High temperature heat pumps with subsequent steam compressors – a promising combination for low carbon process steam supply

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May 2023

Decarbonization of heating sector is essential to meeting global emissions targets and requires usage of Renewable Heat

~50%

of global final energy consumption is heat[1]

76%

from non-renewable sources[1]

40+%

of global energy related carbon emissions[1]

e.g., IEA analysis[1]

Use of Renewable Heat is key!

Thermal use of Modern Biomass
(Special industries / countries)

Thermal use of Renewable Electricity
(Global)

my focus

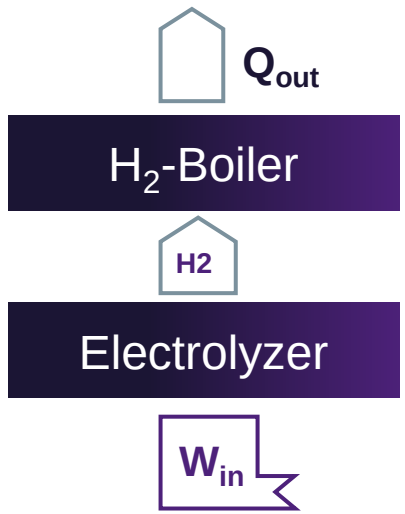
[1]IEA (2021), *Renewables 2021*, IEA, Paris https://www.iea.org/reports/renewables-2021

Heat pumps facilitate an energy efficient means of using Renewable electricity for heating purposes

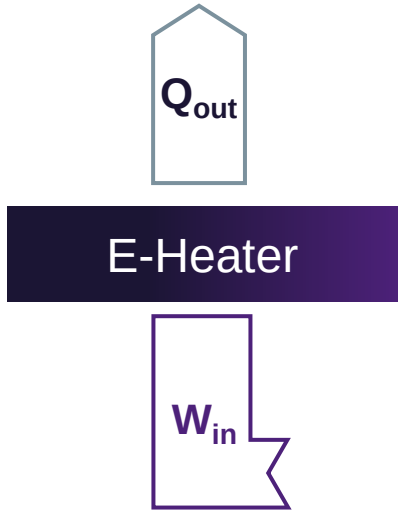
Coefficient of Performance

$$COP = \frac{\text{Thermal Energy } (Q_{OUT})}{\text{Electrical Energy } (W_{IN})}$$

