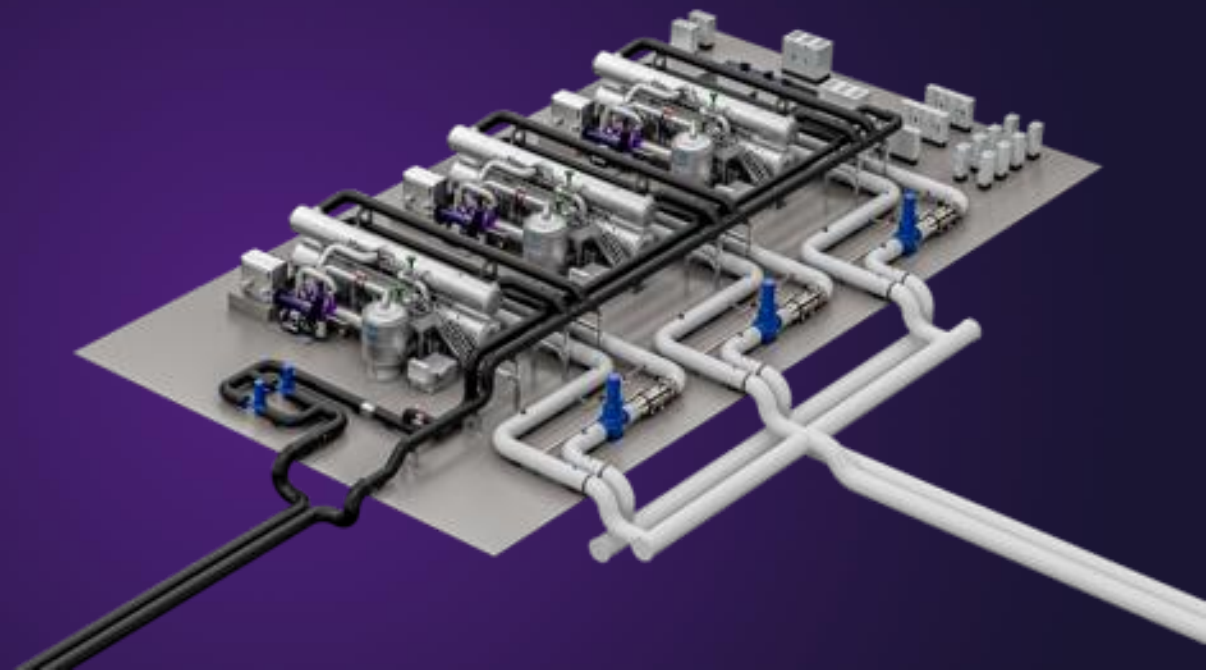
9. Dialogplattform Power to Heat
Optionen und Strategien zur Wärmewende

Entwicklung und Anwendung von Hochtemperatur - Wärmepumpen



07. Dezember 2023

Dirk Fährmann, Siemens Energy

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

~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 Electricity in Heating Sector is key!

District heating and/or cooling

Heat pumps can be used to decarbonize district heating and cooling.

Industrial applications

Efficient use of energy in industries, e.g., food & beverage, chemical, petrochemical & pharmaceutical, pulp & paper

[1]IEA (2022), Renewables 2022, IEA, Paris https://www.iea.org/reports/renewables-2022

Heat pumps offer the most efficient way to decarbonize heat !

