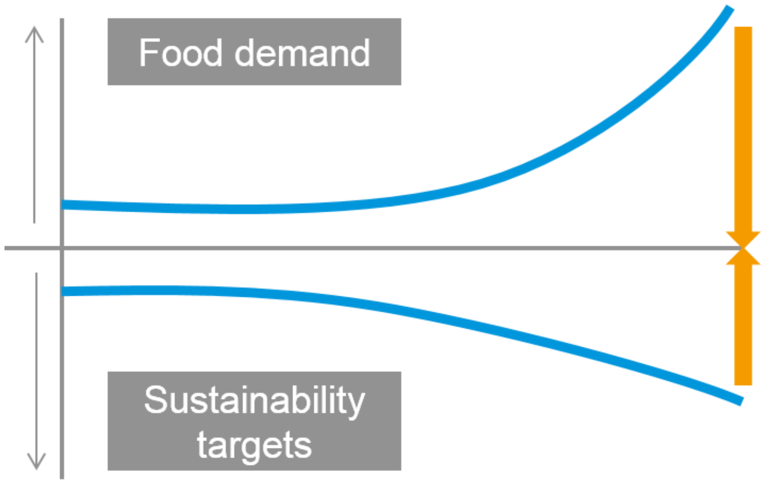
Large scale heat pumps for high efficiency district heating projects

SIRACH

Kenneth Hoffmann, July, 2018

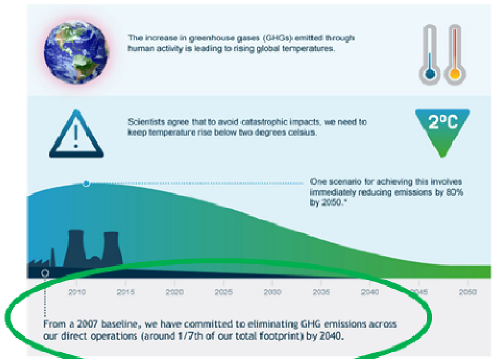
Why are industrial heat pumps needed?



That's why we've set targets to reduce our emissions, regardless of how much our business grows. Through our Sustainable in a Generation program, we've pledged to eliminate all greenhouse gas emissions from our operations by 2040 and reduce emissions from our product deliveries to retail customers as much as we can.

CLIMATE CHANGE

We have the power to act now to prevent further climate change. As it stands now, the consequences are dire — changing rainfall patterns, floods, droughts and the spread of pests and diseases are putting whole habitats and communities at risk.



* Source: Meinshausen

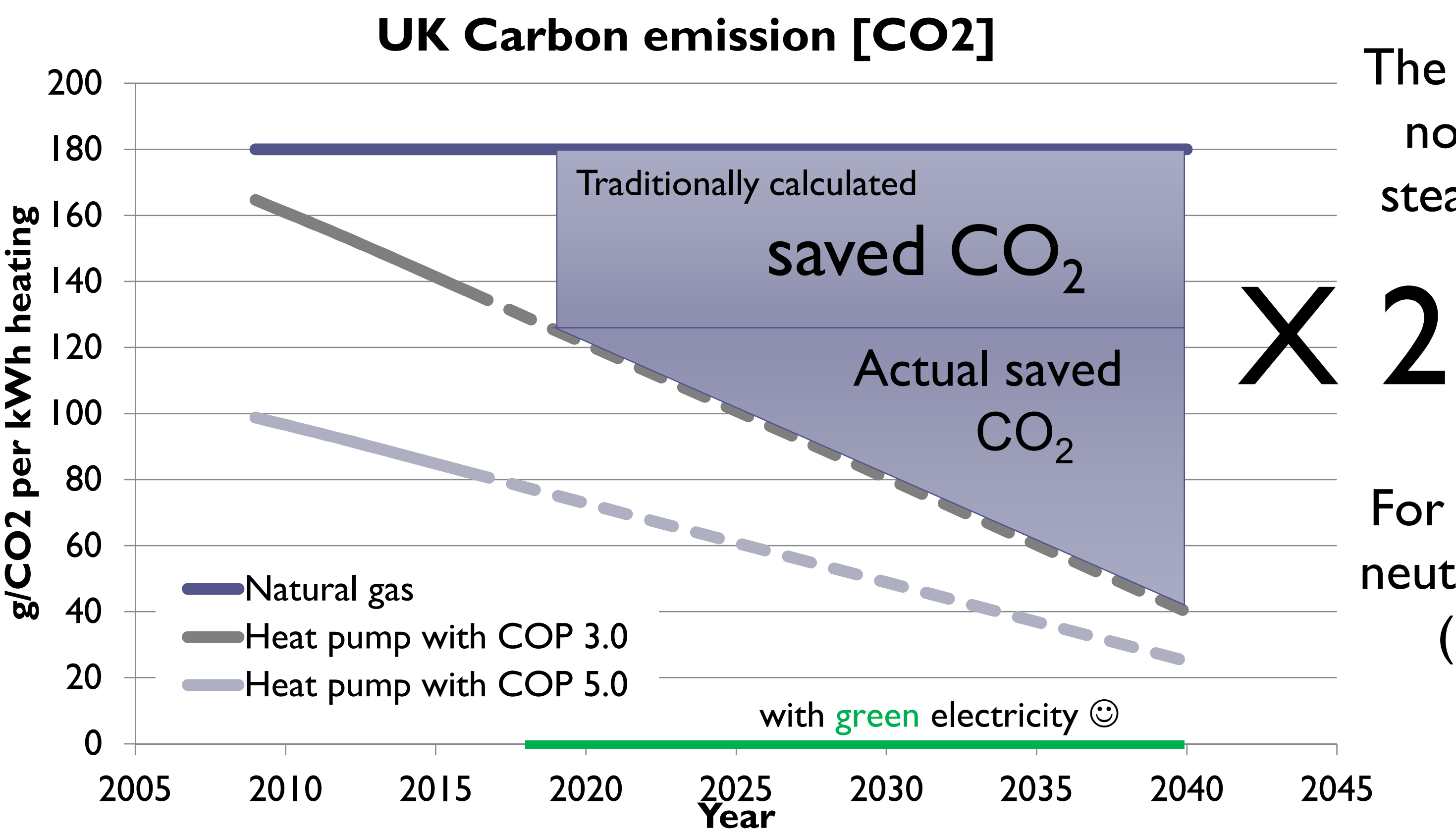
No use of fossil fuels as from 2040

How do industrial heat pumps contribute ?