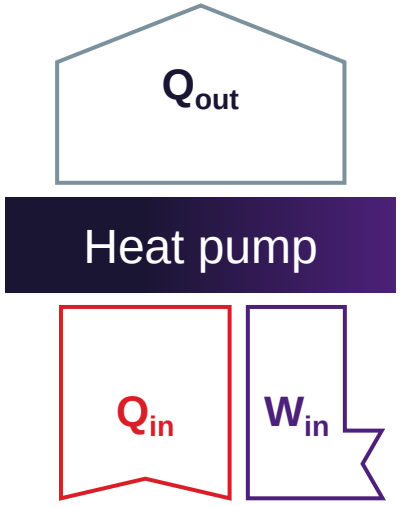
Technological options



$COP_{green\ H2} < 0.75$

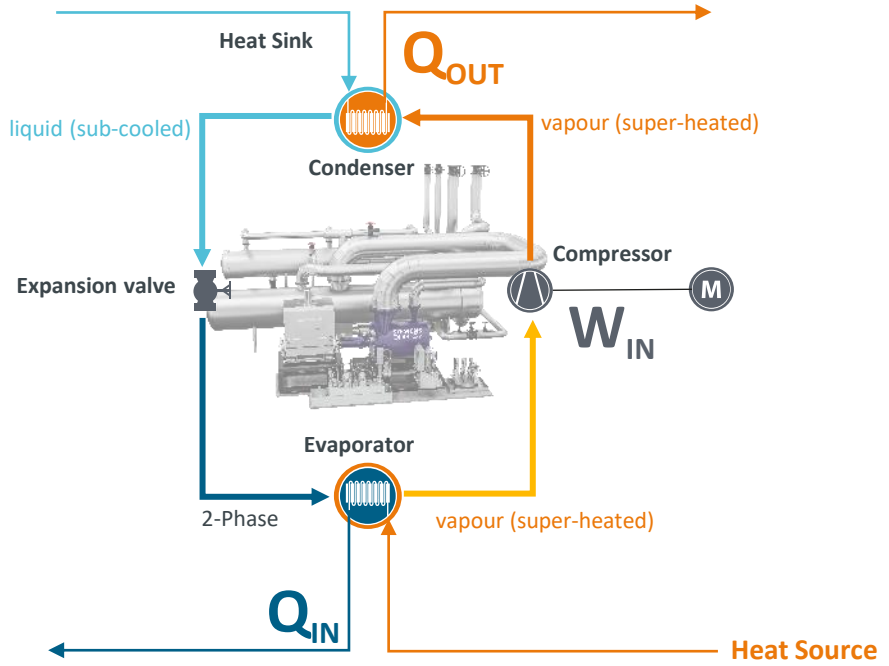


$COP_{RH} \sim 1$



$COP_{HP} = 2…6$

Heat Pump Process Scheme



Working principle

Heat flows naturally from a higher to a lower temperature. Heat pumps, however, are able to force the heat flow in the other direction, using a relatively small amount of high-quality drive energy e.g., electricity. Thus, heat pumps can transfer heat from a low temperature to a high temperature level[1].

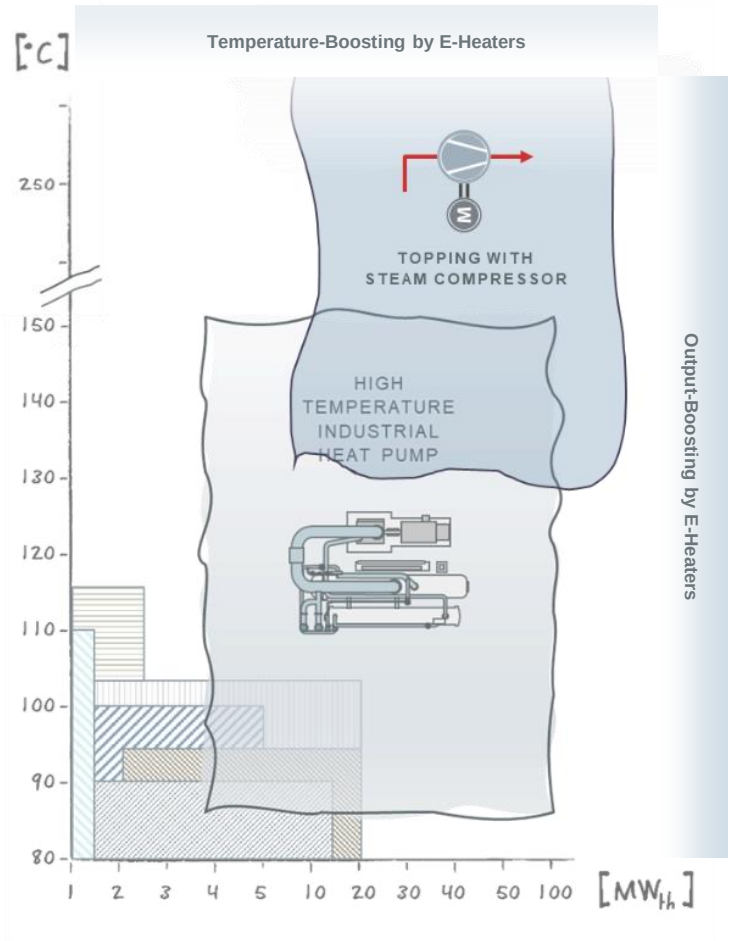
Large scale heat pumps from Siemens Energy address both district heating and industry applications

