grid stability and renewable energy integration.

High temperature lifts reducing system COP: Large source-to-sink temperature differentials reduce system efficiency, affecting both energy performance and economic attractiveness.

Opportunities

R&D progress in high-temperature heat pumps. Reference installations demonstrating steam production above 150°C and COP values above 2.5 are beginning to emerge, signalling increasing technical maturity at the high-temperature frontier directly relevant to the Push2Heat project scope. AI-driven process optimisation and smart control systems can further enhance system efficiency, predictability, and operational confidence.

Standardisation as a market development lever. Two complementary approaches are emerging. The first focuses on component and system standardisation, particularly through modular designs that allow multiple units to be connected in



parallel, enabling partial standardisation even for larger installations. The second focuses on process-level standardisation, developing blueprints for specific industrial applications rather than individual systems. The [collaboration](#) between EHPA and CEPI resulting in a default paper manufacturing process showing how waste heat can be recovered using heat pumps is a leading example of this approach. EU-funded projects such as [EXQUISHEAT](#) and [HP4Industry](#) are extending this methodology to other industrial processes including pasteurisation, evaporation, drying, and refrigeration. Greater standardisation at both system and process level is identified as one of the key recommendations at the roundtables and a central lever for accelerating deployment and reducing costs across sectors.

European Grids Package: The European Grids Package, voted by the European Parliament on 3 July 2026, and the guidance developed at EU level on efficient and timely grid connections provide an important framework for addressing the grid access bottleneck. For Member States, four priority actions have been identified: urgently implementing the Electricity Market Directive to improve incentives for industrial flexibility and data transparency on grid connection queues; designing state aid schemes under CISA to de-risk capital investments in non-fossil fuel flexibility technologies; implementing the Guidance on efficient and timely grid connections by adopting best practices from other Member States; and ramping up grid investments aligned with forecasted industrial demand, with electrification and grid reinforcement requirements explicitly reported in National Energy and Climate Plans.⁵³



4.5 Environmental

The environmental dimension of industrial heat pump deployment is characterised by a fundamental paradox: heat pumps are one of the most powerful tools available to reduce industrial greenhouse gas emissions, yet their deployment is complicated by environmental regulations governing the very substances that make them work. At the same time, the environmental case for HUTs is reinforced by a growing body of evidence on their lifecycle performance and their role in integrating renewable energy into industrial energy systems.

Refrigerant regulatory uncertainty	Major barrier	Manufacturers need predictability on permitted substances over the next 10–15 years
Refrigerant transition complexity	Major barrier	No universal refrigerant solution exists: each natural refrigerant carries specific safety, cost, and performance trade-offs requiring project-by-project selection
Reactive sustainability culture	Minor barrier	Voluntary environmental incentives limited by industrial stakeholders acting only under regulatory pressure
Natural refrigerants as a sustainable pathway	Major opportunity	Ammonia, CO ₂ , and propane-based systems already in use — zero GWP, R&D ongoing to extend applicability to higher temperatures
A cleaner electricity grid	Major opportunity	As the EU grid gets cleaner, HP environmental performance improves without any technology change

EU Taxonomy recognition of waste heat recovery	Minor opportunity	Official EU recognition of WHR as a green investment helps companies access sustainable financing
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Barriers

Refrigerant regulatory uncertainty. The revised F-Gas Regulation (EU 2024/573) introduces a steeper phase-down of high global warming potential HFCs by 2050, alongside bans on certain heat pump applications using HFCs, stricter requirements on refrigerant handling, recovery, recycling and destruction, and stronger technician certification and training obligations for alternative refrigerants. Heat pumps containing F-gases must also comply with labelling requirements, reporting obligations, quota-related provisions, and import and export licensing requirements. In practice, this means that future systems will increasingly need to use refrigerants with lower GWP, requiring manufacturers and end-users to adapt their technology choices and safety infrastructure. An additional layer of uncertainty is introduced by the European Chemical Agency's proposal to restrict the use of PFAS under the EU's REACH chemicals regulation, which can affect not only refrigerants but also other heat pump components including sealings and coatings. The timeline for final decisions on both the F-Gas and PFAS frameworks remains unclear. What the analysis of these regulatory processes reveals is that the core challenge for the sector is not the choice of refrigerant itself, but the absence of predictability: without clarity on which substances will be permitted over the next 10 to 15 years, investment decisions in R&D, product design, and manufacturing capacity are systematically deferred, slowing the entire technology development trajectory of the sector.

Refrigerant transition complexity. The choice of the optimal refrigerant for a given industrial application involves a complex set of trade-offs between thermodynamic performance, safety, regulatory compliance, and cost. Natural refrigerants are increasingly favoured in Europe due to regulatory pressure on fluorinated alternatives, but each comes with specific constraints: propane, isobutane, and isopentane are highly flammable and require specific safety measures and ATEX zoning; ammonia offers excellent thermodynamic efficiency and zero global warming potential but is toxic and requires dedicated safety infrastructure; CO₂ operates at high pressures in transcritical cycles and is best suited for applications requiring large temperature increases; and water, while theoretically attractive for high-temperature steam

applications, requires vacuum evaporation for source temperatures below 100°C. This diversity of options means that there is currently no universal refrigerant solution for industrial HUT applications, and the selection process requires close collaboration between heat pump manufacturers and industrial end-users on a project-by-project basis⁵⁴

Environmental impact contingent on electricity mix. The environmental benefit of replacing fossil fuel boilers with industrial heat pumps is not unconditional – it is highly dependent on the source of electricity used to power the heat pump. In electricity grids with a high share of fossil fuels, such as Poland, Serbia, or the Czech Republic, the environmental impact of operating a heat pump in the categories of climate change and human health can be significantly greater than that of an equivalently sized natural gas boiler⁵⁵. This means that the environmental case for HUT deployment is strongest in countries with cleaner electricity grids, and that the decarbonisation of the power sector and the electrification of industry are complementary processes that must advance together.

Reactive rather than proactive sustainability culture: Many industrial companies continue to rely on external regulatory pressure rather than taking proactive internal sustainability action, limiting the effectiveness of purely voluntary environmental incentives.

