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Sector Collaboration for the Market Uptake of High-Temperature Heat Pumps: Mapping Barriers, Opportunities, and Integration Pathways within IEA HPT Project 68 – Task 2

Summary

High-temperature heat pumps (HTHPs) represent a key enabling technology for industrial decarbonization. Despite technical maturity, their large-scale deployment remains limited due to process-specific, economic, and systemic barriers. Within the framework of the IEA HPT Project 68 – Task 2, a structured sector collaboration approach addresses these challenges through coordinated stakeholder engagement within several industrial sectors: district heating, pulp and paper, dairy, brewery, textiles, pharmaceuticals, chemicals, recyclate and petrochemical industries. This abstract exemplarily summarizes the intermediate outcomes of these Sector Collaborations, presenting a comprehensive mapping of value chains, sector-specific barriers, and opportunities linking technological, economic, and organizational aspects to stakeholder perspectives for HTHP adoption. Enhanced sectoral understanding and communication supports standardization, modularization, and integration, thereby accelerating the market uptake of HTHP technologies.

Keywords: High-Temperature Heat Pumps, Sector Collaboration, Integration concepts, Stakeholder Integration

Field of application for the findings: Industrial heat pump applications

Addressed audience: HTHP Track

1. Introduction

HTHPs represent a pivotal technology for industrial decarbonization by enabling the replacement of fossil-fuel-based process heat with efficient, electrically driven systems. Although more than 40 demonstration cases have been documented within IEA HPT Project 68 Task 1, market adoption remains limited due to economic, technological, and systemic barriers. These include high capital costs caused by missing standardization and modularization, process-specific integration challenges, and unfavorable electricity-to-reference price ratios. Additionally, knowledge gaps regarding suitable system integration points and limited full-scale demonstrators impede market uptake. To overcome these challenges, IEA HPT Project 68 Task 2 focuses on sector collaboration, stakeholder engagement, and the identification of integration possibilities for HTHPs across major industrial sectors.

2. IEA HPT Project 68 – Task 2: Sector Collaboration

Task 2 aims to accelerate industrial HTHP deployment by promoting structured cross-sector collaboration. Through coordinated activities within representative industries—such as pulp and paper, dairy, brewery, textiles, pharmaceuticals, chemicals, recycling, petrochemical industries, and district heating—the project develops a shared understanding of sector-specific barriers and opportunities. Collaborative workshops ("Sector Collaborations") provide a methodological framework to jointly explore process characteristics, map value chains, and define technological integration possibilities.

These collaborations yield key outputs: a barrier–opportunity matrix linking technical, economic, and organizational factors to stakeholder roles and actions outlining specific steps for technology providers, industrial end users, policymakers, and system integrators. The project highlights enabling measures including business model development, demonstration, standardization, and risk-sharing mechanisms. Such a structured engagement approach fosters knowledge transfer, reduces uncertainties in implementation, and supports systemic market integration of high-temperature heat pumps.

3. Stakeholder Mapping

Stakeholder mapping serves as a diagnostic framework that systematically characterizes actors along the sector-specific HTHP value chain. Relevant stakeholder groups include technology suppliers, industrial end users, system integrators, utility and energy providers, engineering consultants, research institutions, and public authorities.

The analysis identifies shared barriers and opportunities:

- Technological: Limited demonstrator projects, high safety requirements, and process constraints such as transient process conditions and flexibility requirements.
- Economic: High initial investment costs, uncertain electricity prices, and lack of financial incentives and business models.
- Regulatory and organizational: Approval procedures, limited standardization, and fragmented supply chains.

Opportunities arise from coordinated R&D, new business models (e.g., leasing or service-based models), renewable electricity integration, and knowledge dissemination. The barrier–opportunity matrix developed under Task 2 relates each challenge to specific stakeholder actions. For instance, manufacturers can address modular design and interoperability issues, while end-user can share process insights and success stories.

4. Example – Pulp and Paper

For this abstract, the pulp and paper sector serves as a representative case. The sector-specific barrier–opportunity matrix reveals that collaboration between technology suppliers, equipment manufacturers, and end users fosters mutual understanding and reduces deployment risks (cf. Tab.1). Deeper process integration and consistent operation data facilitate improved efficiency, while standardization and modularization lower total investment costs. Cooperative partnerships and reports on successful demonstration projects build trust – even in a conservative industry.