Two Complementary Product Lines …

…with enhanced features…

SHP-STC-XX W/S

SHP-C600 / SHP-C750



… to Serve the Needs of our Customers

Heat supply

~7 – 70 MW_{th} per unit

Temperatures

up to **150°C** directly from heat pump

Environment friendly work medium

low **GWP[1]** and **ODP[2]**

Various drive concepts

Electrical or **mechanical**

Combination with steam compression

for **higher temperatures** and **pressures** for process steam production

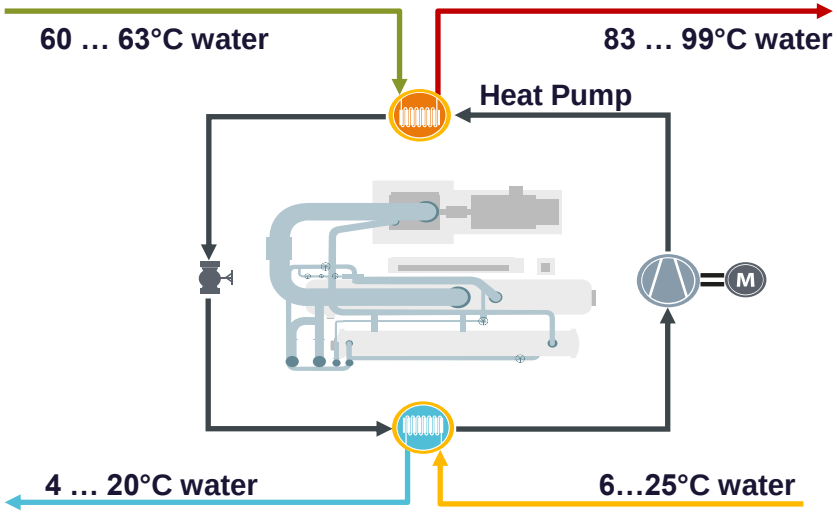
Scope of supply

Component up to **turnkey supply**

[1] GWP = Global Warming Potential
[2] ODP = Ozone Depletion Potential

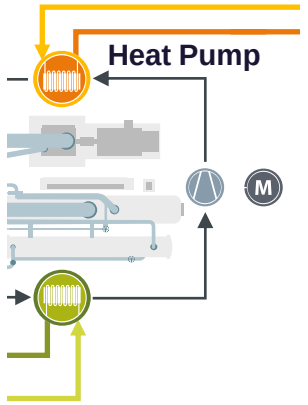
Recent examples for large scale heat pumps (1/2)

District heating system, Mannheim, local utility MVV, Germany



Thermal capacity	max. 20 MW_{th}	**COP** (overall)	2.7 (average)
Expected benefits	• District heat for 3500 households • CO2 savings: ~ 10000 t/a		

District heating system, Berlin, Vattenfall, Germany



Thermal capacity	max. 8 MW_{th}	**COP** (overall)	3 (average)
Expected benefits	• District heat production: ~ 55 GWh/a • CO2 savings: ~ 6500 t/a • Cooling water savings:~ 120 000 m³/a		