- Heat pumps upcycles waste heat and is the most efficient use on natural energy source.
- Sustainable biomass only harness 1% of the solar energy
- Green electricity grid makes heat pumps a zero carbon heat source !

- Using seawater, sewage water, waste water, ground source water, cooling tower water etc, gives high efficient heating all year, independent on ambient temperature.
- Proven technology, competitive investment
- District heating / District cooling is key to improved energy optimisation for carbon neutral EU by 2050
- Temperatures of network at getting reduced each year - > implying higher COP's

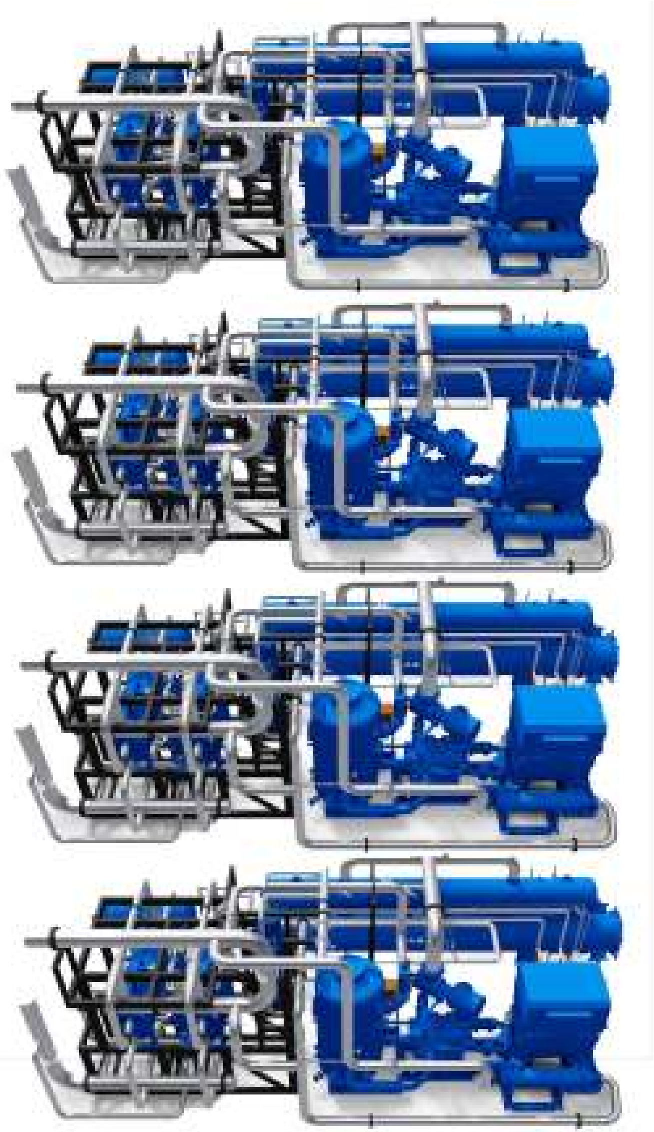
CO_2 Emission Reduction by using a Heat Pump

