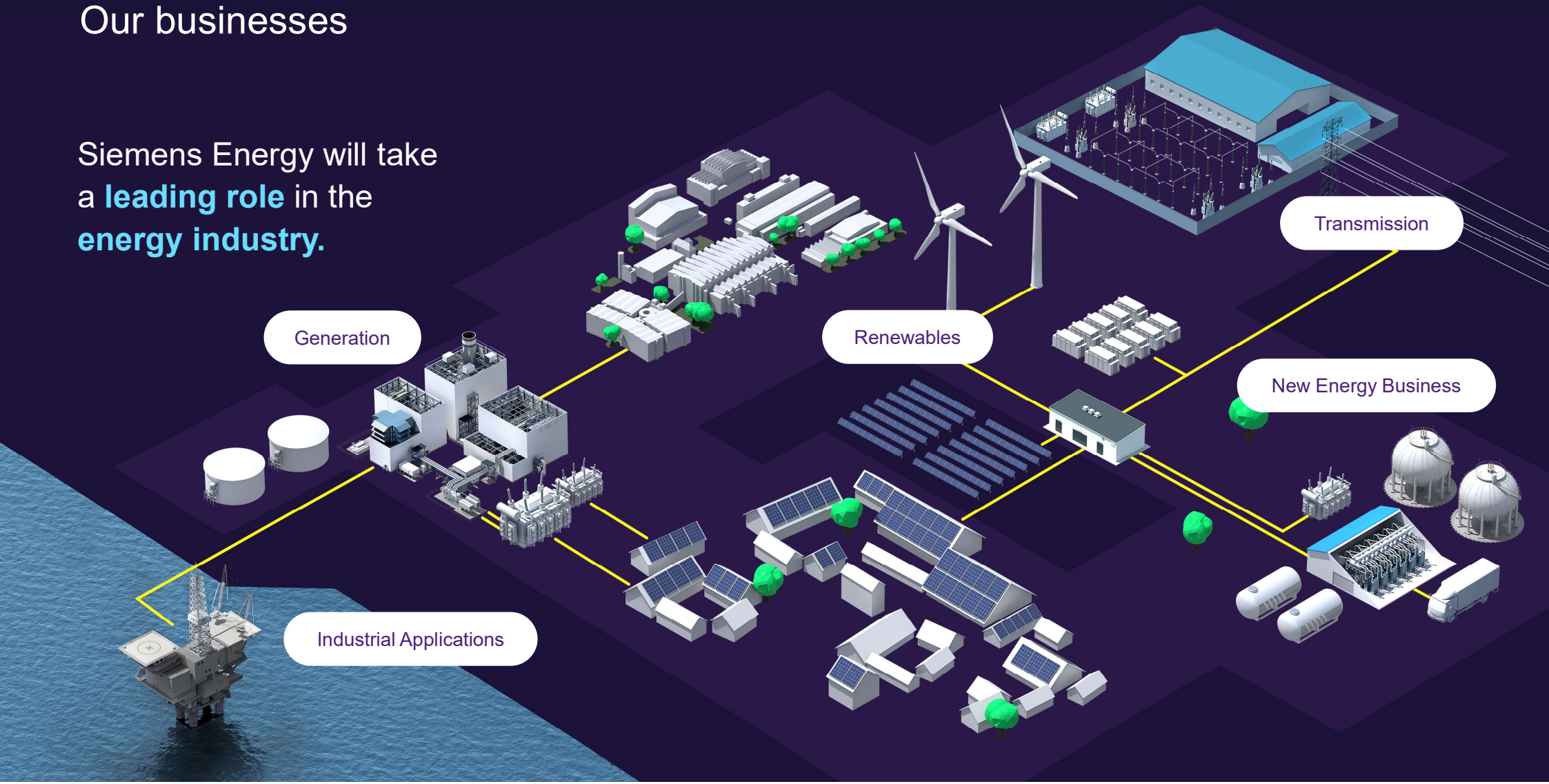
Siemens Energy
Large scale heat pumps

Petar Tatomirović
Head of Controls and Digitalization

April 2024

The entire energy value chain
Our businesses

Siemens Energy will take a **leading role** in the **energy industry.**



Siemens Energy is a

global leader in the energy business

~ 1/6

of global electricity generation is based on our technology.

97,000

employees work as a team to energize society.[1]

We are present in

> 90 countries.

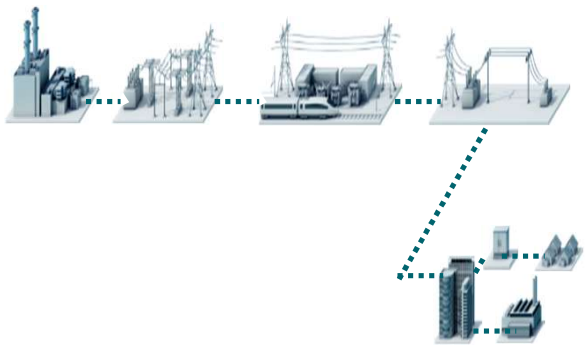
Order backlog

€118.0bn

1 Number of employees as of December 31, 2023

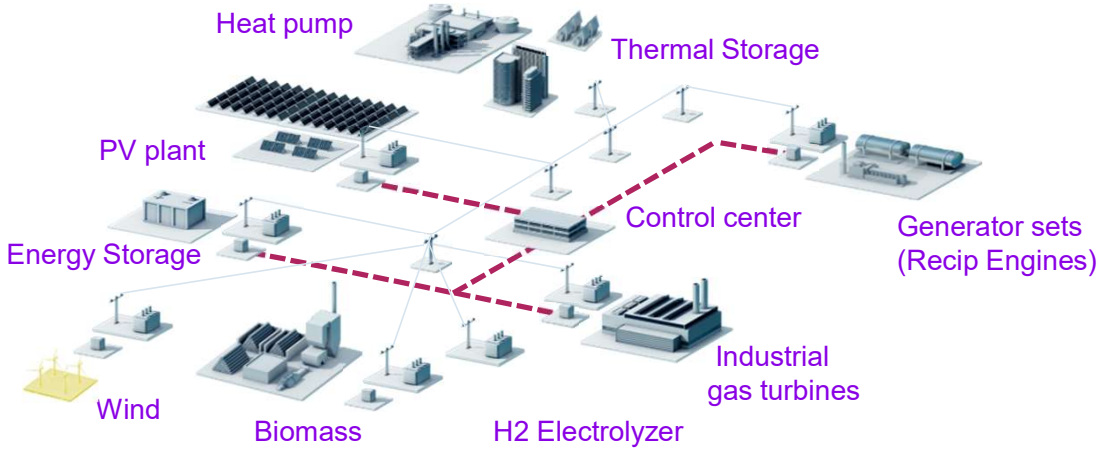
Siemens Energy Hybrid Solutions providing reliable generation through an integrated approach