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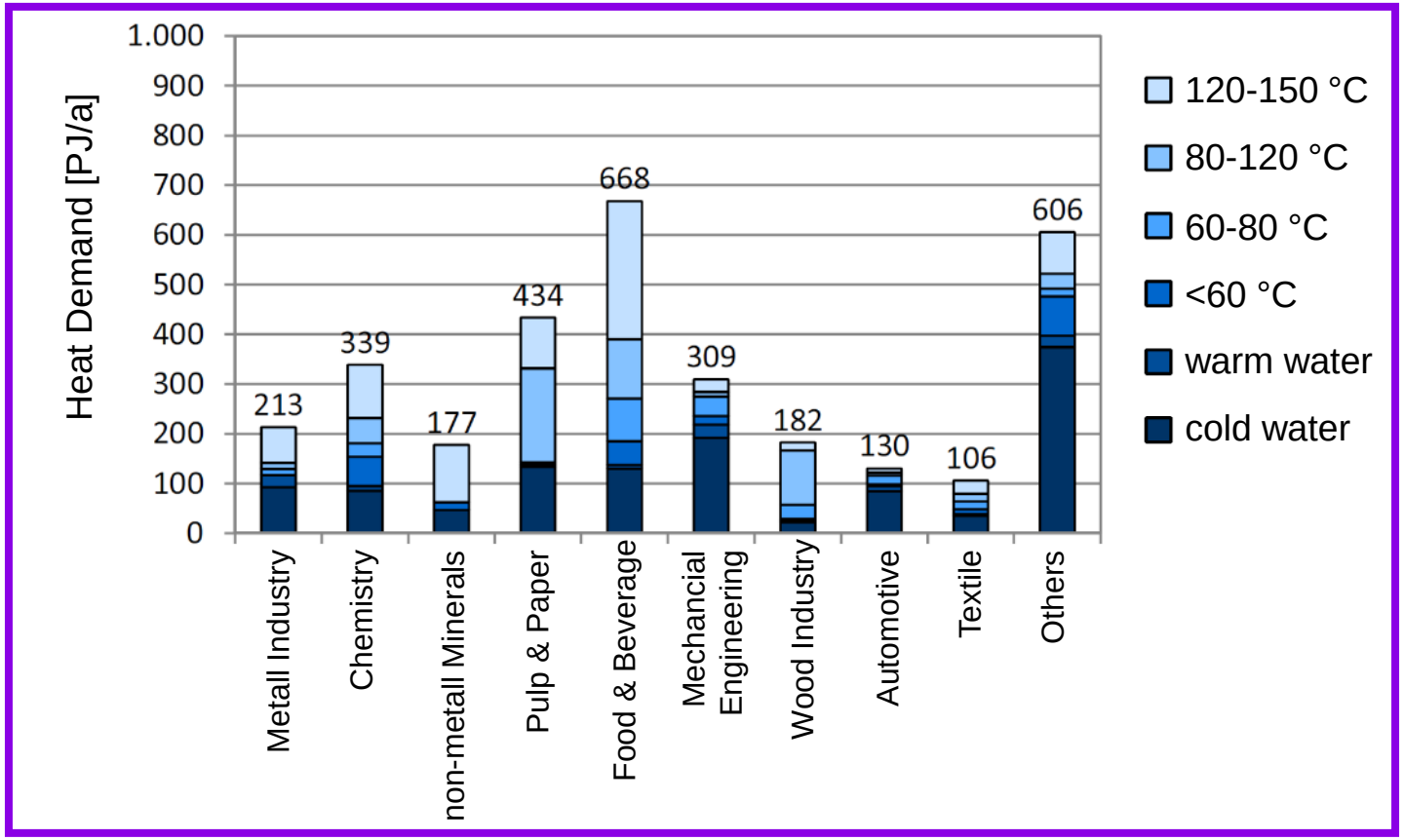
High Temperature Heat Pumps open-up new options for heat supply to industrial processes and district heating systems