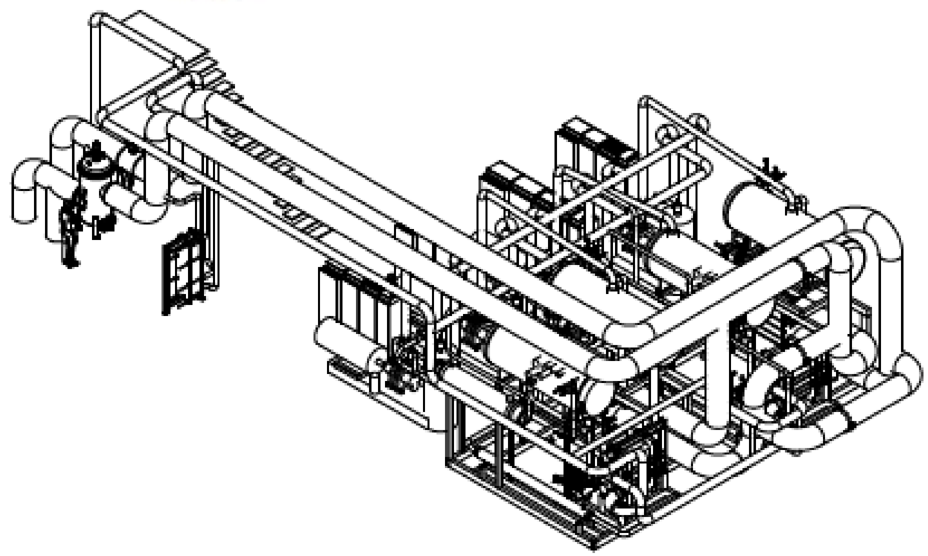


The World is no longer steady state

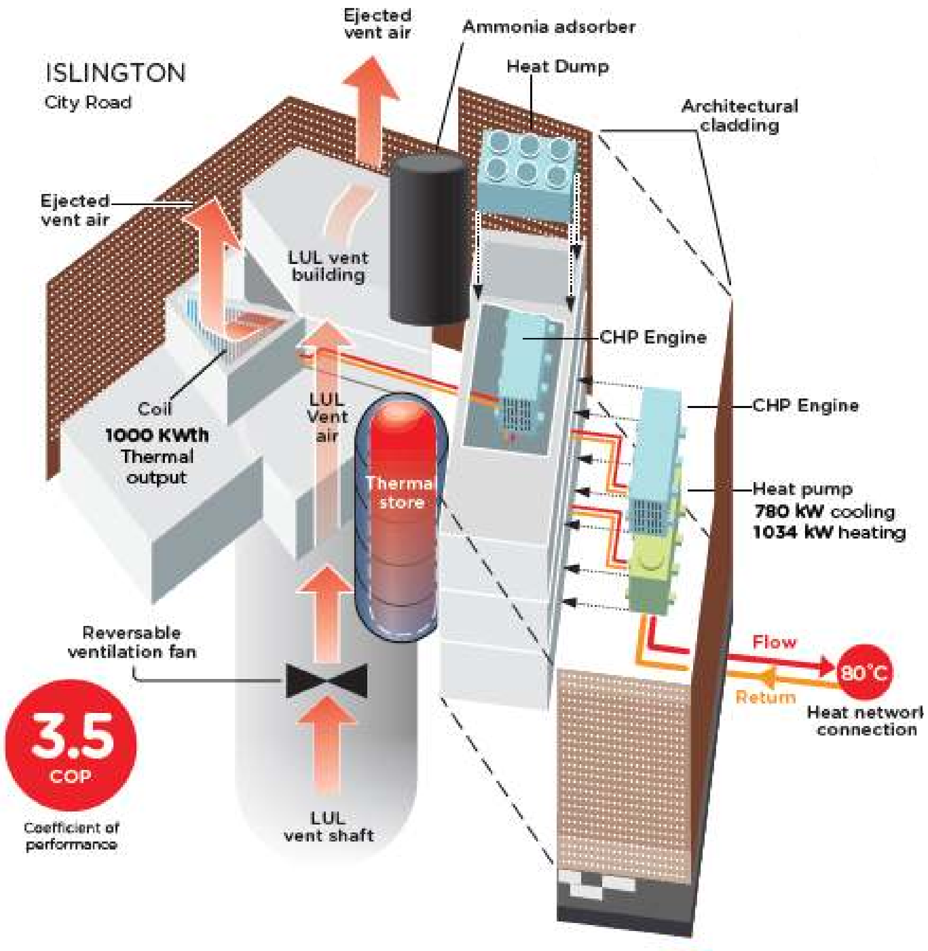
For a carbon neutral future (2050)