From centralized…



- Large-scale generation
- Power supply is the main application
- Grid connection and long-distance transmission

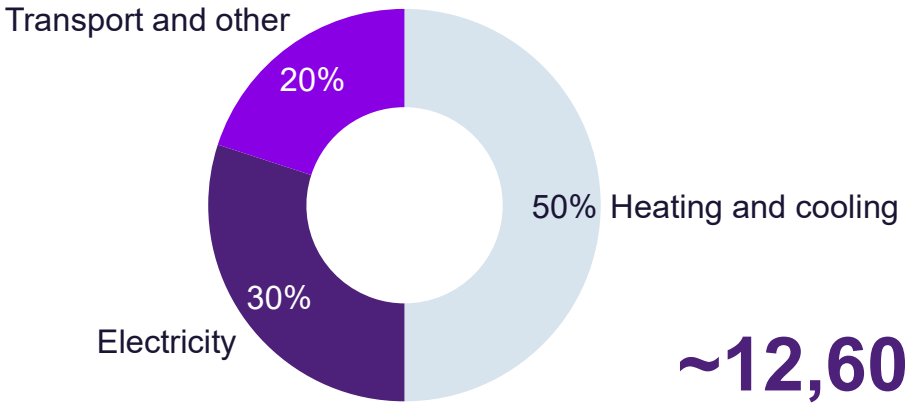
… to decentralized and hybrid energy systems



- Small-scale generation closer to end-user
- Allows more than one type of “fuel”
- Multiple applications including power, heat and cooling
- Generation with a single or multiple technologies in a hybrid system

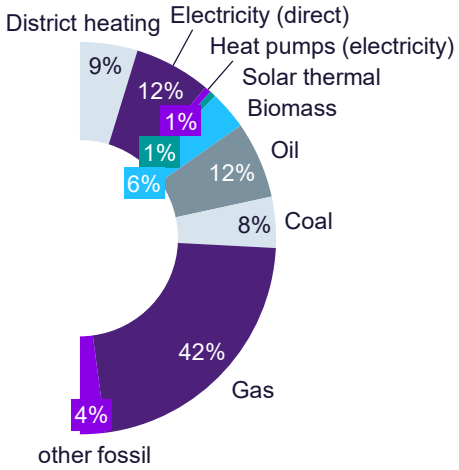
Heat in Europe is still largely produced from fossil sources

Final energy consumption EU28



~12,600
TWh *(2015)*

Heating and cooling in EU28 by carrier



~6,300
TWh *(2015)*

50%
of final energy use is heat → more than double comparing electricity

2/3 heat
is produced from fossil fuels → ~40% of energy related CO_2 emissions

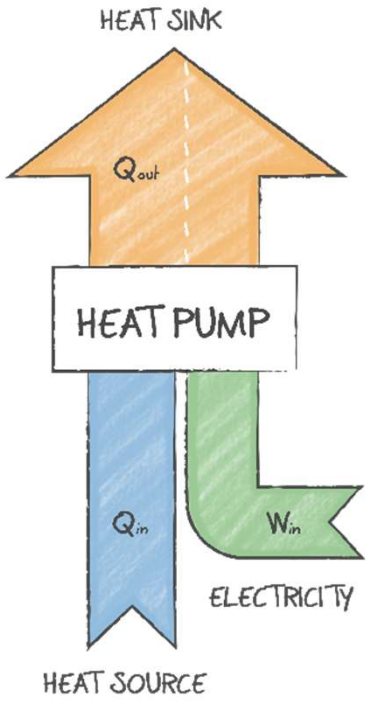
Decarbonizing the heat sector requires

- Efficiency improvements (e.g., thermal insulation, use of waste heat)
- **Replacement of fossil fuels** with renewables or renewable power

Siemens Energy, April 2024

Basic principle of compression heat pumps

SCHEME



WORKING PRINCIPLE

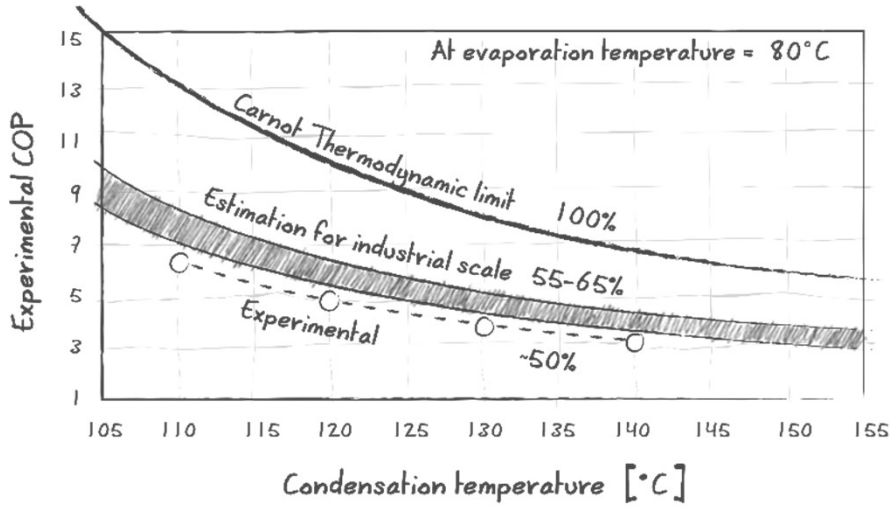
Heat flows naturally from a higher to a lower temperature. Heat pumps, however, are able to force the heat flow in the other direction, using a relatively small amount of high quality drive energy, e.g. electricity. Thus heat pumps can transfer heat from a low temperature to a high temperature level[1].