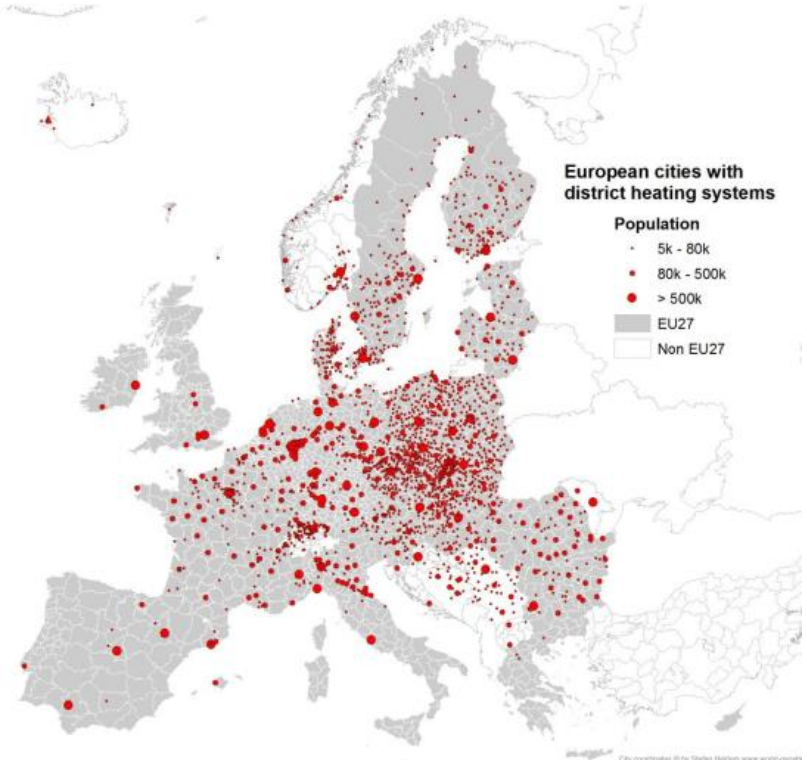
Process heat demand in the EU



Process heat demand in the range of 80 to 150°C sums up to 1300 PJ/a

Source: University Stuttgart, Institute for Energy Economics and Rational Use of Energy, Heat pumps for industrial applications, Chillventa, 2014

District heating systems in the EU

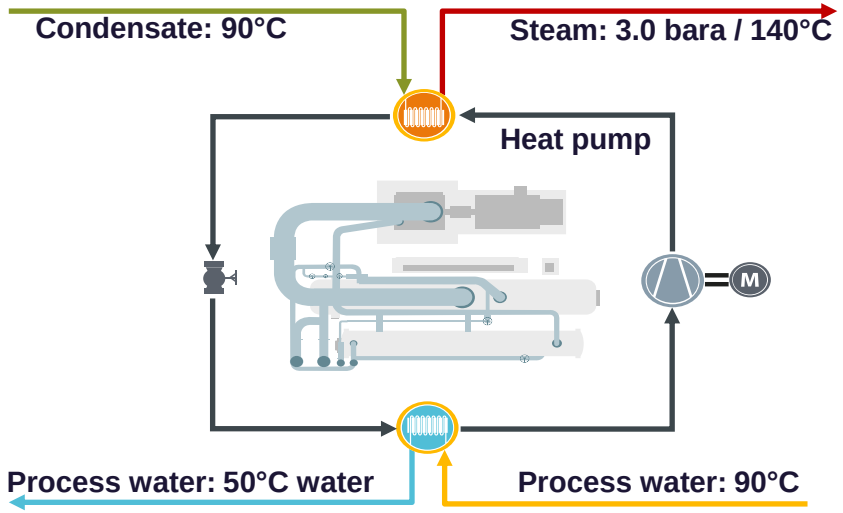


Heat Demand of 1400 PJ/a

Source: Heat Roadmap Europe 2050, First Pre-Study for the EU 27, 2012

High Temperature Heat Pumps
Use Case – “LP steam from process water”