Application with large district heating solutions





2 stage heat pumps in London, UK



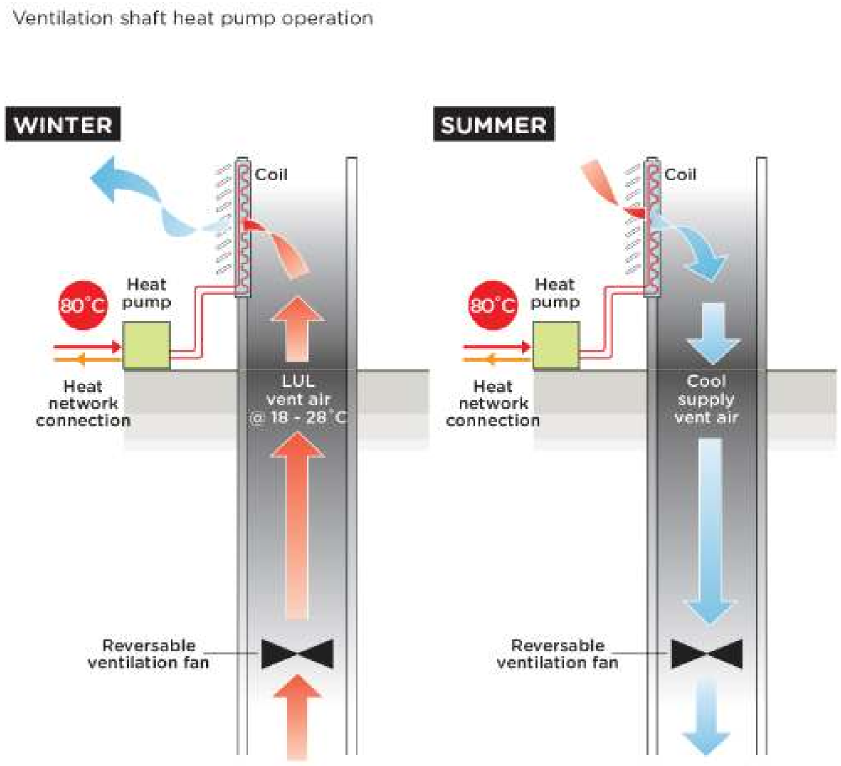
Combined cooling and heating

Heat source:
Underground ventilation air
18^{0}C to 30^{0}C

Heat sink:
District heating water
55^{0}C to 75^{0}C

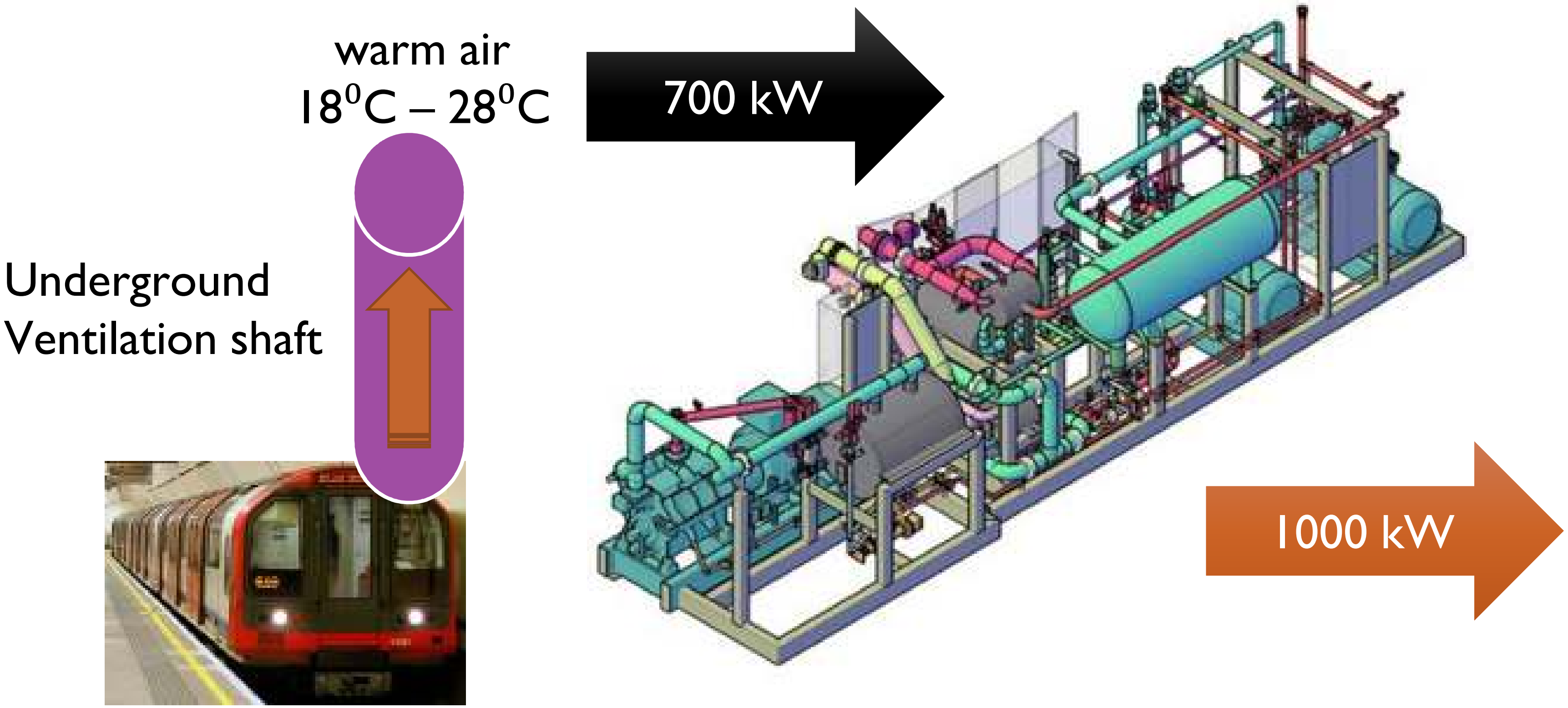
Heating COP >3.50

Ventilation shaft operation

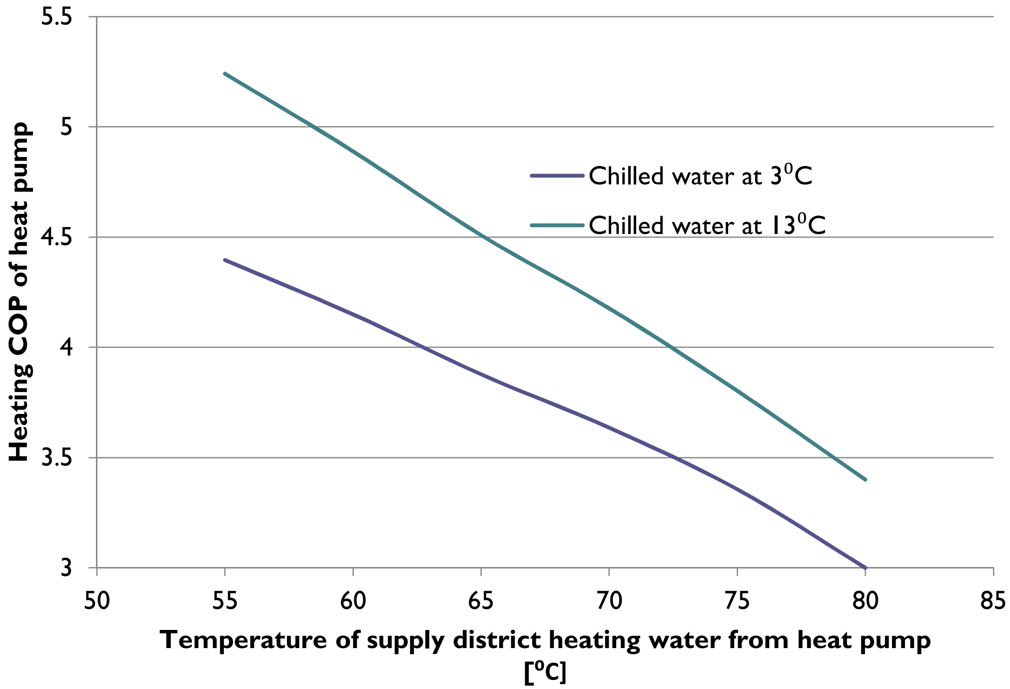


Reversible fan ensure both waste heat recovery and active cooling can be provided of the underground train tunnels

Heat recovery from London Underground



2 stage piston heat pump



Heat recovery from London Underground

700 kW of cooling (can be reversed in summer)