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

$\text{COP}_{HP} = 3\ldots6$	**H**eat **P**ump
$\text{COP}_{RH} < 1$	**R**esistive **H**eater
$\text{COP}_{\text{green H2}} < 0.75$	Green Hydrogen

[1]IEA Heat Pump Centre,
URL:http://www.heatpumpcentre.org/en/aboutheatpumps/heatpumptechnology/Sidor/default.aspx, Stand 11.02,2013

COP* – CARNOT INDUSTRIAL SCALE (> 5 MW), EXPERIMENTAL (~10 KW)



SYSTEM EFFICIENCY (FOR COMPARISON OF DIFFERENT APPLICATION CASES)

$$\text{System Efficiency} = \frac{\text{COP}_{real}}{\text{COP}_{Carnot}}$$

> 55%	Industrial Heat Pump
< 35%	Household Heat Pump

*Coefficient of Performance

Industrial scale Heat Pumps from Siemens Energy

TWO COMPLEMENTARY PRODUCT LINES …

SHP-STC-XX W/S

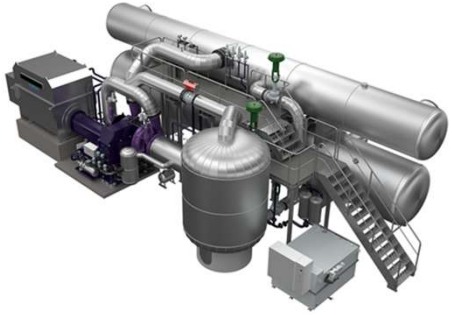
HIGH TEMPERATURE HEAT PUMP

5 – 70 MW, UP TO 150 °C (HOT WATER OR STEAM)

SHP-C600

BASED ON PROVEN DESIGN (SINCE 1980_S)

15 – 45 MW, UP TO 100 °C (HOT WATER)



… TO SERVE THE NEEDS OF OUR CUSTOMERS

HEAT SUPPLY

~5 - 70MW_{th} per unit

TEMPERATURES

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

ENVIRONMENT FRIENDLY WORK MEDIUM

low **GWP** and **ODP**

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**

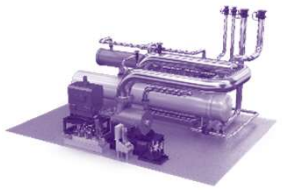
Siemens Energy, April 2024

Industrial scale Heat Pumps from Siemens Energy

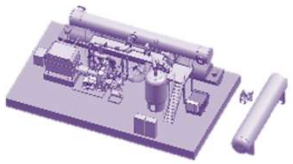
TWO COMPLEMENTARY PRODUCT LINES …

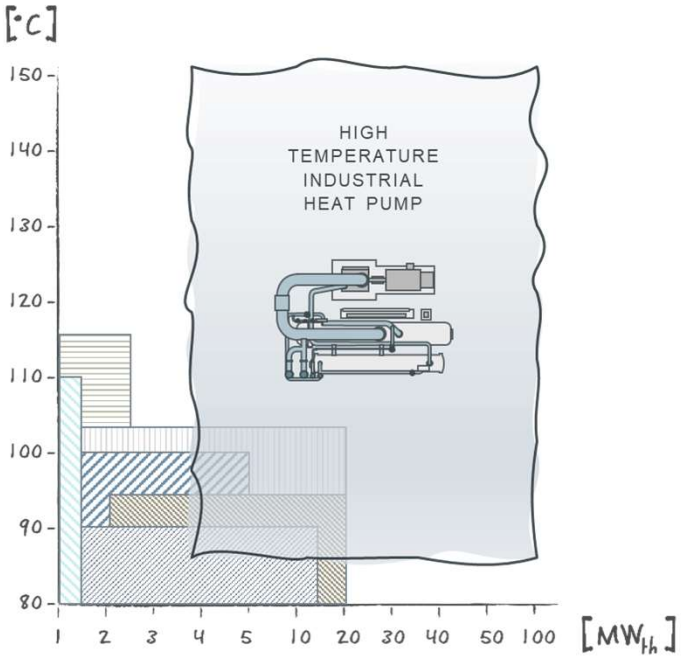
…WITH ENHANCED FEATURES…

SHP-STC-XX W/S



SHP-C600





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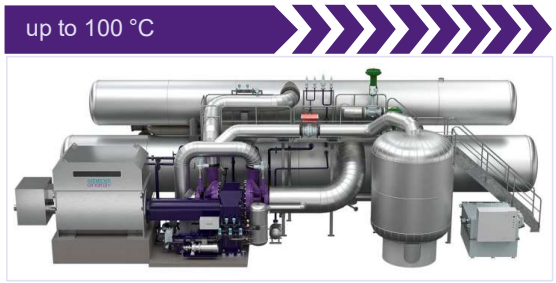
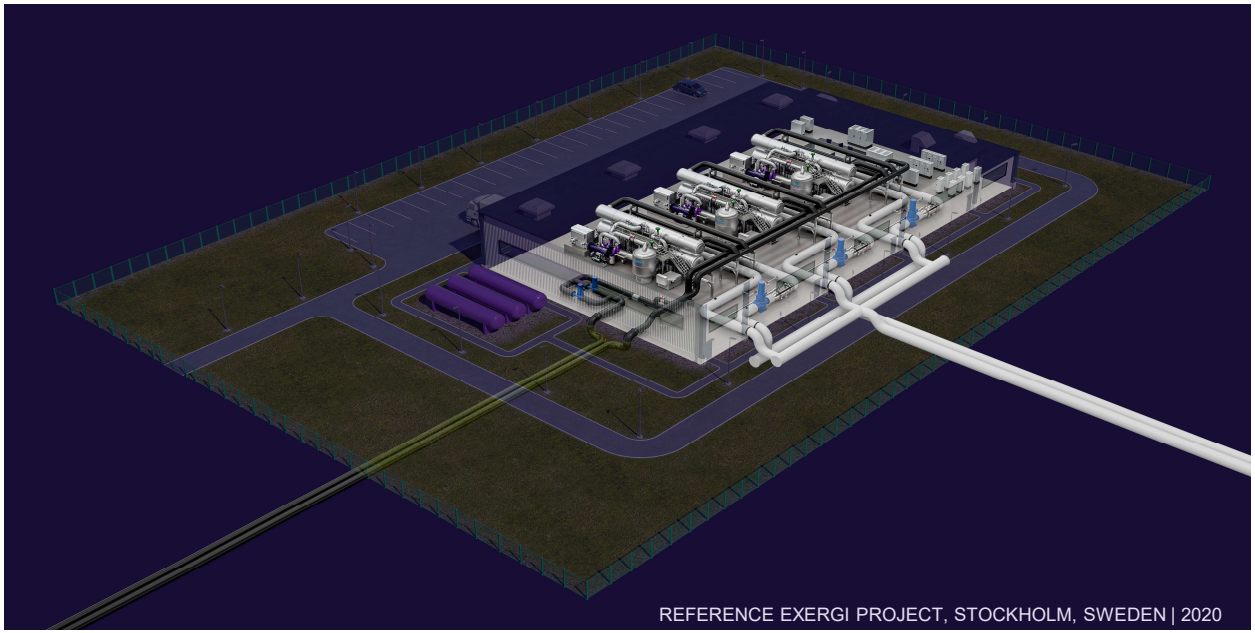
Industrial scale Heat Pumps from Siemens Energy