Opportunities

Natural refrigerants as a sustainable pathway. Non-fluorinated refrigerants are already in use in a growing number of industrial heat pump installations and represent the most environmentally sustainable long-term solution for the sector. Ammonia offers zero ozone depletion and zero global warming potential; CO₂ is nontoxic, nonflammable, and nonfluorinated; and propane-based systems are already commercially available for a range of industrial applications. Active R&D investment is ongoing across these refrigerant families, supported by EU funding and manufacturer initiatives, with the goal of extending their applicability to higher temperature ranges and more complex industrial process configurations⁵⁶

A cleaner electricity grid as a growing advantage: The environmental benefit of industrial heat pumps improves automatically as the EU electricity grid becomes cleaner, with 71% of EU electricity already generated from clean energy sources in 2024⁵⁷. Countries with cleaner grids achieve the greatest reductions in climate impact when replacing fossil boilers with heat pumps — Sweden, for example, achieves up to 96% lifetime GHG emission reductions⁵⁸. As the energy transition advances, the environmental case for HUT deployment will continue to strengthen across all EU Member States without requiring any modification to the technology itself.

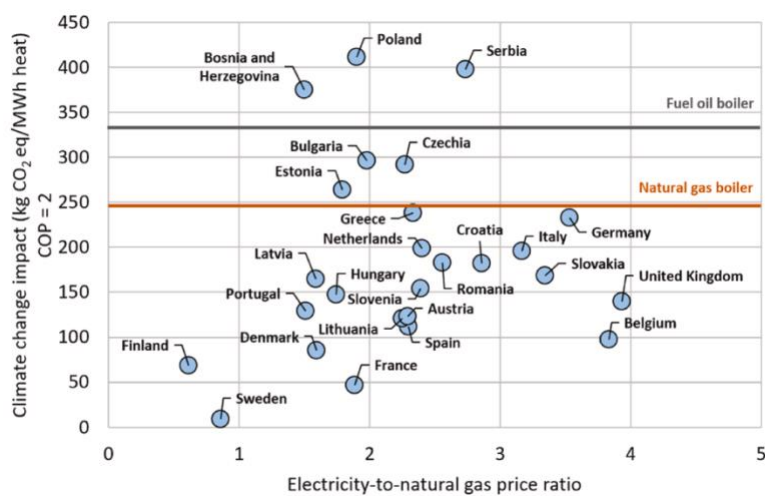


Figure 20. Electricity-to-natural gas price ratios and the Climate change impact of generating 1 MWh heat using grid electricity to operate a VHTHP with a COP=2.

(Source: Högnabba, K., Tveit, T.-M., Vittor, S., & Zevenhoven, R. (2024). Economic and environmental)

EU Taxonomy recognition of waste heat recovery. Waste heat recovery is already recognised as a climate mitigation measure under the EU Taxonomy Regulation, specifically under Section 4.25 of the Climate Change Mitigation delegated act, which confirms that waste heat recovery brings a substantial contribution to climate change mitigation and is compliant with the Do Not Significant Harm principle⁵⁹. This

institutional recognition facilitates access to green finance and sustainable investment instruments for HUT projects, and provides a clear regulatory signal that industrial waste heat recovery is aligned with EU sustainability objectives.

4.6 Legal

The legal dimension of industrial heat pump deployment concerns the specific regulatory and compliance frameworks that govern how HUT systems can be designed, installed, operated, and commercialised across EU Member States. While political barriers relate to what policymakers choose to do, legal barriers concern what is currently defined, permitted, or required by law and the gaps, ambiguities, and fragmentation in the existing legal framework that create uncertainty and additional costs for industrial operators and project developers.

Absence of on site waste heat recovery definition in law	Major barrier	On site waste heat not recognised as a strategic energy resource in most national frameworks
Safety compliance costs and legal fragmentation	Major barrier	ATEX zoning and national deviations from EU requirements add significant costs not consistently accounted for in project financing
No harmonised framework for inter-company heat supply	Minor barrier	No clear EU rules on selling or sharing waste heat between companies creates legal uncertainty
Towards a harmonised legal framework	Major opportunity	Standardising contracts, harmonising safety requirements, and clarifying inter-company heat supply rules would reduce transaction costs and improve project bankability

Barriers

Absence of standardised contractual frameworks for HUT projects. Industrial heat pump projects typically involve multiple parties — heat pump manufacturers, engineering procurement and construction contractors, and industrial end-users — each with distinct responsibilities, risk profiles, and commercial interests. The absence of standardised contractual frameworks for HUT integration increases transaction costs, extends project development timelines, and creates legal uncertainty around liability allocation. A particularly sensitive issue concerns production downtime risk: if the installation or commissioning of a heat pump causes unplanned production interruptions, the legal responsibility for the associated losses is often unclear, and the absence of established contractual precedents means that this risk is either unallocated or priced conservatively by all parties, increasing the overall cost of projects.⁶⁰

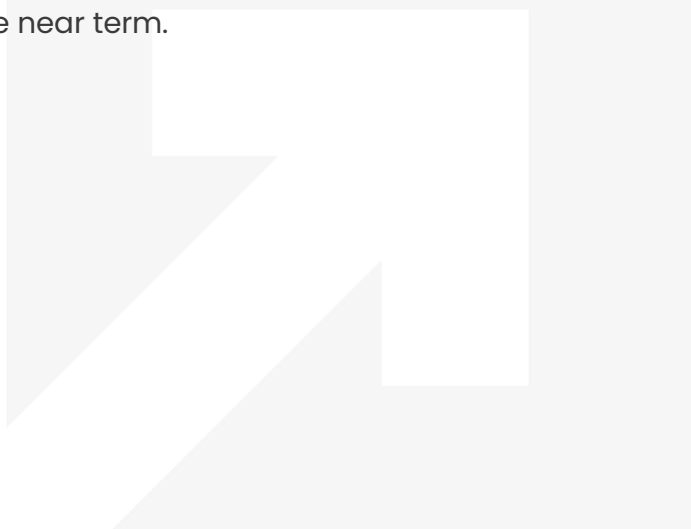
Safety compliance costs and legal fragmentation across Member States. The safety compliance framework for natural refrigerants, including ATEX zoning requirements under Directive 2014/34/EU, pressure vessel regulations, and EN 378 standards, imposes significant additional costs on HUT projects that are not consistently accounted for in project financing models. This was confirmed directly by the industrial end-user at the first roundtable, whose installation required additional gas detection systems, alarms, and a mandatory food risk analysis on top of standard safety compliance. Furthermore, national deviations from EU-level requirements, including different grid connection codes, building regulations, and certification requirements across Member States, fragment the legal landscape in ways that increase complexity and cost for manufacturers and project developers operating across borders.

No harmonised EU legal framework for inter-company heat supply. Industrial waste heat recovery increasingly involves the transfer of thermal energy between companies — from one industrial site to a neighbouring facility or district heating network. The legal framework governing these arrangements, including property rights over waste heat, liability for supply interruptions, and the contractual basis for long-term heat supply agreements between industrial operators, remains underdeveloped and inconsistent across Member States. This creates transaction

costs and legal risks that deter the development of industrial energy symbiosis projects, even where the technical and economic conditions are favourable.