300 kW of electricity

1000 kW heating

District heating water: 55^{0}C - 75^{0}C

Yearly heating COP: 3 – 4.5

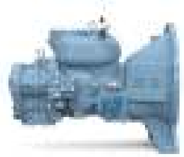
Payback of heat pump only: 2 - 3 years

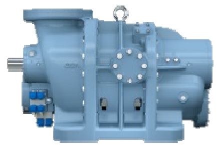
Payback of total project: 8 - 10 years

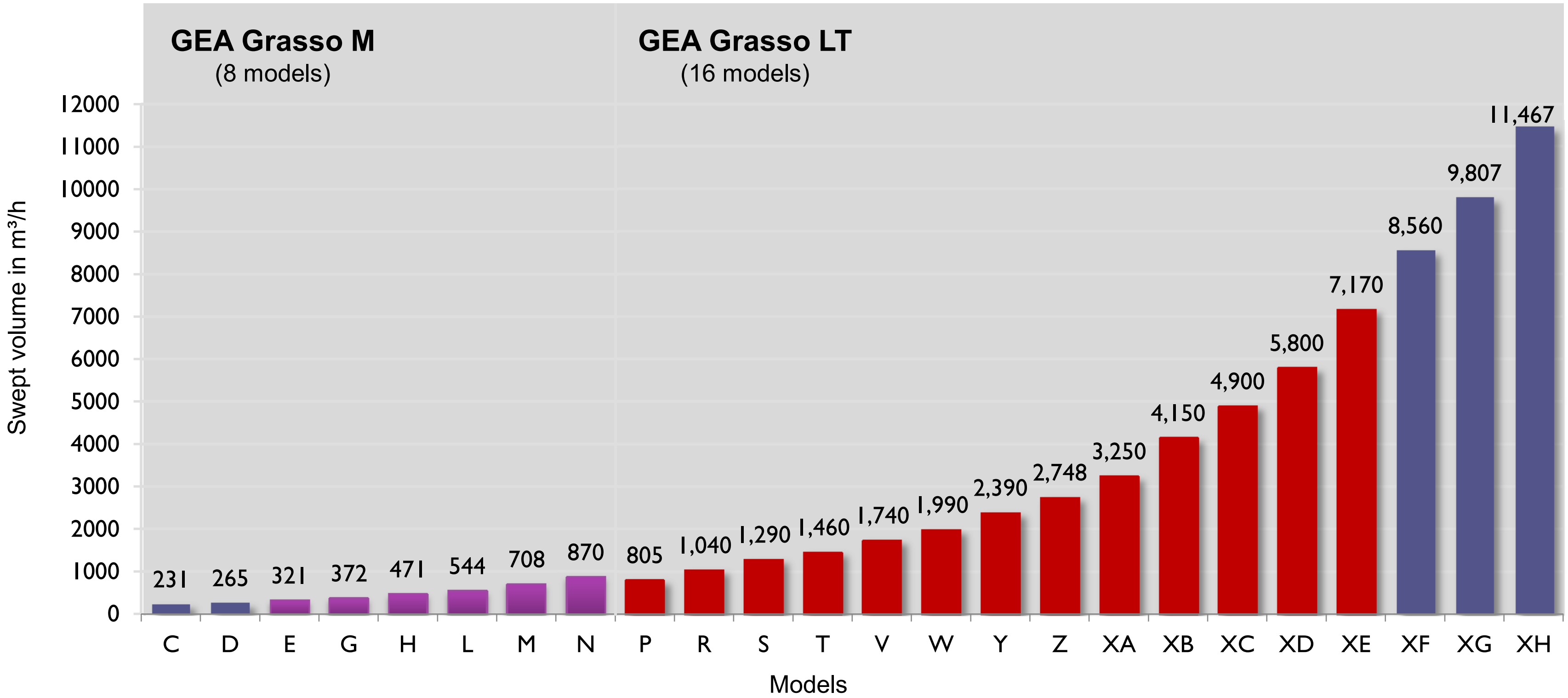
Lessons learned and future prospects

- It has proven a very lengthy process to replace a fan in a TFL ventilation shaft and install new district heating pipes in central London. Heat pump delivered April 2017, expected start-up September 2018
- FAT test have shown the heat pump meeting the expected performance
- 250 more midtunnel ventilation shafts with similar airflows across London
- Lower cost of heating for council flats => end to fuel poverty
- Reduction of CO_2 emissions
- Elimination of NO_x emissions