Siemens Energy is delivering this updated type of large-scale, **low-temperature heat pump** to provide thermal capacity of **up to 45 MWth** which will be capable of **flexibly** delivering flow temperatures e.g., in the district heating network **up to 100 °C.**
With the existing fleet Siemens Energy has over the years **truly proven** the robustness of the heavy-duty industrial heat pump. The design is based on over 50 deliveries, starting in mid 80s, with more then 6 millions accumulated operating hours.

- Outstanding performance
- Operational flexibility
- Deep knowledge-based heat pump
- Flexible modularized concept




REFERENCE EXERGI PROJECT, STOCKHOLM, SWEDEN | 2020

SHP-C600

Low temperature heat pump

Heat generation

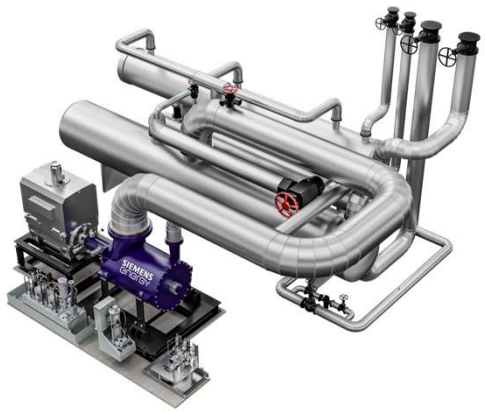
Heat supply	15 – 45 MWth
Temperatures	up to 100 °C (hot water or steam)

Industrial scale Heat Pumps from Siemens Energy

Siemens Energy is delivering this new type of large-scale, **high-temperature heat pump** to provide thermal capacity of **up to 70 MWth**, which will be capable of **flexibly** delivering flow temperatures e.g., in the district heating network. This is one way in which technology can make a further contribution toward **replacing fossil-based heating** in urban district heating networks.

- Outstanding performance
- High flexibility
- Proven technology based on > 2.100 compressors delivered since 1948