Tab. 1: Barrier-Opportunity-Matrix of Pulp and Paper sector (Schlosser et al. 2026)

Barrier	Opportunity	Stakeholder
High OPEX	Deep process integration (e.g. cylinder group-specific HP integration)	Process equipment manufacturer, HTHP supplier, system integrator
	Process modifications are possible to improve process conditions for HTHP integration (e.g. lower temperatures, higher dew points)	R&D, end user
Complex and transient process conditions along paper machines (e.g. temperature requirement, humidity of air)	Dynamic paper machine simulations for virtual evaluation of HTHP integration and their influence on system behavior and conditions	R&D
Conservative industry mindset, fear of production issues, reliability of large-scale HTHP concepts	Partnership, real-world demonstration cases	End user, HTHP supplier, process equipment manufacturer, system integrator
Long investment cycles, high investment, lock-in effects such as steam from CHP	Planning certainty over a long period through stable regulatory framework conditions, funding	Regulatory

The paper machine represents one of the most energy-intensive operations, involving significant drying heat at temperatures where large-scale HTHPs can operate effectively. However, challenges include heterogeneous process designs that limit scalability and the economic uncertainties arising from long investment cycles,

fluctuating electricity prices and existing CHP assets. Simulation studies play a crucial role in identifying suitable integration points and minimizing operational risks. Demonstration projects are essential to validate both technical and economic feasibility.

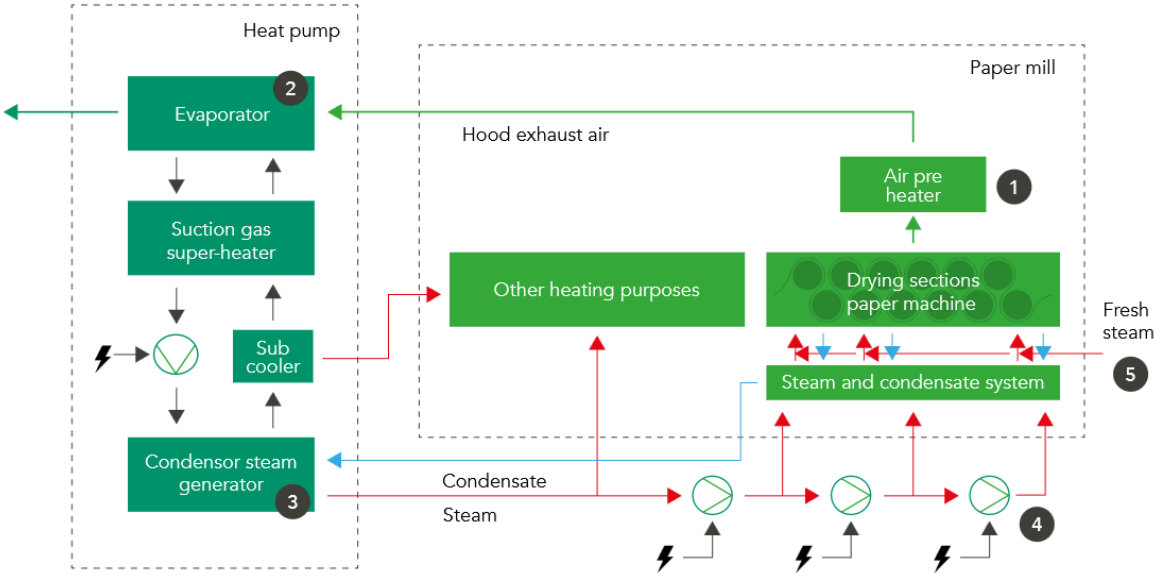

Fig. 1: Integration possibility of HTHP into the paper machine (EHPA and Cepi, 2023)

Fig. 1 shows possible points at which a HTHP could be integrated. The warm, humid exhaust air – even after air preheating (cf. Fig. 1-1) - represents a high-calorific waste heat source for the evaporator of the HTHP (cf. Fig. 1-2). The higher the temperature and humidity levels, the more suitable it is as a heat source. The paper machine is conventionally heated using cascading steam in cylinders (cf. Fig. 1-5). The required temperature level increases along the length of the paper machine. For this reason, closed HTHP cycles can be used to generate condensate (cf. Fig. 1-3). The steam generated can then be raised to the required temperature level using steam compressors or can directly provide the highest necessary temperature level (cf. Fig. 1-4). The latter option is less efficient, but the existing steam cascade system could be utilised. Energy-efficient, temperature-appropriate integration requires in-depth knowledge of the paper machine's transient operating range.

5. Conclusion

The results of IEA HPT Project 68 Task 2 underline that coordinated sector collaboration is a crucial enabler for industrial HTHP market uptake across diverse industries. The collaborative approach of stakeholder integration provides a structured framework to translate barriers into practical opportunities and actionable strategies. The development of the barrier–opportunity matrix and sector-specific integration schemes—such as for pulp and paper—demonstrates how stakeholder-driven innovation and systemic cooperation can accelerate the transition toward sustainable, low-carbon industrial heating solutions.

6. References

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