Opportunities

Towards a harmonised legal framework. The legal barriers identified in this analysis share a common root: the absence of a coherent, harmonised EU legal framework specifically designed for industrial heat pump deployment and waste heat recovery. Closing the definitional gap on waste heat, developing standardised contractual frameworks for HUT projects, harmonising safety requirements across Member States, and clarifying the legal basis for inter-company heat supply arrangements would collectively reduce transaction costs, improve project bankability, and create the legal predictability that investors and industrial operators require. These are not new legislative initiatives but rather targeted clarifications and harmonisation measures within existing frameworks — making them politically and technically achievable in the near term.



5. SWOT Analysis

The SWOT analysis builds directly on the findings of the PESTEL analysis to provide a structured assessment of the conditions for Heat Upgrade Technology deployment at scale in Europe. While the PESTEL mapped the external macro-environment, the SWOT combines those external factors with an internal evaluation of the HUT sector itself, considering its technical maturity, market readiness, and structural limitations. Strengths and Weaknesses reflect factors intrinsic to the technology and the current state of the European HUT market, whereas Opportunities and Threats are drawn from the external landscape described in the PESTEL. Together, the four quadrants provide the analytical foundation for answering the key questions of Task 5.5:

Q1 *When (under what circumstances) does HP technology become attractive? (at what gas/electricity ratio, geographic, location, temperature range, etc.).*

Q2 *Which partners of the value chain need to participate in the business innovation?*

Q3 *What are the innovation and exclusion risks?*

Q4 *To what extent can HP technologies influence the decarbonisation of the EU by 2040 (short and long term)?*

Q5 *How much energy and CO₂ emissions could be saved? (by emissions trading, CO₂ certificates for monetization)*

Q6 *What regulation adaptation needs to be recommended for quick technology uptake?*

Strengths

S1. A commercially mature technology with proven industrial performance

Industrial heat pump technology has reached a level of commercial maturity that positions it as a deployable solution today, not a technology of the future. Systems capable of delivering process heat across the full 90°C to 160°C range have been proven under real industrial operating conditions across multiple sectors, removing technical feasibility as a primary barrier to adoption. With efficiency levels three to five

times higher than conventional fossil fuel boilers, and up to five to nine units of useful energy per unit of electricity when heating and cooling are provided simultaneously, heat pumps represent a fundamentally superior energy conversion technology whose economic case strengthens progressively as the electricity grid decarbonises.

S2. A strategic European industrial asset

Beyond its technical credentials, the heat pump sector carries a strategic weight that extends well beyond climate policy. Heating and cooling account for around half of Europe's total final energy consumption, and the continued reliance on fossil fuels for these applications generated an import bill of approximately €340 billion in 2025 alone. Heat pump deployment offers a measurable contribution to reducing this dependence: in 2025 alone, heat pumps across the EU avoided approximately 20 billion cubic metres of gas consumption, a volume equivalent to the combined annual gas consumption of Belgium and Spain. Europe also benefits from a strong and resilient industrial base: more than two thirds of the heat pumps installed in Europe are manufactured locally, across over 300 production and component sites supporting more than 433,000 direct and indirect jobs, with a complete value chain covering all key components.

S3. A large and largely untapped market opportunity

The scale of the opportunity is illustrated by the industrial waste heat potential alone: the untapped waste heat generated by EU industry is estimated at approximately 917 TWh per year, a volume equivalent to the total energy demand for heating and hot water in all residential and service sector buildings across the EU27, which stands at approximately 3,180 TWh per year. This comparison illustrates the extraordinary scale of energy currently being wasted: even partial recovery would make a substantial contribution to EU heating and cooling demand without requiring any new energy generation.

Weaknesses

W1. Deployment readiness and integration complexity

The most significant internal limitations concern deployment readiness rather than technology performance. Unlike conventional boilers, HUTs require bespoke engineering for each installation, which increases costs, extends timelines, and demands specialist expertise that is currently in short supply across Europe. This skills shortage is structural in nature and can only be addressed through reskilling initiatives



at EU scale, including harmonised qualification frameworks and mutual recognition of skills across Member States. Survey data confirm that integration into existing production structures is rated as both the most important and the most challenging aspect of the heat pump purchasing process, driven by concerns about production downtime risk during installation and commissioning. The limited number of publicly documented high-temperature reference installations further sustains a trust deficit that slows adoption even where the economic case is sound.

W2. Financial and business model immaturity

Heat-as-a-Service, ESCO-based approaches, and leasing models, which could substantially reduce upfront cost barriers, are not yet widely deployed, and the market remains dominated by direct purchase arrangements that concentrate the full financial burden on the industrial end-user. The systematic underestimation of total project costs compounds this problem: the heat pump unit typically represents only approximately 50% of total investment, with additional expenditure required for heat source connection, grid connection, planning, and construction. This consistent miscalculation distorts ROI assessments and contributes to investment hesitation in projects that are economically sound when properly evaluated on a lifecycle basis.

W3. Market and regulatory fragility

The fragility of the current market was illustrated by the 2023 to 2024 sales downturn across most European countries, which resulted in at least 4,000 jobs lost and over 6,000 workers impacted, and placed at risk a pipeline of €7 billion in planned manufacturing and R&D investments. At the regulatory level, fragmented and inconsistent product legislation forces repeated product redesigns and recertifications, imposing disproportionate costs particularly on small and medium-sized manufacturers. The absence of standardised contractual frameworks for HUT projects further increases transaction costs and creates legal uncertainty around liability allocation, particularly regarding production downtime risk during integration.

Opportunities

O1. An emerging EU policy and financing framework

The external environment for HUT deployment has been transformed by the publication of the EU Electrification Action Plan on 17 July 2026, which for the first time sets quantitative targets directly relevant to industrial heat pump deployment: a maximum electricity-to-gas price ratio of 2.0 for industry by 2030, a waste heat



recovery KPI of 11% of EU heat demand by 2050, and a target of 4 million heat pump installations per year by 2030. The plan explicitly recognises that around 60% of industrial fuel-based energy demand can be electrified using heat pumps, and backs this with concrete support measures including the Industrial Decarbonisation Bank, a second Innovation Fund industrial heat auction, sector-specific electrification roadmaps, and an EU Waste Heat Initiative expected by Q2 2027. This builds on the already operational CISAF, which entered into force on 25 June 2025 and mobilises over €100 billion for EU-based clean manufacturing, and on the Innovation Fund Heat Auction whose second round has been confirmed for launch by end of 2026.