up to 150 °C



REFERENCE QWARK² PROJECT, VATTENFALL, BERLIN, GERMANY | 2022

SHP-STC-XX W/S

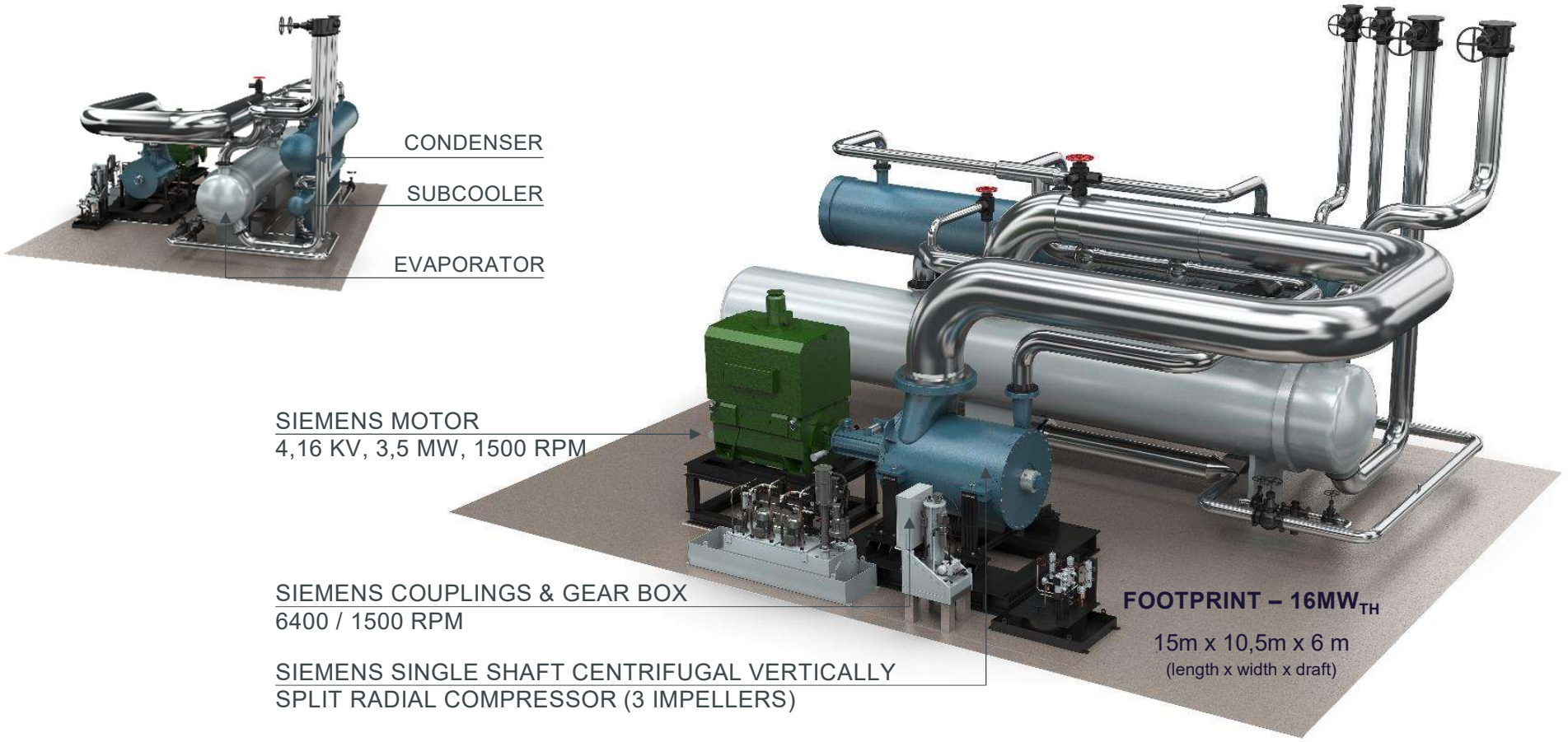
High temperature heat pump

Heat generation

Heat supply	5 – 70 MWth
Temperatures	up to 150 °C (hot water or steam)

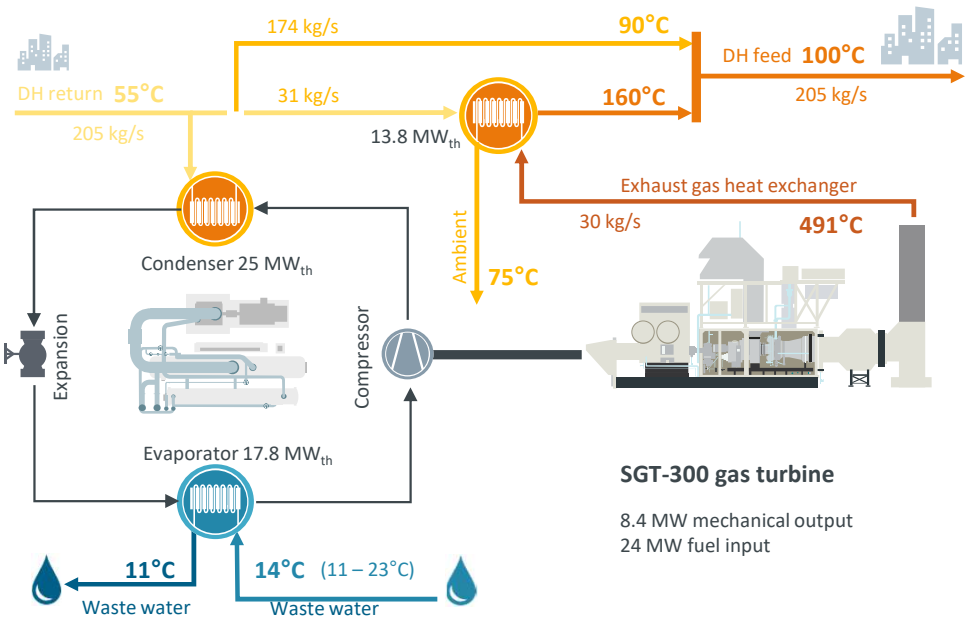
Siemens Energy, April 2024

Major core components – 16 MWth example



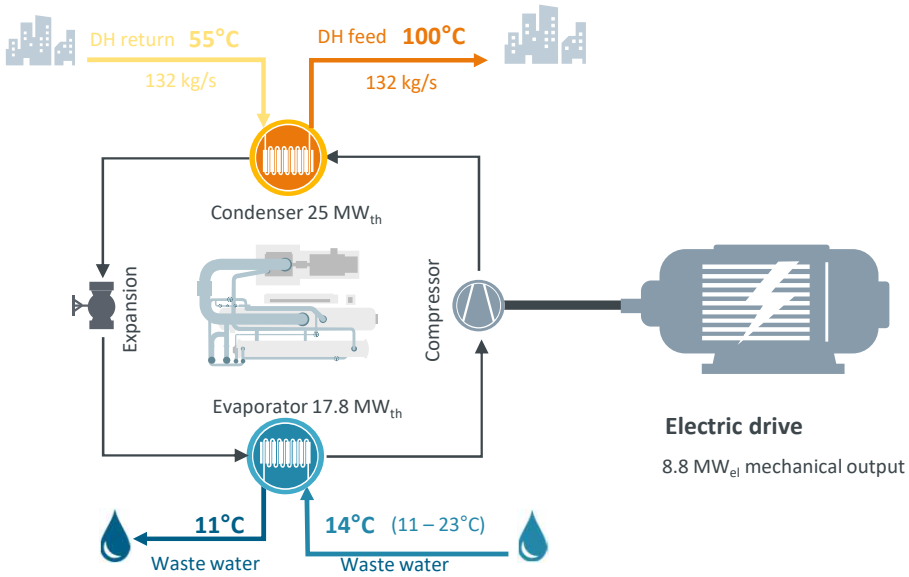
Gas turbine driven heat pump with utilization

OPTION 1: GAS TURBINE DRIVE



- COP = 3.0
- 38.8 MW of heat with 24 MW of fuel consumption

OPTION 2: ELECTRIC DRIVE



- COP = 2.8
- 25 MW of heat with 8.8 MW el. Consumption
- 38.8 MW of heat with 13.7 MW el. consumption

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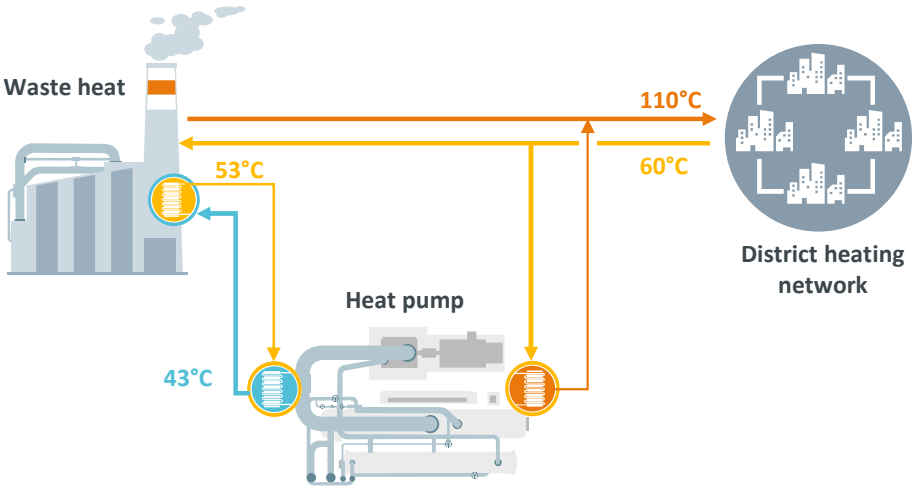
Integration of Industrial Heat Pump – Project Example