Screw compressors used for ammonia heat pumps



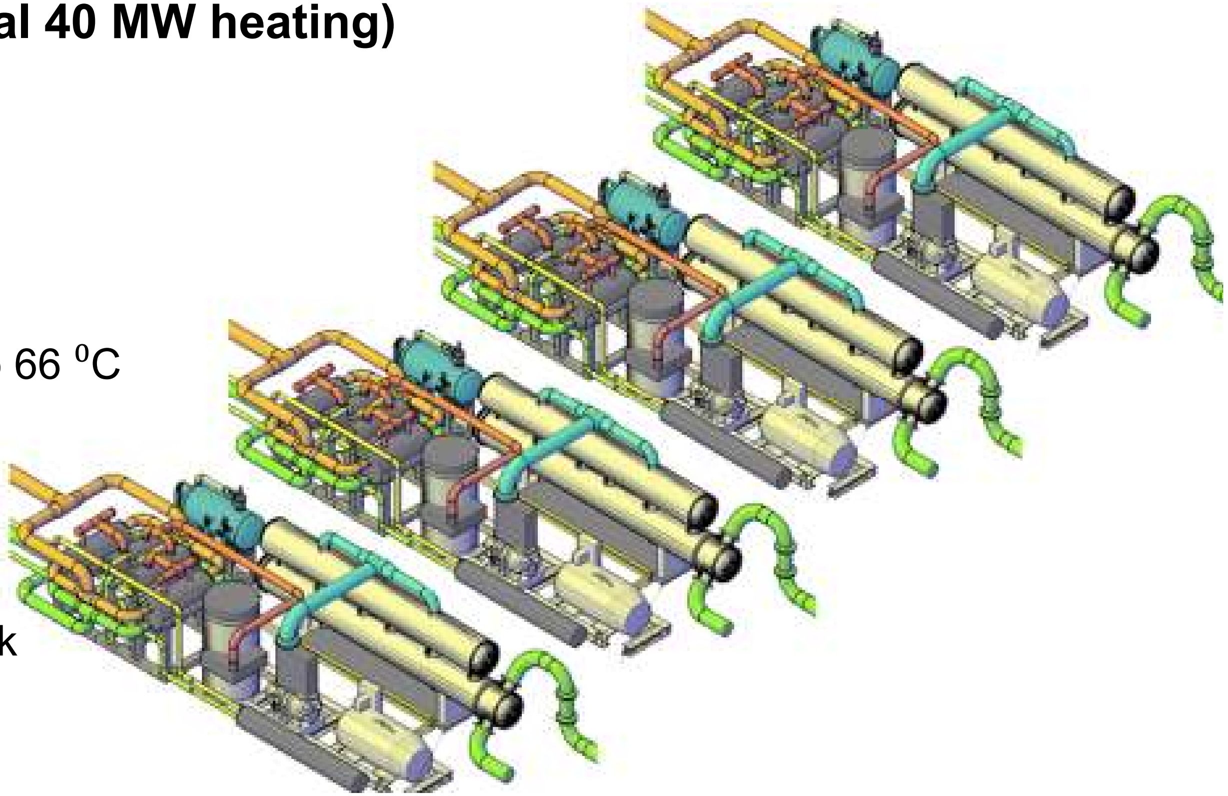




World's largest ammonia heat pump city of Malmö, for E.ON

4 off XD compressors (Total 40 MW heating)

- Heat source:
  sewage water, 14 ^{0}C to 8 ^{0}C
- Shell and tube evaporator
- Heat sink:
  district heating water, 57 ^{0}C to 66 ^{0}C
- Heating COP >3.50
- Plate and shell condenser
- 50,000 tons/y CO_2 saved
- **8% of Malmö heating** network capacity (10,000 households)



Malmö city to be 100% renewable by 2030

- By the year 2020 the internal organisation of the city of Malmö is to have achieved carbon neutrality and by 2030 the whole city will be provided with 100% renewable energy
- By the year 2025 E.ON will supply 100% recycled or renewable energy to its district heating customers in Malmö
- Old heat production plants needed to be replaced. First step in the renewal process was to investment in a new heat pump installation
- Ammonia safety can be handled by placing it in an industrial area and thorough robust design
- Alternative with R134a has a high global warming effect and will be phased out globally

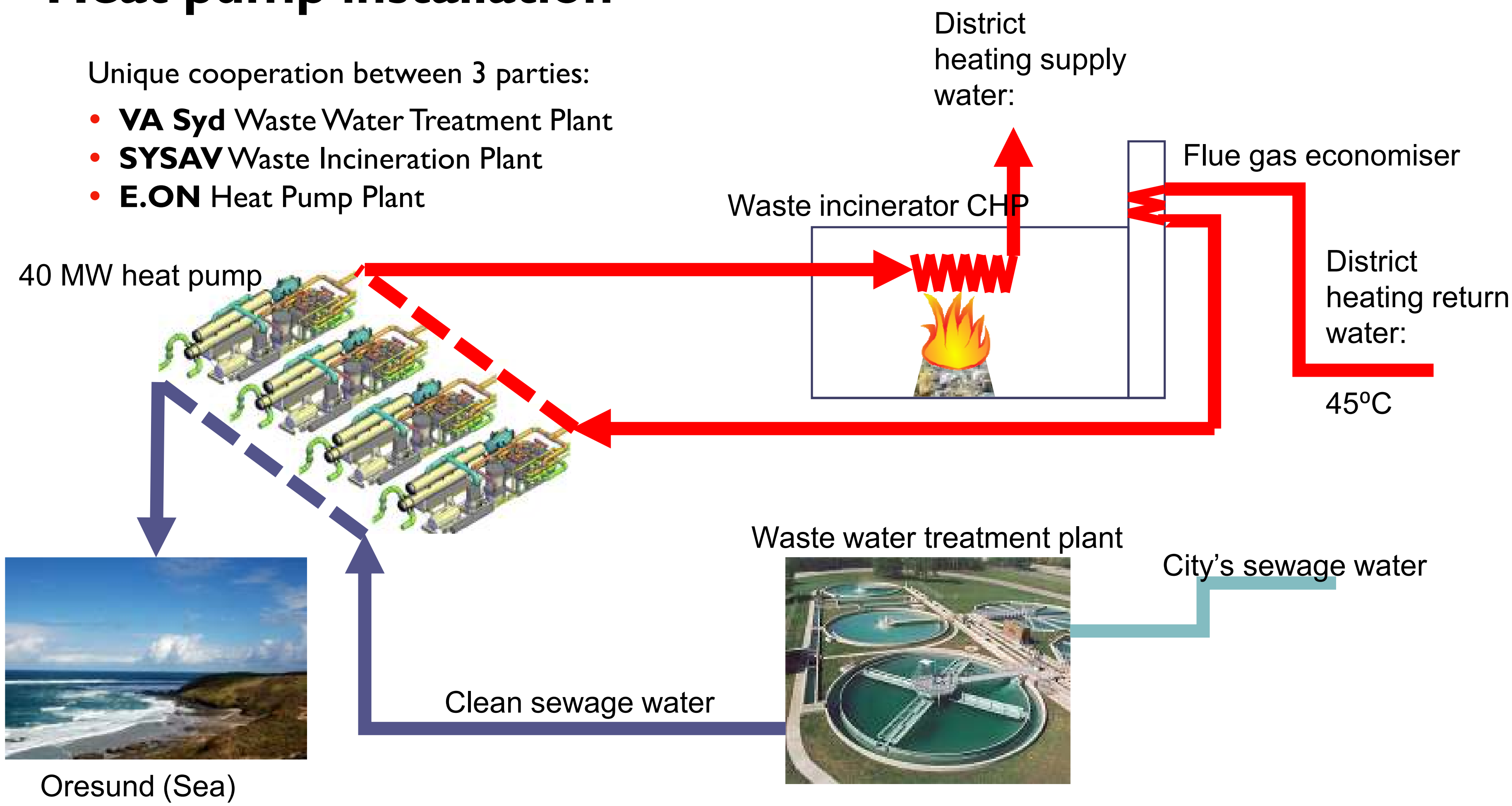
Heat pump installation

- 4 Heat pumps
- 40 MW heat. COP 3,5.
- Location: VA Syd sewage water treatment plant Sjölunda, Malmö, Sweden
- Waste heat taken from cleaned sewage water, which is chilled 6 degrees
- Outgoing DH-water is further heated in a waste incineration plant
- Heat pumps can be shut down during electricity peak load, in order to use the electric grid in an efficient way. In this case heat will be produced in other heat plants instead.
- Full load production from October to April. Part load during summer months
- 200 GWh/year, 8% of Malmös annual heating demand
- 50 000 ton less CO_2 per year, renewable electricity will be used
- Quick start and stop.
- Investment ca 200 MSEK