O2. Addressing the electricity-to-gas price ratio

The most powerful near-term opportunity lies in correcting the energy taxation distortions that currently make electrification economically irrational for most industrial operators. Eight of seventeen European countries currently tax electricity at least three times more than gas, and all of them rank among the smallest heat pump markets relative to their population. The EU Electrification Action Plan's legislative proposal to rebalance electricity-to-gas price ratios, targeting a maximum ratio of 2.0 for industry by 2030, represents the most significant political commitment to addressing this structural distortion ever made at EU level. Countries that have already corrected this imbalance, such as Finland and Sweden, demonstrate significantly higher and more stable heat pump deployment rates and achievable lifetime GHG emission reductions of up to 96% compared to natural gas boilers⁶¹.

O3. Regulatory pull mechanisms and flexibility value

Beyond financing, regulatory design offers significant untapped potential. The introduction of binding requirements for industrial facilities to develop waste heat recovery plans, and the EU Waste Heat Initiative expected by Q2 2027, would generate a large policy-driven pipeline of HUT-eligible projects. The European Grids Package, voted by the European Parliament on 3 July 2026, directly addresses the grid access bottleneck by granting electricity grids overriding public interest status and streamlining permitting processes. Heat pump flexibility represents an additional largely untapped economic opportunity: the new network code proposed in the Electrification Action Plan will enable seamless integration of heat pumps into demand

response markets, allowing industrial operators to reduce energy costs while contributing to grid stability.

Threats

T1. Structural energy price distortions

The most persistent external threat to HUT deployment is the systematic distortion of energy pricing across EU Member States. Electricity carries a disproportionate burden of taxes, levies, and grid charges compared to gas, making fossil-based heating the financially rational choice for most industrial operators. In countries such as Germany and the United Kingdom, where the electricity-to-gas price ratio reaches three to four, industrial heat pump deployment remains economically unviable even under favourable technical conditions and even with significant carbon prices applied. The continued reliance on fossil fuels that this distortion perpetuates is not only an environmental failure but a strategic one: the EU's €340 billion annual fossil fuel import bill in 2025 represents a structural drain on European industrial competitiveness and energy sovereignty.

T2. Policy instability and regulatory fragmentation

The continued bias of Member State subsidy schemes toward fossil fuel-based industrial heating actively undermines the political goals of the European Green Deal. Regulatory fragmentation across EU Member States, inconsistent national policy frameworks, and diverging product requirements deter the large capital commitments that HUT installations require. The 2023 to 2024 market downturn demonstrated concretely that policy instability translates directly into investment withdrawal and job losses, even in a sector with strong underlying demand fundamentals. Refrigerant regulatory uncertainty, stemming from the F-Gas Regulation phase-down and the unclear future of PFAS restrictions, creates additional long-term planning risks: without clarity on which substances will be permitted over the next 10 to 15 years, investment decisions in R&D, product design, and manufacturing capacity are systematically deferred.

T3. Infrastructure and market access barriers

At the operational level, inadequate grid infrastructure and long delays in obtaining connection upgrades represent a concrete threat that can block otherwise viable HUT projects. Real-world evidence is stark: the German Paper Manufacturers Association reports average delays of 5 to 10 years for projects in the 10 to 50 MW range, while in



Spain only 10% of industrial grid connection capacity requested was awarded a connection in 2024. The inability of most industrial operators to access dynamic electricity contracts further limits the monetisation of heat pump flexibility, reducing the economic case for electrification and leaving a significant source of grid value untapped.