Heat pump for stream production – Utilization of waste heat



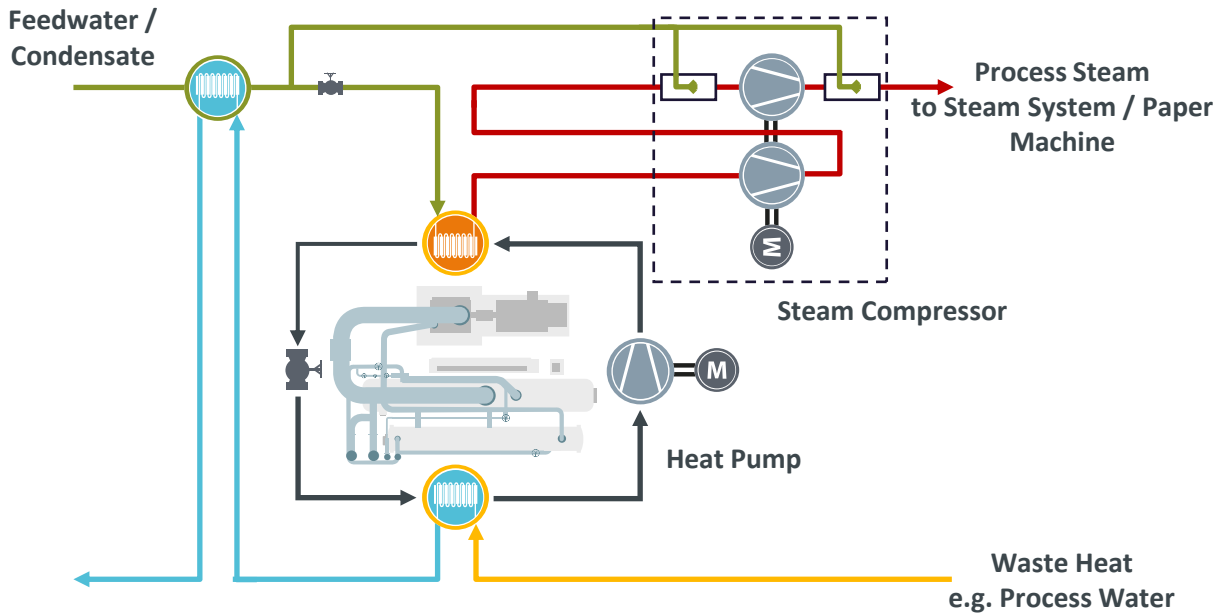
- High temperature heat pump utilizes waste heat from process water to produce saturated steam from condensate
- COP: 2.7
- Thermal output: 46 $MW_{th.}$

Benefits

- Heat recovery increases overall energy efficiency → lower primary energy demand
- Use of electricity instead of fossil fuel
- Decrease in CO2 emissions
- Reduced dependence on fossil fuel(s)

High Temperature Heat Pumps w/ Steam Compressor
Use Case – “MP steam from process water”

Heat pump for stream production – Utilization of waste heat



- High temperature heat pump utilizes waste heat from process water to produce saturated steam from feedwater
- Saturated steam is fed to steam compressor (multi-stage intercooled)
- Final adjustment of steam parameters by attemperation