OVERVIEW



BENEFITS

- Heat pump lifts the temperature level of waste heat from flue gas to the temperature level of the district heating system
- Heat supply with reduced carbon footprint
- Local emission reduction

KEY FIGURES

CAPACITY	1 Unit ~16 MWth
AVERAGE COP	~4.9
SCOPE	Turnkey
REFRIGERANT	Hydro-(chloro)-fluoro-olefin (H(C)FO)
ARRANGEMENT	Brownfield (integration in existing building)
HEAT SOURCE	waste heat from flue gas scrubber via closed cooling water cycle (53 ->43°C)
HEAT SINK	District heating (55 – 110°C)
ELECTRICAL EQUIPMENT	SIEMENS Motor 4,16 kV; ~3,5 MW / SIEMENS Frequency Converter / SIEMENS Transformer
COMPRESSOR	SIEMENS single shaft centrifugal vertically split radial compressor
LUBE & SEAL OIL SYSTEM	Combined lube and Seal Oil System
HEAT EXCHANGER	Shell & Tube Heat Exchangers (Evaporator, Condenser, Subcooler)
I&C SYSTEM	**T3000 compact solution**

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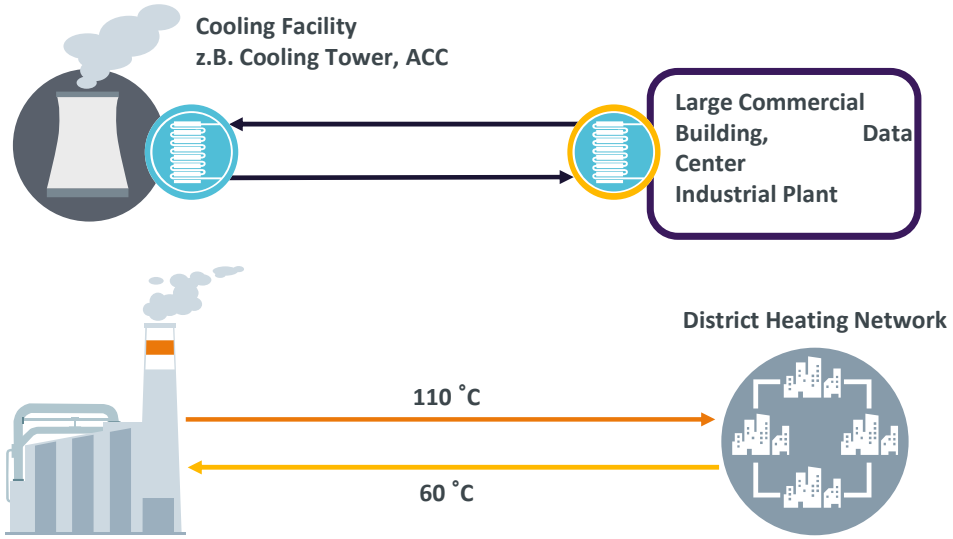
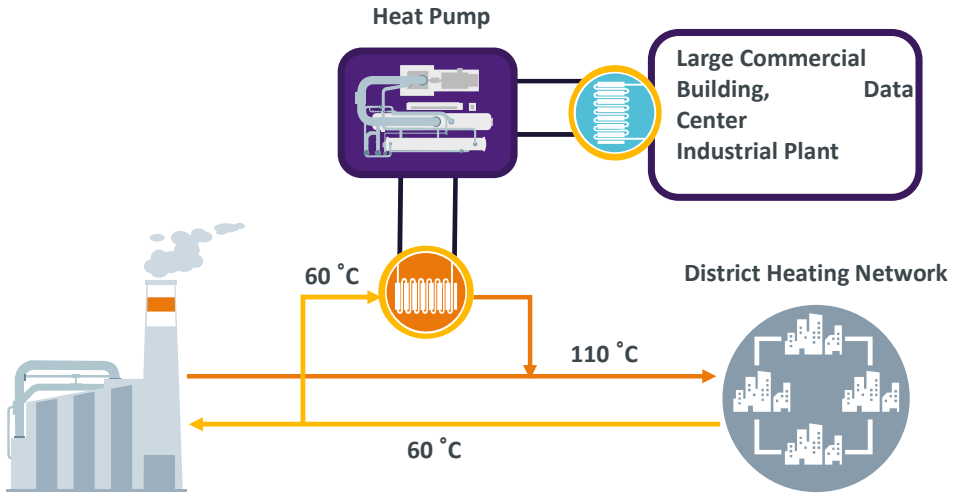
Integration of large cooling systems