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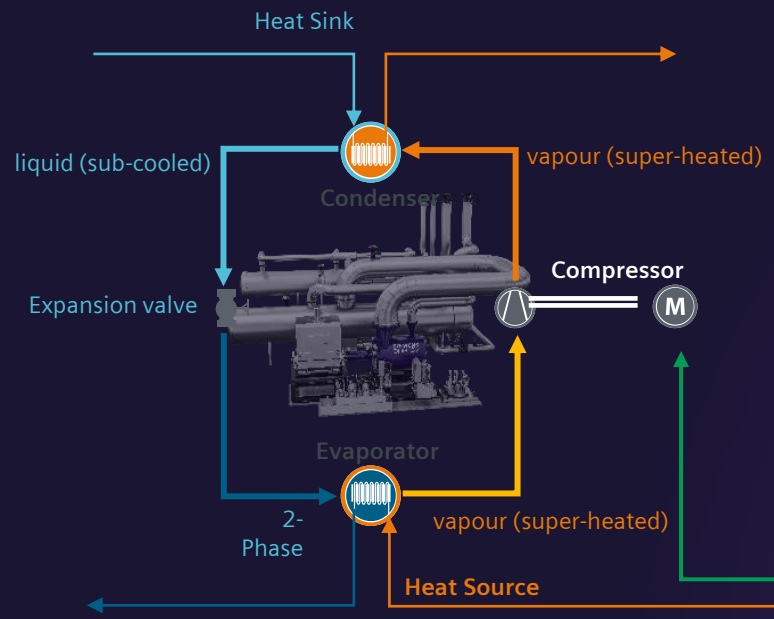
HEAT PUMP PROCESS SCHEME



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

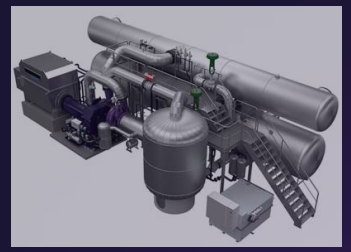
EFFICIENCY COMPARISON TO ELECTRIFY HEAT

COP = coefficient of performance

Industrial Heat Pumps & Compressors covering a huge application range

Complementary product lines …

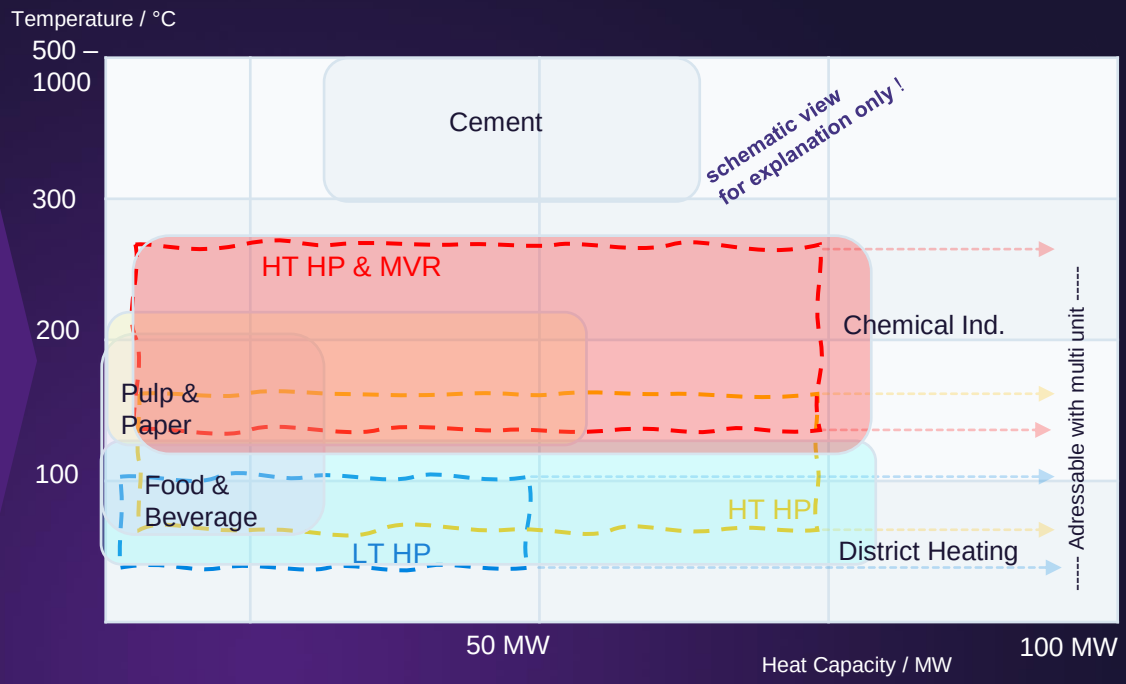
SHP-C600 / C750
Based on proven design since 1982
15 – 45 MW, up to 99 °C
(hot water)