Benefits

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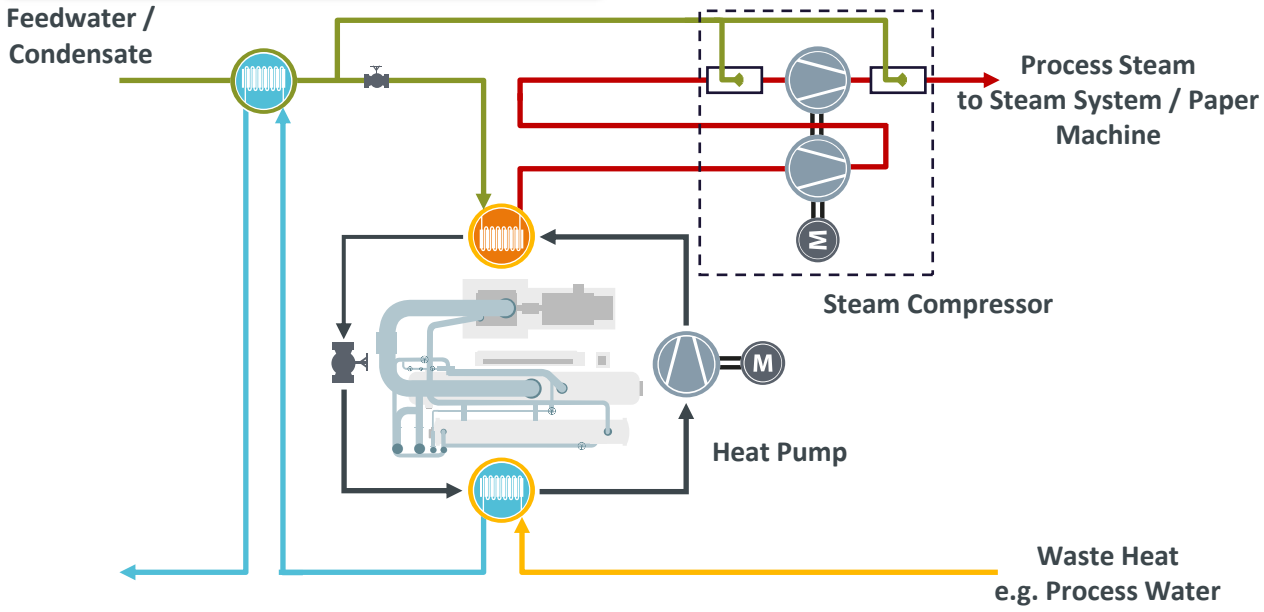
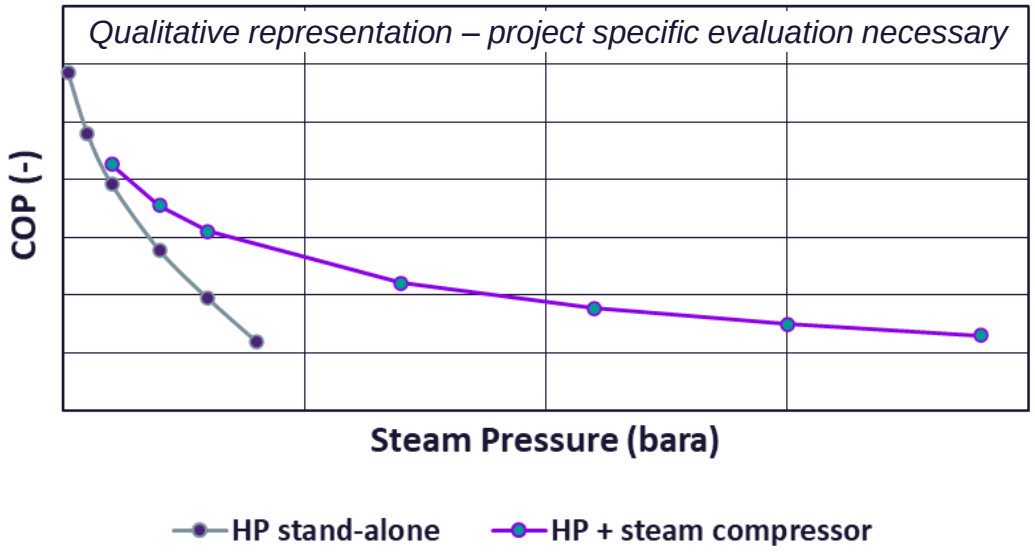
MP Steam from Waste Heat