Heat pump installation

Unique cooperation between 3 parties:

- **VA Syd** Waste Water Treatment Plant
- **SYSAV** Waste Incineration Plant
- **E.ON** Heat Pump Plant



Heat pump installation

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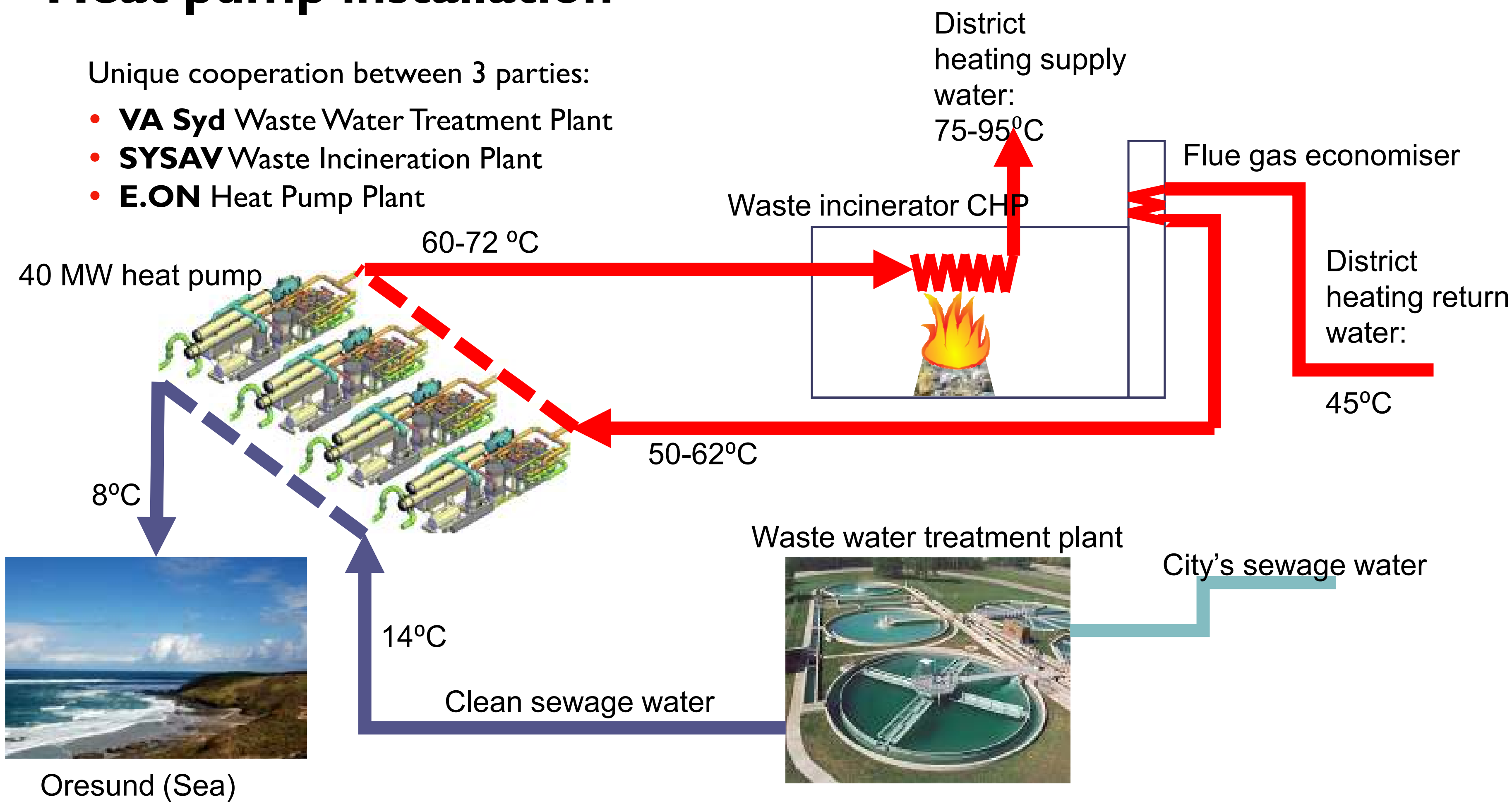


Lessons learned and future prospects

- With the European wide expansion of district heating network this project shows how zero carbon emission can be achieved for these networks

- A step on the way for EU's target for Carbon neutral heating by 2050 (in 22 years)

- By using natural refrigerant with 0 GWP the installation complies with the Kigali agreement from 2016 which sets out to globally phase out of all high GWP refrigerants.

- The heat pumps have proven to supply cheaper heat than gas heating, which can end fuel poverty across Europe.