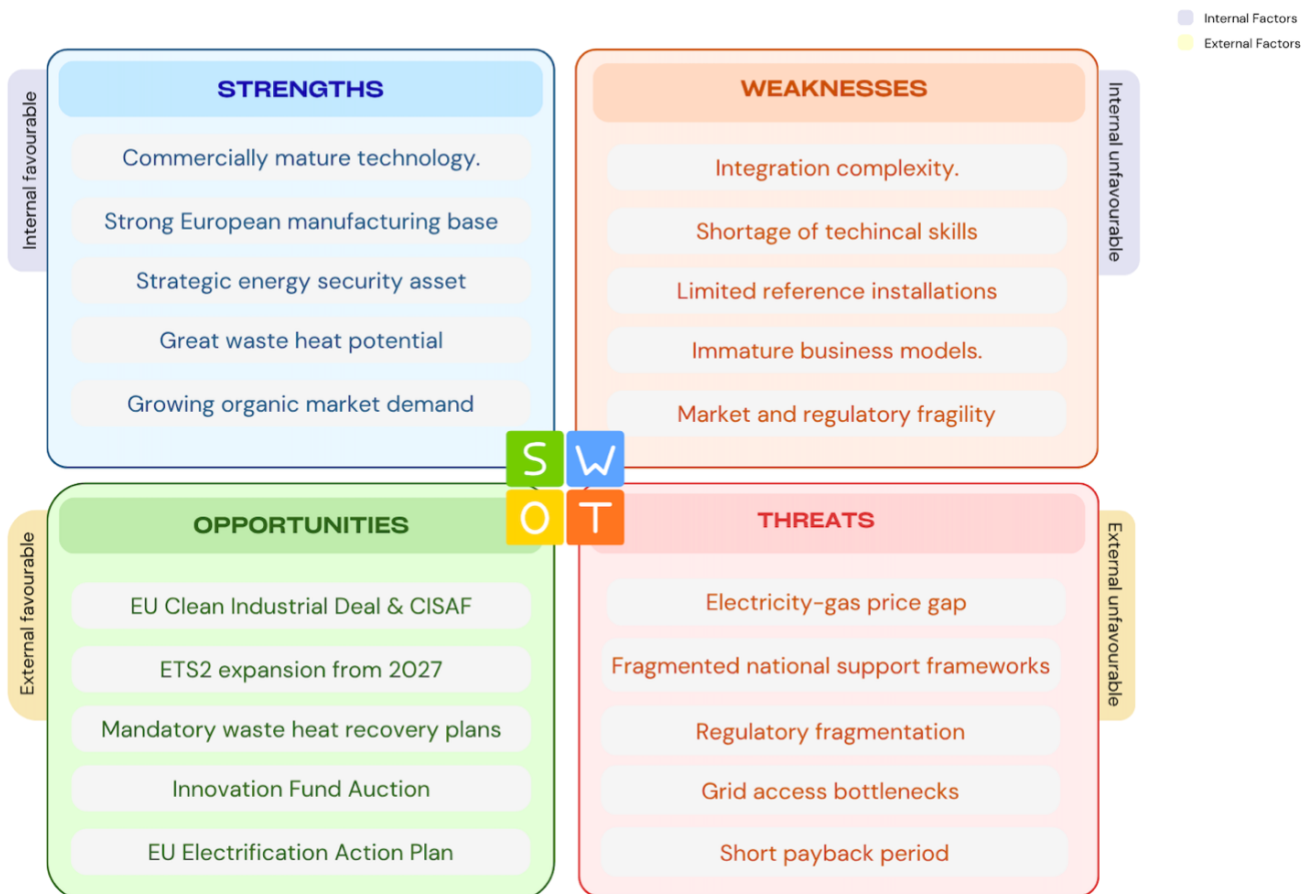


Figure 21. SWOT Analysis

Key questions — Task 5.5 findings

Task 5.5 of the Push2Heat project was specifically designed to analyse the barriers and opportunities for Heat Upgrade Technology deployment in Europe and to answer a set of key questions defined at the outset of the work. These questions guided the entire analytical process, from the stakeholder survey and national roundtables to the PESTEL and SWOT analyses, and the findings presented throughout this deliverable collectively build toward answering them. The responses below synthesise the evidence gathered across all empirical sources and represent the consolidated analytical output of Task 5.5, directly informing the policy recommendations presented in Section 6.

Q1 – When does HP technology become attractive?

HP technology becomes economically attractive when the following conditions are met:

- **Favourable energy pricing:** electricity-to-gas price ratio does not exceed 2.0 (currently met in Finland, Sweden, and Denmark; Germany and UK at 3–4, making deployment unviable)
- **Effective carbon pricing:** ETS2 from 2027 will extend carbon pricing to 8,000–11,000 smaller industrial installations currently outside the framework
- **On-site waste heat availability:** majority of industries with HUT experience generate more than 1,000 MWh/year of recoverable waste heat
- **Timely grid access:** current delays of 5–10 years in Germany and 90% connection refusal rate in Spain block deployment even where economic conditions are favourable
- Industrial sectors with **process heat needs between 90°C and 160°C** represent the primary target market.

Q2 – Which value chain partners need to participate in business innovation?

Successful deployment requires coordinated participation across the full value chain: HUT manufacturers and component suppliers; engineering and integration firms with industrial process expertise; energy service companies (ESCOs) and financing institutions to develop viable business models such as HaaS and leasing; industrial end-users willing to act as early adopters and reference cases; grid operators to ensure timely connection; and policymakers at EU and national level to provide regulatory certainty and financial support.

Q3 – What are the innovation and exclusion risks?

Policy instability and unfavourable energy pricing lock in fossil-based industrial infrastructure before HUT deployment reaches sufficient scale. Exclusion risks concern SMEs and industries in Member States with high electricity taxation, limited subsidy access, or insufficient grid capacity, which may be structurally unable to adopt HUTs without targeted support. Refrigerant regulatory uncertainty and fragmented product legislation also risk slowing product development and market entry.

Q4 – To what extent can HP technologies influence EU decarbonisation by 2040?

In the short term (to 2030), industrial heat pumps can make an immediate contribution by displacing fossil-based process heat in sectors where the technology is already mature, while demonstration projects build the reference base needed for broader confidence. In the medium term (2030 to 2040), systematic deployment across major energy-intensive sectors could substantially reduce industrial CO₂ emissions.

Q5 – How much energy and CO₂ emissions could be saved? (by emissions trading, CO₂ certificates for monetization)?

Quantifying the energy and CO₂ savings achieved through industrial heat pumps requires drawing on evidence at different scales, from EU-wide scenarios to individual installation data. Together, three complementary sources have been collected to provide an increasingly specific picture of the technology's decarbonisation potential.

At a broader scale a market analysis conducted within the SPIRIT project⁶² estimates that full adoption of high-temperature heat pumps across the industrial sectors assessed could reduce CO₂ emissions from 123.8 to 27.2 million tonnes of CO₂eq per year, an absolute reduction of 96.6 million tonnes, equivalent to a 78% decrease.

At the installation level, analysis of very high temperature heat pump deployment across European countries confirms that the climate impact is highly dependent on the national electricity mix: in Sweden, a VHTHP replacing a natural gas boiler achieves up to 96% lifetime GHG emission reductions, while countries with cleaner grids consistently demonstrate the greatest environmental gains⁶³.

On the waste heat recovery dimension, fully enabling recovery through an integrated approach has the potential to save €67.4 billion per year across the EU by 2050⁶⁴.

To provide the most concrete and grounded answer to this question, we draw on real-world deployment evidence from the Push2Heat and SPIRIT demonstration sites. The data presented in Table 4 are based on detailed engineering calculations and the design conditions of the Heat Upgrade technologies.

Table 4. Expected energy savings and CO₂ emission reduction from P2H and SPIRIT projects

Source	Demo site	Country	Sector	Heating capacity	Energy savings (MWh/year)	CO ₂ reduction (tCO ₂ /year)
Push2Heat Demo 1	Weissenborn	Germany	Paper drying	1,200 kW	2,651	468
Push2Heat Demo 2	Cartiere di Guarcino	Italy	Paper industry	851kW	3,435	698
Push2Heat Demo 3	Cartiere di Guarcino	Italy	Paper industry	343 kW	2,808	542
SPIRIT Demo 1	Stella Polaris	Norway	Prawn processing	1,200 kW	1,000 MWh	600*
SPIRIT Demo 2	Tiense Suiker	Belgium	Sugar production	4,000 kW	7,500	2,139**
SPIRIT Demo 3	Smurfit Kappa	Czech Republic	Pulp and paper	700 kW	Not available	793,5**

*Spirit Demo 1 (Stella Polaris): values based on design calculations at an early stage of the project, compared to the original propane boiler. Since these calculations were performed, Stella Polaris has installed an electric boiler powered by Norwegian hydropower, which carries near-zero CO₂ emissions. The actual CO₂ reduction compared to the current reference system would therefore be negligible.

**Spirit Demo2 values depend on the numbers of operating hours the plant operates, which varies from year to year.

***Spirit Demo 3 (Smurfit Kappa): CO₂ reduction ranges from 254.8 tCO₂/year based on the current Czech electricity mix to 793.5 tCO₂/year assuming 100% renewable energy, reflecting the strong dependency of environmental performance on the national electricity mix.

Table 5 presents the results of the replication studies conducted by the Universitat Politècnica de València (UPV) within the Push2Heat project for the three demonstration sites. Energy savings are calculated as the difference between the energy consumption of the HUT system, including a backup boiler where necessary to cover 100% of heat demand, and a reference case based on a conventional natural gas boiler. The same methodology applies to CO₂ emission reductions, with percentage values expressing savings relative to the reference scenario.