SITUATION TODAY



IMPROVED SITUATION WITH HEAT PUMP

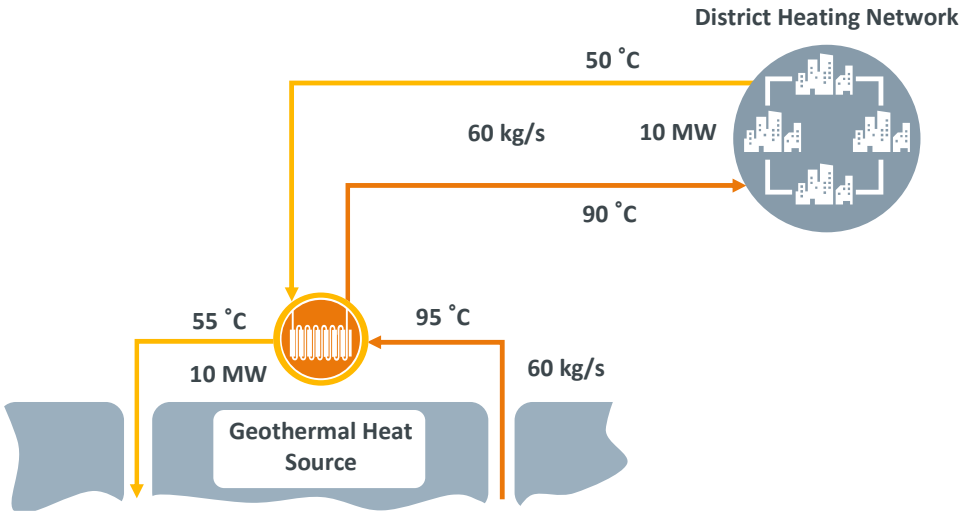


BENEFITS

- Waste heat from large commercial buildings, data centers and industry can be utilized for district heating → opening up new sources for district heating
- Combined-Heat-and-Power-and-Cooling → re-use of waste heat → reduced heat rejection to ambience
- no additional cooling facilities needed anymore → e.g. reduction of aux. consumption, make-up water
- “cooling” as additional product for heat pumps

Improvement of existing heat sources – geothermal heat

SITUATION TODAY



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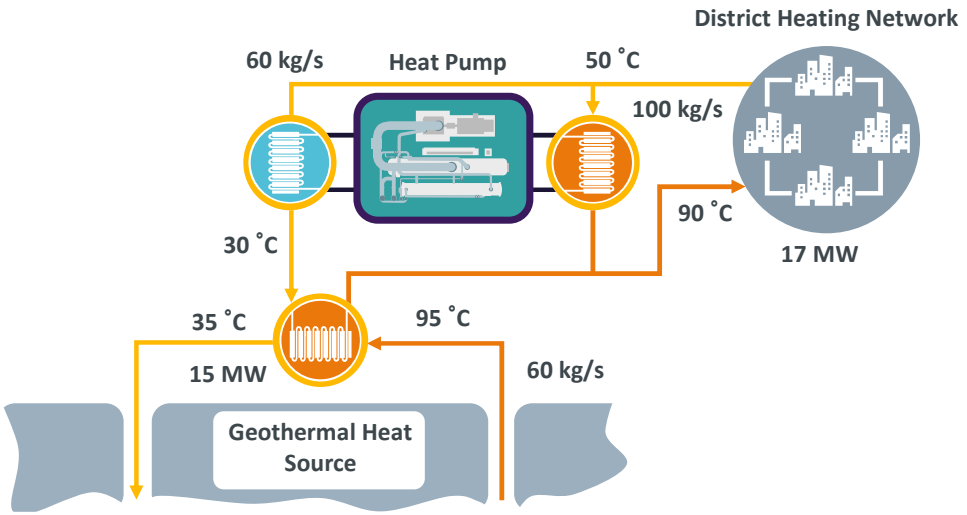

BENEFITS

- improved heat recovery from a geothermal source +50%
- increased heat supply to district heating system +70%
- unchanged flow rates in the well (no changes at the geothermal heat source)
- principle also applicable to boost CHP plants

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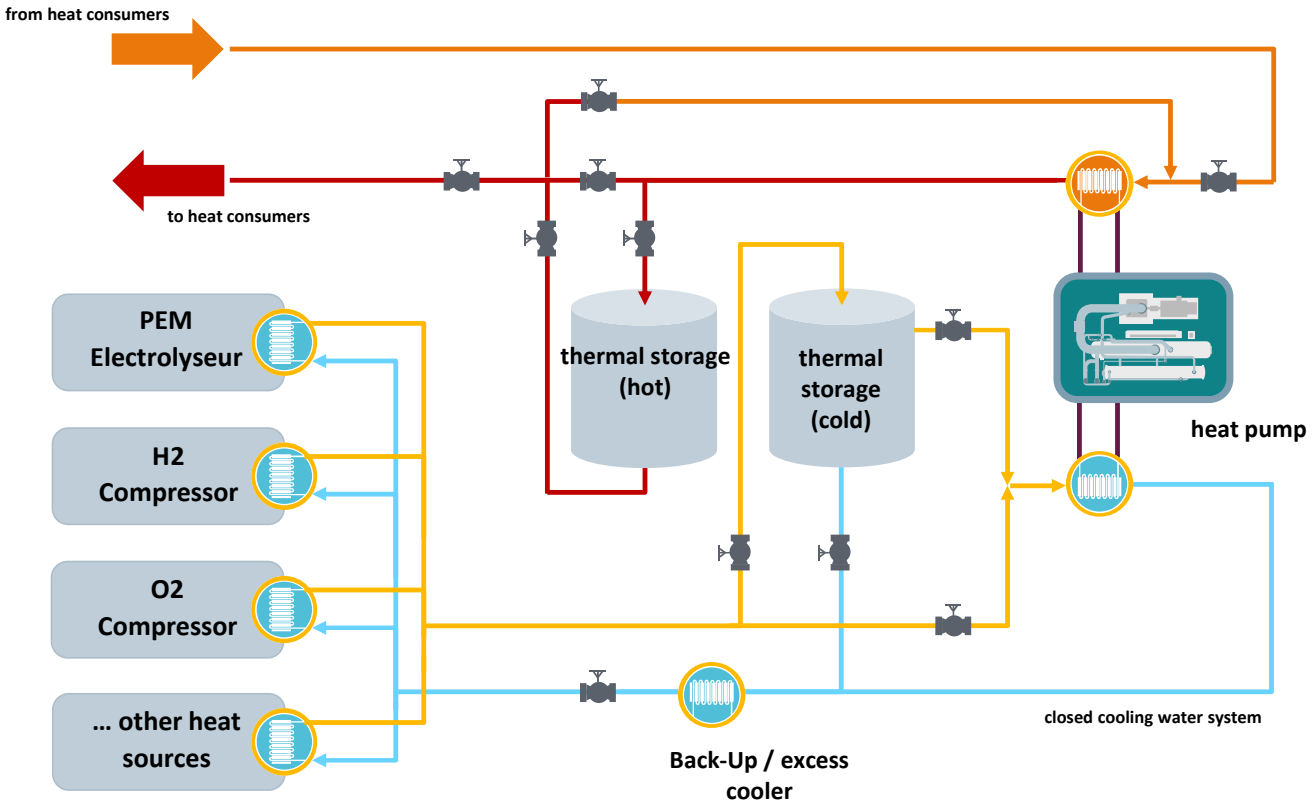
Concept – Waste Heat Utilization for Electrolyzes