Impact of steam compressor



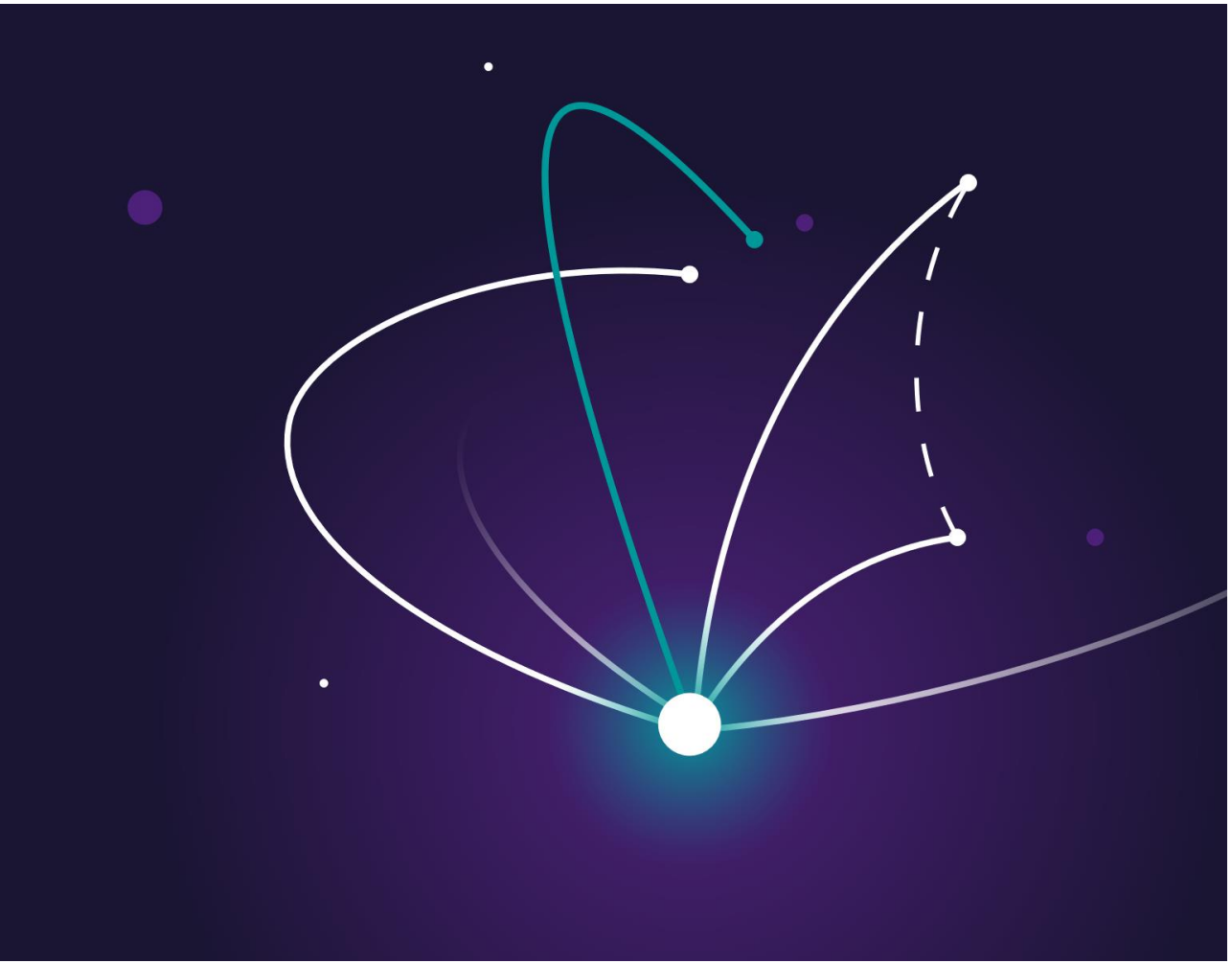
Benefits of steam compressor

- New option for steam supply up to 55 bara and 270°C
- Enhanced COP at typical “low pressure” steam levels

Summary

- The electrification of the heating sector is key to meeting global emissions targets.
- Heat pumps allow for energy efficient electrification of the heating sector.
- High temperature heat pumps facilitate low carbon heat supply to district heating systems & process industries. Subsequent steam compression facilitates steam supply to up to 55 bara and 270°C.
- Siemens Energy has a track record as heat pump supplier at temperatures of up to 99°C and advanced products to facilitate heat supply at higher temperature levels.
- Siemens Energy can be your One-Stop-Shop for decarbonization – from the initial assessment and technical analysis to a heat pump ready for low carbon operation.

Contact



Published by Siemens Energy

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