Table 5. Energy savings and CO₂ emission reduction from P2H replication studies

Demo site	Country	Sector	Heating capacity	Energy savings (MWh/year)	CO ₂ reduction (tCO ₂ /year)
Push2Heat Demo 1	Germany	Paper drying	1,200 kW	3,192 (28%)	538 (22%)
Push2Heat Demo 2	Italy	Paper industry	892 kW	4,435 (57%)	719 (43%)
Push2Heat Demo 3	Italy	Paper industry	343 kW	2,599 (81%)	557 (80%)

Monetisation pathways are increasingly available: under ETS2 from 2027, avoided CO₂ can be directly priced through carbon allowances, currently trading at €79–82 per tonne of CO₂eq, while the Innovation Fund Heat Auction provides performance-based support priced in €/tonne CO₂ avoided.

Q6 – What regulation adaptations are needed for quick technology uptake?

Five priority regulatory adaptations emerge from this analysis: (1) rebalancing energy taxation so that energy pricing favours electrification over fossil fuel use (2) introducing mandatory waste heat recovery plans for industrial facilities as a condition of new permits and licence renewals; (3) making heat pumps the default option for industrial processes below 200°C in permitting and licensing of new and renovated facilities; (4) guaranteeing timely grid access for industrial electrification projects; and (5) simplifying state aid provisions to enable Member States to deliver effective financial support without excessive administrative burden.

5.1 SWOT cross-analysis

A SWOT analysis is most useful not as a static list of factors but as a tool for identifying strategic connections. Looking at the four quadrants in isolation (strengths, weaknesses, opportunities, and threats) gives a useful picture of the landscape, but the real analytical value comes from asking: how do these factors interact with each other? Can a strength be used to capture an opportunity? Can an opportunity help address a weakness? Does a threat make an existing weakness more dangerous?

To answer these questions, we cross-linked the factors identified in the SWOT analysis, pairing elements from different quadrants and assessing what each combination implies for policy and market development. From this process, ten priority pairings were selected based on two criteria: **the potential impact of the combination on industrial heat pump deployment, and the feasibility of the policy action it suggests.**

Each pairing falls into one of four strategic categories:

- Offensive (Strength + Opportunity): how to use what we have to capture what is available
- Defensive (Strength + Threat): how to use what we have to protect against risks
- Corrective (Weakness + Threat): how to address vulnerabilities before they become critical

- Transformative (Weakness + Opportunity): how to use emerging opportunities to fix structural weaknesses

Together, these ten pairings provide the analytical foundation for the policy recommendations in Section 6. The last column of the table below “Rec” indicates the corresponding policy recommendation for each pairing. These links were added after the recommendations were formulated, to allow the reader to trace the analytical logic behind each proposed action. The full text of each recommendation can be found in Section 6.

N.	Pairing	Strategy	Rationale	Policy statement	Rec.
1	S2 + O2	Offensive	Europe has the manufacturing base; correcting the price ratio would immediately convert latent demand into market uptake	Establish a binding EU electricity-to-gas price ratio of max 2.0 for industry by 2030, backed by national implementation plans	1a
2	S1 + O1	Offensive	The technology is ready; the new EU financing architecture provides the conditions to move from pilot to scale	Make the Innovation Fund Heat Auction a permanent instrument and link it directly to EU manufacturing scale-up targets	1b
3	W2 + O1	Transformative	CISAF and the Innovation Fund can fund new business models – HaaS, ESCO, leasing – not just individual projects	Adapt state aid rules to explicitly cover innovative financing models for industrial heat pumps	1b
4	S3 + O3	Offensive	917 TWh/year of waste heat already available – mandatory recovery plans would activate it through regulatory pull	Mandate waste heat recovery plans for all industrial facilities above 8 MW as a condition of new permits	5a+5b
5	W1 + O1	Transformative	The EAP Alliance and Pact for Skills can address the structural skills gap blocking technically viable projects	Integrate HP training into EU skills frameworks and fund EU-wide certification programmes for HUT integrators	4b
6	W3 + T2	Corrective	Policy instability and refrigerant uncertainty	Commit to long-term product legislation	2a+2b

			together create a double exposure that destroys investment confidence	timelines and a clear refrigerant transition roadmap by 2027	
7	S1 + T1	Defensive	Technical maturity alone cannot drive market growth when pricing makes deployment economically irrational	Prioritise energy taxation reform as a prerequisite for any industrial HP deployment strategy	1a
8	W1 + O2	Transformative	Correcting the price ratio makes early adopters viable without subsidy, generating the references needed to break the trust deficit	Link price ratio correction to demonstration programme funding to maximise trust-building impact	4a
9	S3 + T3	Defensive	917 TWh/year of waste heat potential is blocked by grid access delays, not by technology	Implement first-ready first-connected grid principle and accelerate industrial connections for electrification-ready projects	3a+3b
10	W2 + T1	Corrective	HaaS and ESCO models cannot become viable when electricity prices make OPEX prohibitive – the two must advance together	Address price ratio and business model enablement simultaneously – neither works without the other	1a+1b

6. Policy Recommendations

The following recommendations are directed at EU and national policymakers, regulatory bodies, and industry stakeholders. They are derived from the findings of the PESTEL and SWOT analyses and grounded in a review of the relevant scientific literature and policy positions on industrial heat pump deployment. They address the five principal barriers identified throughout this analysis: **economics, regulation, energy system integration, knowledge and skills, and waste heat recovery.**

1 Improve the business case

1a. OPEX — Improve the electricity to gas price ratio

i. Ensure fair energy taxation to enhance industrial competitiveness and accelerate electrification. A clear and strategic approach to energy taxation is urgently needed at both EU and national level. The revision of the Energy Taxation Directive should ensure that taxes, levies, and grid charges on electricity do not discourage electrification, and that the true societal and environmental costs of fossil fuels are reflected in energy bills.. The EU Electrification Action Plan (July 2026) sets a maximum ratio of 2.0 for industry by 2030, a landmark commitment that must now be swiftly converted into binding national measures.

ii. Ensure that electricity costs, levies, and grid charges are all designed to increase electrification. This needs to happen at both national and European level to ensure that regulated and anticipatory costs do not discourage electrification before the transition is underway. EU-level guidance on best practices for levy design (including recommendations on which costs to assign to the general budget rather than the electricity bill) would support Member States in rebalancing their national frameworks. In parallel, operational expenditure support for industrial processes should be made eligible for EU funding under CISA and the Decarbonisation Bank during the transition period. Operational expenditure support for industrial processes should also be eligible for EU funding under CISA and the Decarbonisation Bank during the transition period, given that efficiency gains of 10–40% from heat pump adoption are often insufficient to bridge the cost gap until ETS2 carbon pricing takes full effect.