PROCESS FLOW SCHEME



PRINCIPLE

- Heat Pump absorbs the heat from the H2 production and lifts it to higher temperature level e.g. for process heating (hot water or steam)

CHALLENGES

- Heat demand and waste heat from H2 production may timewise not be congruent
- Fluctuating heat from H2 production (esp. when driven be renewable electricity)

CONCEPT

- Decoupling of waste heat production and heat demand by thermal storage
- Optimized sizing of heat pump by integrating a thermal waste heat storage for electrolyzers

References | since 1980

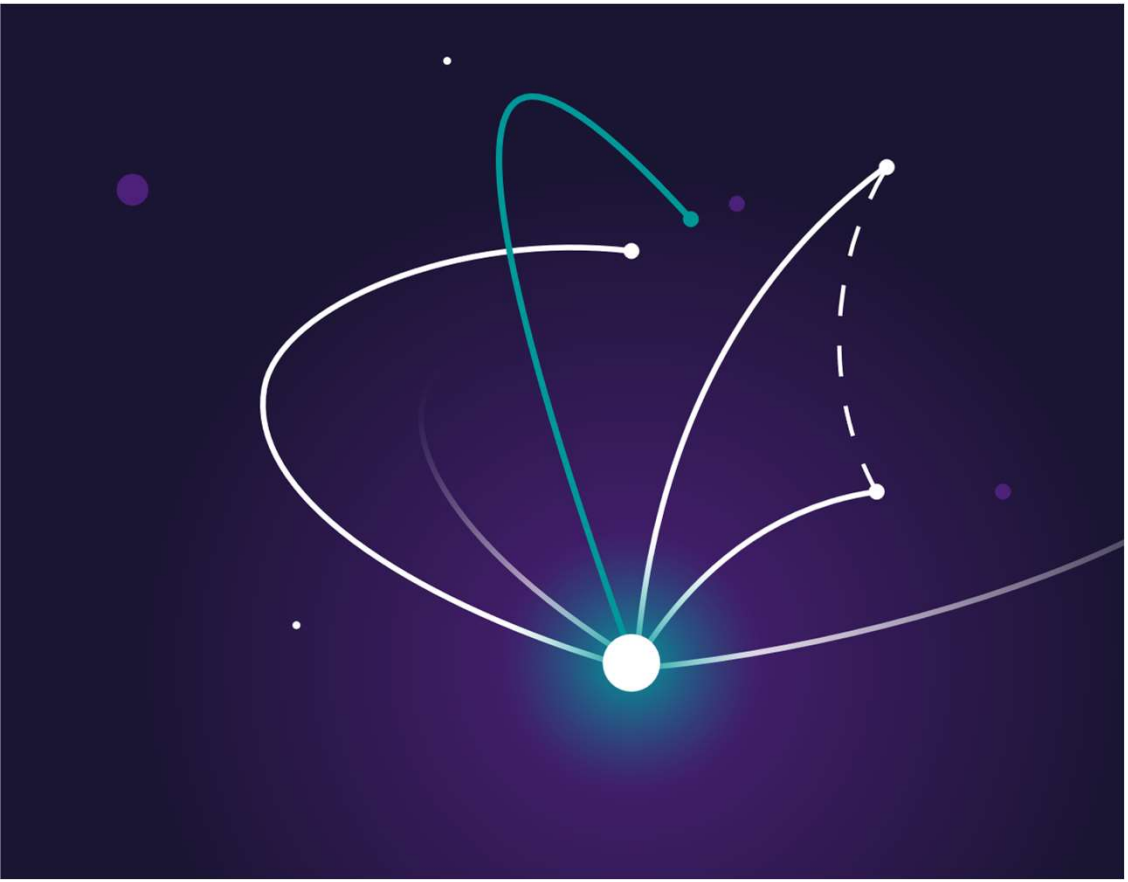
SIEMENS energy

Since 1980

50 Large Scale Heat Pumps from Siemens Energy

Nr.	Project	Heat Output	Nr.	Project	Heat Output
1	Ludvika 1	11 MWth	26	Lund GEO	20 MWth
2	Västeras 1	12 MWth	27	KungsängenVP1	8 MWth
3	Uppsala 1	13 MWth	28	Örebrö VP1	20 MWth
4	Uppsala 2	13 MWth	29	Örebrö VP2	21 MWth
5	Uppsala 3	13 MWth	30	Huskvarna	7 MWth
6	Visby	12 MWth	31	Hammarby VP1	20 MWth
7	Borlänge 1	12 MWth	32	Hammarby VP2	20 MWth
8	Borlänge 2	12 MWth	33	Hammarby VP6	30 MWth
9	Västeras 1	12 MWth	34	Hammarby VP7	30 MWth
10	Lund1	13 MWth	35	Akersberga VP1	6 MWth
11	Malmö1	13 MWth	36	Järfälla VP1	20 MWth
12	Malmö2	13 MWth	37	Järfälla VP2	20 MWth
13	Malmö3	13 MWth	38	Solna VP1	30 MWth
14	Eskilstuna 1	13 MWth	39	Solna VP2	30 MWth
15	Upplands Väsby 1	11 MWth	40	Solna VP3	30 MWth
16	Upplands Väsby 2	11 MWth	41	Solna VP4	30 MWth
17	Sandviken	12 MWth	42	Lund Geo 2	27 MWth
18	Gävle 1	14 MWth	43	Ropsten VP91	25 MWth
19	Eskilstuna 2	13 MWth	44	Ropsten VP92	25 MWth
20	Borlänge 3	12 MWth	45	Ropsten VP93	25 MWth
21	Kalmar VP1	13 MWth	46	Ropsten VP94	25 MWth
22	Örnsköldsvik VP1	14 MWth	47	Lindesberg VP1	5 MWth
23	Örnsköldsvik VP2	5 MWth	48	Eslöv VP1	9 MWth
24	Umea VP1	17 MWth	49	Jönköping	25 MWth
25	Umea VP2	17 MWth	50	Hammarby VP 5	30 MWth

Thank you and stay energized!



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