SHP-STC-XX W/S
High **T**emperature **H**eat **P**ump
15 – 70 MW, Up to 150 °C
(hot water OR steam up to 3.7 bara)

HT HP* + Steam Compression
High **T**emperature **H**eat **P**ump & steam compression
15 – 70 MW, Up to 270 °C
(steam up to 55 bara)

… covering the output range for the use cases



* MVR = Mechanical Vapor Recompression; HT HP = High temperature heat pump; LT HP = Low temperature heat pump

High Temperature Heat Pumps vs. other Heating Options
What are the challenges to find the optimal solution?

Evaluation of a business case with ...

- Investment costs €/MWth
- Performance data (e.g. CoP, heat capacity)
- Energy costs

Cost

A holistic approach in the search to find …

- **Optimum cost-benefit ratio due to appropriate sizing**
- **Low Lifetime Cycle Costs**
- **Optimum of operational flexibility**

Excellence

CAPEX vs. OPEX

→ It is worth analyzing the project-specific boundary conditions

… to find a long term economically optimized solution !

High Temperature Heat Pumps
Challenge to find the excellent solution

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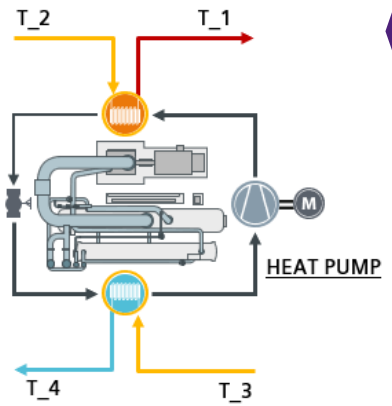
Technical boundary conditions

Operating behavior

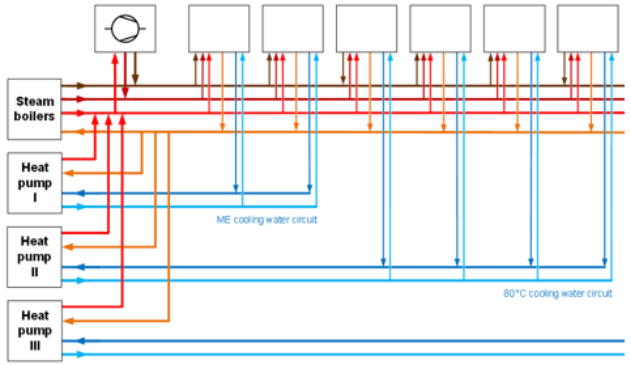
Environment

Business Case

1



2



check the floating consumption to the design point

other sources available?

Review of the boundary conditions according to….

- the **temperature lift / temp. glide** has a strong impact on COP
- the **mass flows** have a significant influence on the dimensioning
- **steam generation** may require additional MVR
- required **steam pressure**: Higher the steam pressure results in lower COP → optimization with MVR
- **optimized configurations** in the overall system may lead to a reduced OPEX effort and optimal CAPEX solution

High Temperature Heat Pumps
Challenge to find the excellent solution

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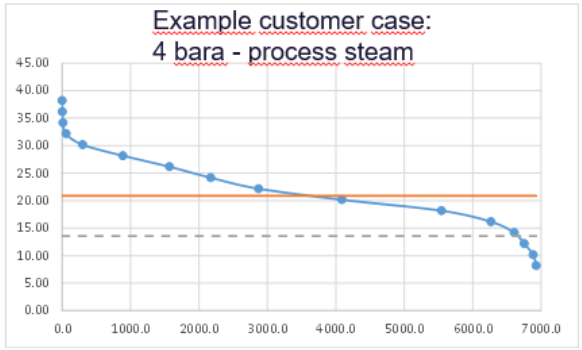
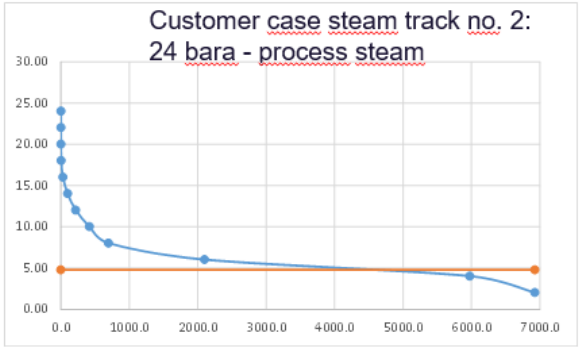