1b. CAPEX — Financial support and innovative financing models

i. Encourage Member States to put in place financial support for industries that decarbonise their production systems.

High upfront investment costs remain a primary barrier, compounded by the systematic underestimation of total project costs — the heat pump unit typically represents only around 50% of total investment. Member States should put in place targeted grants, tax rebates, and low-interest loan programmes for sectors where heat demand is addressable by today's heat pump technologies, with particular focus on food and beverage, chemicals, paper and pulp, and machinery.

ii. Enable innovative financing models through adapted state aid provisions.

Heat-as-a-Service, ESCO-based approaches, and Power Purchase Agreements must be actively supported, as current state aid rules make these models significantly more costly than direct purchase. Removing these barriers would substantially broaden the pool of industrial operators able to adopt heat pump technologies, particularly SMEs and industries with constrained capital.

iii. Establish the Innovation Fund Heat Auction as a permanent instrument and redirect existing EU funds toward industrial HP investments.

The Innovation Fund Heat Auction should become a structural part of the Decarbonisation Bank rather than a pilot mechanism. Existing EU funds, including the Recovery and Resilience Facility, the Social Climate Fund, and the European Regional Development Fund, should be explicitly directed toward industrial heat pump investments, prioritising SMEs and less-advantaged regions.

EU POLICYMAKERS MUST THEREFORE:

- Rebalance energy taxation so electricity is no longer taxed more heavily than fossil fuels
- Phase out fossil fuel subsidies that undermine electrification, affordability and energy autonomy
- Ensure timely implementation of ETS2, guaranteeing regulatory stability as an enabler for HP investment
- Direct EU funds (RRF, Social Climate Fund, ERDF) explicitly toward industrial HP investments, prioritising SMEs
- Make the Innovation Fund Heat Auction a structural part of the Decarbonisation Bank

2 Offer stable policies for long-term growth

2a. Electrification targets and permitting

i. Create an improved framework for the accelerated deployment of heat pumps: develop the necessary policy and financing frameworks to help the sector reach the REPowerEU target of 60 million additional heat pumps installed in Europe by 2030. This is essential for industrial actors to justify large capital investments in electrification. The current renewable energy directive only encourages Member States to increase renewables in industry by indicative minimum percentage points (RED art. 22a). This should be strengthened by requiring this from Member States instead of only encouraging. It should be strengthened by making heat pumps the default option for industrial processes below 200°C, including as a requirement in permitting of all new and renovated industrial facilities. The EU Electrification Action Plan (July 2026) explicitly recognises that 60% of industrial fuel-based demand can be electrified using heat pumps; this political recognition must now be operationalised through binding national targets and a clear phase-out date for financial incentives supporting fossil fuel heating where mature alternatives exist.

2b. State aid simplification and NECPs

i. Recognise industrial heat pumps and waste heat recovery in National Energy and Climate Plans (NECPs): The current state aid framework makes support for industrial heat pump technologies difficult to deliver in practice. Administrative requirements, including complex NPV calculations and forecasts of investment in alternative technologies, create significant burdens that slow down delivery of support schemes. These requirements should be simplified to allow faster, more flexible support for industrial decarbonisation investments. Innovative financing models such as HaaS and energy performance contracting must be explicitly covered. At the planning level, industrial heat pumps and waste heat recovery should be mandatory elements in National Energy and Climate Plans, ensuring Member States develop concrete deployment strategies aligned with EU goals.

ii. Support European heat pump manufacturing scale-up through stable and predictable demand signals. The pipeline of industrial heat pump projects currently remains limited relative to the process heat potential, which constrains the ability of manufacturers to invest at the scale that would drive costs down through learning and volume. Making the Innovation Fund Heat Auction a permanent annual instrument, combined with long-term regulatory certainty and mandatory electrification assessments in industrial permitting, would create the predictable demand signal that manufacturers need to justify investment in



expanded production capacity. A stronger alignment between demand creation, standardisation efforts, and industrial scaling is required to secure Europe's leading position in this strategic sector

EU POLICYMAKERS MUST THEREFORE:

- Recognise heat pumps as a strategic energy security technology across buildings, industry and district heating
- Strengthen RED III by making HPs the default for industrial processes below 200°C in permitting of new and renovated facilities
- Set a clear phase-out date for financial incentives supporting fossil fuel heating where mature alternatives are available
- Simplify state aid provisions to enable faster, more flexible delivery of support for industrial decarbonisation
- Provide long-term policy certainty — fragmented product legislation increases costs and delays innovation



3 Use heat pumps' efficiency and flexibility

3.a Grid access and industrial connections

i. Guarantee timely grid access for electrified industrial processes: Inadequate grid infrastructure is one of the most concrete and immediate operational barriers to industrial heat pump deployment. Real-world evidence is stark: the German Paper Manufacturers Association reports average delays of 5 to 10 years for projects in the 10 to 50 MW range due to grid congestion, while in Spain only 10% of industrial grid connection capacity requested in 2024 was awarded. The current first-come, first-served queuing approach must be replaced by a first-ready, first-connected principle, prioritising mature projects. Network companies should plan for the net-zero grid through anticipatory investments, ensuring industrial facilities can connect without bearing the full cost of grid upgrades in the short term.

3b. Flexibility and demand-side integration

i. Address barriers to unlocking flexibility and integrate it into grid planning: Different types of demand participation must be recognised to reflect the specific features of different industrial sectors. Demand-side flexibility should be incentivised through fair remuneration, while avoiding penalties for industrial operators with limited flexibility potential. Market price signals must be designed to reward flexibility, supported by de-risking instruments such as guarantees and low-interest loans to encourage investment. State aid schemes should be explicitly designed to de-risk capital investments into non-fossil fuel flexibility technologies for industry, building on the rules set out in CISAF to ensure that operators willing to invest in heat pump flexibility are not deterred by upfront financial risk. At the same time, grid operators must recognise the flexibility potential of industrial heat pumps and incorporate it into net-zero grid planning, doing so can reduce costs for both the energy system and consumers.

