



## High-Temperature Heat Pumps for Industrial Use – Benchmarking Refrigerants and Efficiency Limits

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### **Abstract**

High-temperature heat pumps (HTHPs) offer a promising technology for industrial applications, generating hot water and steam at elevated temperatures while utilizing waste heat from production processes.

This study benchmarks refrigerants and analyzes the thermodynamic efficiency limits and operational capacities of HTHPs in various industrial contexts. The research evaluates performance parameters, including temperature lift, coefficient of performance (COP), and volumetric heating capacity (VHC), across multiple refrigerants, like ammonia, hydrocarbons, and synthetic alternatives (HFOs), while considering environmental regulations on F-gases and their global warming potentials.

Methods involve thermodynamic analysis, comparing Carnot efficiency with practical COP values at temperature lifts ranging up to 120 K and supply temperatures up to 280 °C. Compressor technologies, such as piston, screw, and turbo compressors, are evaluated for their availability and suitability in industrial HTHP systems. Total Equivalent Warming Impact (TEWI) is assessed considering refrigerant leakage, recovery losses, and the national electricity mix's greenhouse gas intensity in European contexts.

Results show a trade-off between VHC and COP, with hydrocarbons and ammonia-based refrigerants demonstrating favorable efficiency and environmental profiles under tightening EU climate regulations. The techno-economic attractiveness of HTHPs strongly depends on the decarbonization of electricity production and carbon pricing policies. The potential for HTHPs to contribute to industrial heat decarbonization is significant, contingent upon the availability of renewable electric power and compliance with environmental standards.

In conclusion, HTHPs represent a key technology for achieving industrial energy transition goals by efficiently utilizing waste heat and reducing greenhouse gas emissions under current and forthcoming regulatory frameworks. Continued research and innovation in HTHP technology and refrigerants are critical for enhancing market adoption.

### **Literature references:**

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