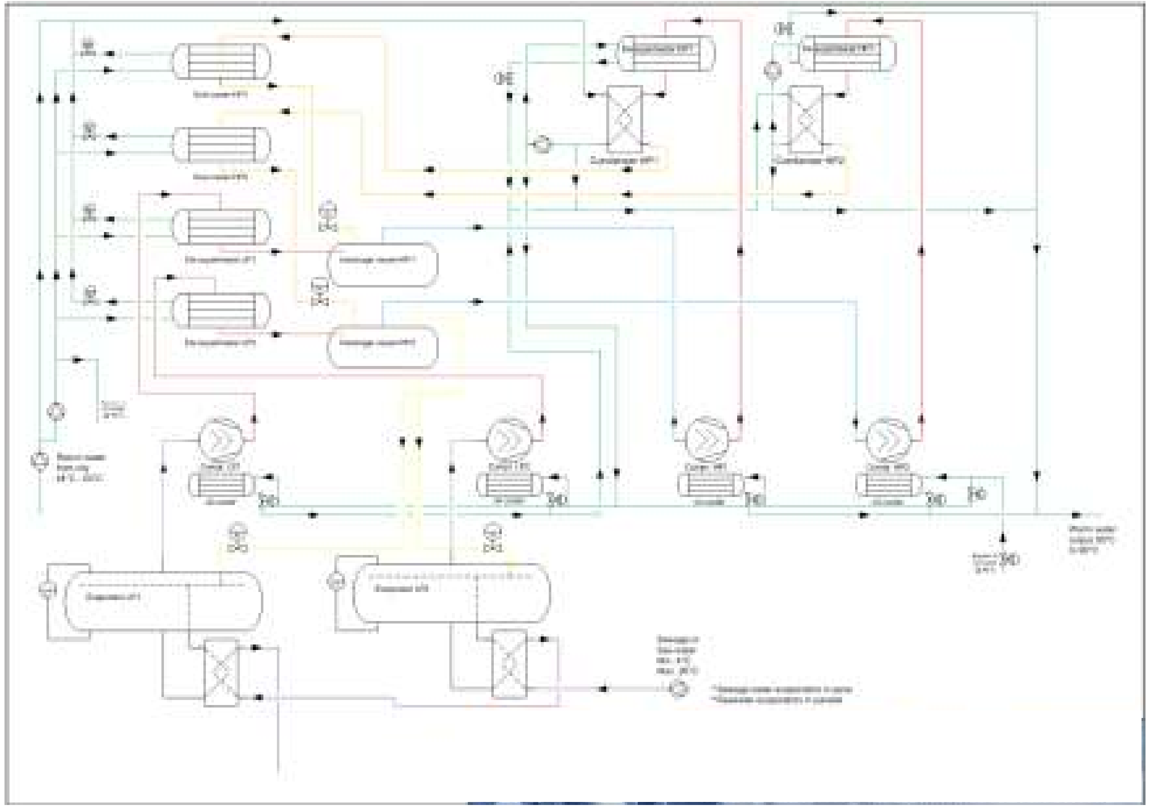
- From all cities there is sewage water, which provides a good source for district heating heat pumps

World's largest ammonia heat pump city of Malmö, for E.ON

Next development step up to 90°C, 5 MW heat pump

2 x 2 stage heat pump

- To be installed in Copenhagen
- Trial before a 600 MW heat pump investment in coming years
- 63 bar compressor
- University and Technology centre involved in testing
- Series and parallel heating and cooling



Combined sewage and seawater heat source

- Test plant using both sewage water and sea water in plate evaporators
- Titanium plates

- Measures to minimise fouling
  - high water velocity
  - Wide plate gaps
  - Reversible water flow

- CIP with Citric acid installed
- Sea water cooling down to -0.5°C
- Sea water flow in parallel
- Sewage water flow in series through heat exchangers

Compact design

- Heating heat exchangers are gasketed plate heat exchangers in 63 bar design
- AISI316 plates
- Designed for up to 90˚C water temperature
- Seriel heating through subcooler, condenser, desuperheater and oilcooler
- Compact design

Large Heat pump references

Project	Date	Country	Temperature (Chilled water flow / hot water flow)	Heating capacity	COP_H
Fynsvaerket	2008-06	DK	+30°C / +55°C	2,815 kW	7.20
Copenhagen Towers	2008-10	DK	+10°C / +60°C	2,955 kW	4.51
Tetra Pak 2	2009-12	SWE	+25°C / +70°C	1,430 kW	4.47
Sarpsborg	2010-01	NO	+27°C / +80°C	2,000 kW	3.81
Nestlé Biessenhofen 2	2010-01	GER	+30°C / +70°C	1,170 kW	4.88
Valldal Fjernvarme	2011-01	NO	+1°C / +70°C	1,285 kW	2.60
Skagerak Energi	2011-09	NO	-2°C / +70°C	1,225 kW	3.02
Bio Energi	2011-12	CZ	+28°C / +80°C	4,090 kW	4.93
Unilever	2011-12	NL	+17°C / +68°C	1,416 kW	5.32
Sogndal I	2012-06	NO	-2°C / +68°C	2,450 kW	3.03
Brista	2012-08	SWE	+31°C / +65°C	7,250 kW	6.51
Sarpsborg II	2012-07	NO	+20°C / +80°C	3,080 kW	3.05
Kalnes Energisentral	2012-12	NO	-10°C / +56°C	1,250 kW	2.45
NTNU	2013-07	NO	+4°C / +81°C	1,315 kW	2.64
Holmen	2014-07	NO	+27°C / +71°C	2,450 kW	5.79
HP Oatly	2014-07	SWE	+7°C / +78°C	560 kW	3.11
Kronoply	2015-01	GER	+30°C / +83°C	4,500 kW	4.70
Vietnam	2016-06	VTN	+6°C / +60°C	12,000 kW	4.62
Copenhagen Markets	2016-06	DK	+6°C / +75°C	3,200 kW	3.05
EON Malmoe	2017-10	SWE	+8 / +66°C	40,000 kW	3.50

Conclusion

1. Heat pumps only needs a **limited electrical energy** to raise the temperature of the waste heat to useful level.
2. Heat pumps will ensure **future reduction in CO_2 emissions**.
3. Using water based heating system instead of steam makes implementation of **heat pumps cheaper and improve efficiency**.
4. It is now possible to achieve **90ºC water** with a ammonia heat pump
5. Large heat pumps in the building services sector can help communities **reach their zero emission targets**

Questions and Answers

We hope you enjoyed this

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