EU POLICYMAKERS MUST THEREFORE:

- Urgently implement the Electricity Market Directive to improve incentives for industrial flexibility and grid queue transparency
- Replace first-come, first-served grid queuing with a first-ready, first-connected principle
- Ensure forward-looking, flexible grid planning and accelerated industrial connections for ready-to-deploy projects
- Recognise HP flexibility and waste heat recovery as strategic pillars of Europe's energy security
- Ramp up grid investments aligned with forecasted industrial demand and require reporting in NECPs

4 Knowledge sharing and skills

4a. Guidelines, awareness and best practices

i. Develop comprehensive EU-wide guidelines for industrial heat pump deployment and waste heat recovery: Low awareness of HUT potential remains widespread across key industrial sectors. Engineers, plant managers, and procurement teams lack practical tools to evaluate and implement HUT projects with confidence. Successful applications in one sector rarely reach decision-makers in others, preventing replication of proven solutions. Comprehensive EU-wide guidelines covering system design, integration pathways, and techno-economic assessment methods are urgently needed. The EAP (July 2026) creates an Electrification Action Plan Alliance and sector-specific roadmaps, these must be adequately resourced and designed with direct input from industrial end-users.

ii. Promote and replicate cross-sector matchmaking initiatives between heat pump manufacturers and industrial end-users. Successful applications in one sector rarely reach decision-makers in others, preventing replication of proven solutions. Initiatives such as the EHPA-CEPI collaboration, which brought together the heat pump sector and the paper industry to identify electrification solutions, should be actively replicated across chemicals, food and beverage, and pharmaceuticals.



iii. Increase EU funding calls for awareness-raising and innovative pilot projects.

The LIFE-CET Heat Pumps Call should be reintegrated into the 2027 programme and expanded to support both awareness-raising and process-level standardisation. Projects funded under this call, such as [EXQUISHEAT](#) and [HP4Industry](#), are already analysing key industrial processes to accelerate the uptake of standardised heat pump solutions, covering applications such as pasteurisation, evaporation, drying, and refrigeration, and demonstrate the concrete value of this funding instrument for industrial deployment. Horizon Europe and Innovation Fund calls should be expanded to support innovative projects aimed at developing pilot sites and integrating industrial heat pumps for the first time in specific industrial settings and processes.

4b. Training, certification and R&D

i. Develop EU-wide certification and training programmes for HUT engineers and integrators. The shortage of skilled engineers, technicians, and integrators capable of designing and maintaining HUT systems is a structural bottleneck that will constrain deployment regardless of financial and regulatory conditions. EU-wide certification and training programmes must be developed, with harmonised qualification frameworks and mutual recognition of skills across Member States, enabling labour mobility and strengthening the Single Market.

EU POLICYMAKERS MUST THEREFORE:

- Develop EU-wide guidelines for industrial HP and waste heat recovery covering design, integration, and techno-economic assessment
- Integrate HP training and reskilling into EU industrial, energy and social policy frameworks including the Pact for Skills
- Support harmonised qualification frameworks and mutual recognition of skills across Member States
- Fund dedicated Innovation Fund calls for industrial electrification with special emphasis on SMEs
- Replicate cross-sector collaboration models (e.g. EHPA-CEPI) with industrial associations in chemicals, food, and pharmaceuticals

5 Unlock waste heat recovery

5a. Regulatory framework for onsite waste heat reuse

i. Regulate the use of industrial heat pumps by making it mandatory for industries to link the required waste heating and cooling in their process design planning. For new industrial sites, it should be mandatory to design heating and cooling systems by combining processes instead of using standalone chillers and boilers/heat pumps. Additionally, mandate the replacement of chillers with heat pumps equipped for heat recovery during equipment upgrades, enabling industries to optimize energy efficiency with minimal extra CAPEX while retaining heating capabilities.

5b. Definition, scope and financial recognition

i. Comprehensive definition of onsite waste heat recovery: the waste heat definition must cover all relevant and feasible waste heat applications, including on-site waste heat recovery, for example from the cooling of buildings. EU legislation provides a narrow definition limited to the waste heat which can only be used in district heating and cooling applications in the current Renewable Energy Directive. Further references to “waste heat” in other legislation indicate either the broader use of waste heat (e.g. Energy Efficiency Directive, Article 23, Annex IX) or exclusively to its use in district heating and cooling (e.g. Energy Efficiency Directive, Article 24, EU Taxonomy). The EU Waste Heat Initiative announced for Q2 2027 must introduce binding obligations rather than advisory guidance to be effective.

EU POLICYMAKERS MUST THEREFORE:

- Mandate waste heat recovery plans for industrial facilities as a condition of new permits extend the EED data centre model to all energy-intensive sectors
- Broaden the RED III waste heat definition to include on-site recovery and single-building applications
- Make waste heat recovery eligible for free ETS allocation to create direct financial incentives
- Ensure the EU Waste Heat Initiative (Q2 2027) introduces binding sectoral recovery obligations
- Update the EU Taxonomy to recognise waste heat to power as a climate mitigation measure

7. Conclusions

The central finding of this PESTEL and SWOT Analysis is clear: **The barriers to industrial heat pump deployment in Europe are not technical but structural.** With 78% of EU industrial process heat already electrifiable using technologies available today, and current installations representing less than 1% of total industrial heating capacity, the gap between potential and reality is driven by **economic distortions, regulatory gaps, and a lack of awareness, not by the absence of viable solutions.**

The political environment has changed significantly. The publication of the EU Electrification Action Plan on 17 July 2026 is a turning point: for the first time, EU policy focuses on boosting electrification of demand, setting concrete targets on the **electricity-to-gas price ratio, waste heat recovery, and heat pump installation rates**, and addressing the full range of barriers identified in this analysis. The framework is now in place. The next challenge is implementation. One of the most urgent actions needed is correcting the electricity-to-gas price ratio. Member States with the lowest ratios record three times more heat pump sales than those where the ratio exceeds three. The EAP sets a clear target of 2.0 for industry by 2030, and Member States must now rebalance energy taxation and phase out fossil fuel subsidies.

Beyond decarbonisation, industrial heat pumps are also a valuable resource for a **smarter and more flexible energy system.** By using electricity when it is abundant and cheaper, they can help balance the grid and reduce energy costs for operators, a benefit that must be recognised in market rules and incentives at the national level.

Europe's manufacturing base for heat pumps is a strategic asset that must be protected and scaled. Europe's strength extends beyond manufacturing to system engineering and process integration, capabilities central to deploying large industrial heat pump projects. Maintaining this leadership requires stable policies, a balanced approach to trade, and continued investment in skills and workforce development. Crucially, the pipeline of industrial projects must grow without sufficient and predictable demand, manufacturers cannot invest at the scale needed to drive costs down and accelerate deployment.

The technology is ready, the policy framework is taking shape, and the market is showing strong demand. The door is open. What is needed now is for EU governments to act quickly and ambitiously, turning legislation into national measures and making industrial electrification a reality within the timelines set out by Europe's climate ambitions.



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