Average value: 20,9 t/h → 5,8 kg/s
→ procced



Average value: 4,8 t/h → 1,33 kg/s
→ low steam volume
→ not further considered → alternative options

Please note: This is a project specific example without general validity!

Specific operating modes needs to be considered like…

- dynamic requirements on the sink (steam)
- storage/buffer capacity (shift consumption) on the sink (water, steam)
- seasonal consumption (winter/summer or day/night operation)
- grid stability (el. consumption)

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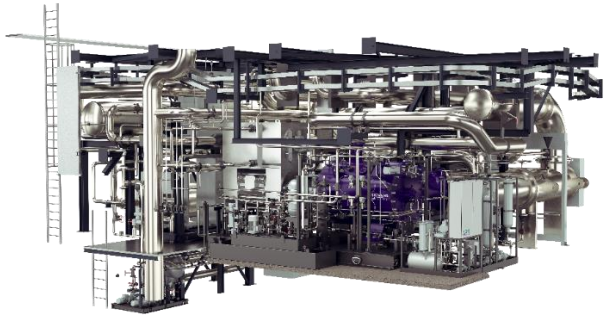
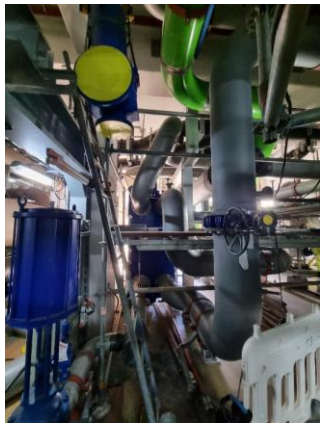


→ special space requirements



Side specific boundary conditions needs to be considered e.g.:

- space availability, footprint
- special requirements on codes & standards (e.g. oil&gas, food, chemistry)
- national/local laws (e.g. water protection law, noise protection)
- availability of (green) power, grid requirements

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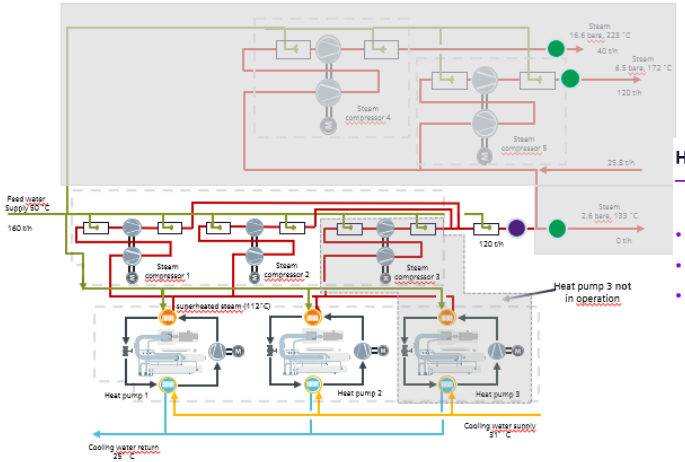

HTHP + Steam Compressor

- COP ~ 2.3 (Total System)
- Electrical power consumption: ~ 61 MW
- Flexibility in customized operating modes

HTHP only

- COP ~ 2.1 (Total System)
- Electrical power consumption: ~ 67 MW
- Lower CAPEX
- Lower Service Costs
- Smaller Footprint

→ Design options and overall maintenance plan have an impact on CAPEX as well on OPEX.

The business case can be improved by….

