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 on climate change. As a result, we see continuous growth — changing weather patterns, floods, droughts and the spread of pests and diseases are putting wildlife habitats and ecosystems at risk.

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
CO₂ Emission Reduction by using a Heat Pump

The World is no longer steady state

For a carbon neutral future (2050)

Traditionally calculated

saved CO₂

Actual saved CO₂

\[\times 2\]
Application with large district heating solutions
Combined cooling and heating

Heat source:
Underground ventilation air
$18^\circ C$ to $30^\circ C$

Heat sink:
District heating water
$55^\circ C$ to $75^\circ C$

Heating COP >3.50
Reversible fan ensure both waste heat recovery and active cooling can be provided of the underground train tunnels.
Heat recovery from London Underground

Warm air
18°C – 28°C

700 kW

1000 kW
2 stage piston heat pump

Heating COP of heat pump vs. Temperature of supply district heating water from heat pump [°C]

- Chilled water at 3°C
- Chilled water at 13°C
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°C - 75°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

GEA Grasso M
(8 models)

GEA Grasso LT
(16 models)

Swept volume in m³/h
World’s largest ammonia heat pump city of Malmö, for E.ON

4 off XD compressors (Total 40 MW heating)

- **Heat source:**
  sewage water, $14 \, ^\circ\text{C}$ to $8 \, ^\circ\text{C}$
- **Shell and tube evaporator**
- **Heat sink:**
  district heating water, $57 \, ^\circ\text{C}$ to $66 \, ^\circ\text{C}$
- **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 Malmö's annual heating demand
- 50 000 ton less CO2 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

40 MW heat pump

**District heating supply water:**

- Waste incinerator CHP
- Flue gas economiser

**District heating return water:**

- 45°C

**Waste water treatment plant**

**City’s sewage water**

**Clean sewage water**

**Oresund (Sea)**

**Heat pump installation**

**Slide 16**
Heat pump installation

Unique cooperation between 3 parties:
- **VA Syd** Waste Water Treatment Plant
- **SYSAV** Waste Incineration Plant
- **E.ON** Heat Pump Plant

**District heating supply water:**
75-95°C

**District heating return water:**
45°C

**Waste incinerator CHP**
50-62°C

**Waste water treatment plant**
14°C

**Clean sewage water**
8°C

**Oresund (Sea)**

**City’s sewage water**
40 MW heat pump

**Flue gas economiser**

40 MW heat pump
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
- Serial heating through subcooler, condenser, desuperheater and oilcooler
- Compact design
## Large Heat pump references

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
<th>Country</th>
<th>Temperature (Chilled water flow / hot water flow)</th>
<th>Heating capacity</th>
<th>COP&lt;sub&gt;H&lt;/sub&gt;</th>
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<td>Fynsvaerket</td>
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Conclusion

1. Heat pumps only need a **limited electrical energy** to raise the temperature of the waste heat to useful level.
2. Heat pumps will ensure **future reduction in CO₂ 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 **90°C water** with an 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 Webinar from the Institute of Refrigeration

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