- an optimized system configuration
- optimized maintenance and spare part concept
- predictive maintenance: remote diagnostics
- consideration of criteria for CAPEX / OPEX
- funding & subsidies
- etc.…

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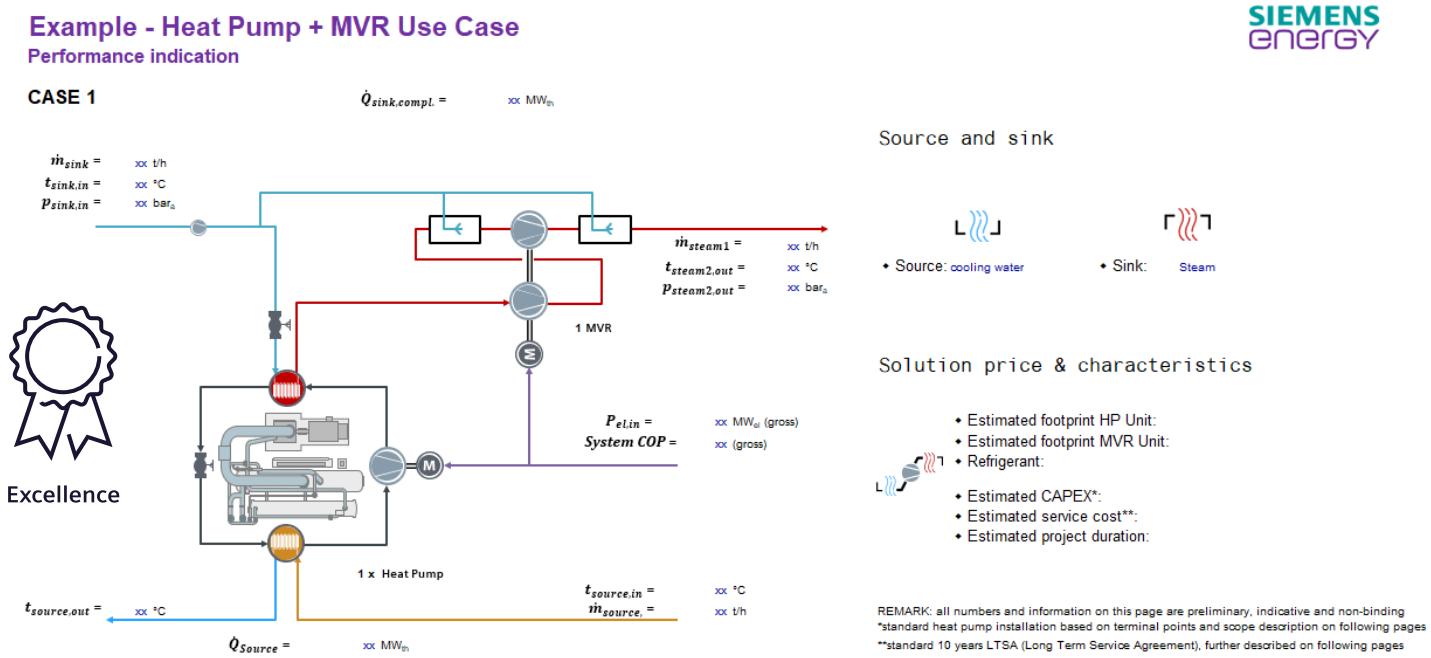

Siemens Energy supports a sustainable customer Business Case by…

- early project support – find optimized concept
- quick price and performance indications

Summary:

- Heat pumps offer the most efficient way to decarbonize heat.
- High Temperature Heat Pumps designed for heat supply from > 100°C up to 150°C. Subsequent steam compression facilitates steam supply to up to 55 bara and 270°C
- Heat pumps can be operated to shift energy consumption away from peak demand
- An effective condition monitoring program and a related service concept can reduce the Long Time Service Costs
- Design options and an overall maintenance plan have an impact on the economically optimal solution
- Early involvement to iterate from first price and performance indications towards positive business case is our offer

Thank you for your attention!

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