Rescue
REnewable SMART COOLING for URban Europe

Work Shop - Seminar
Technical perspectives on district cooling

Bath, 2014-07-23
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Is there a cooling need in UK?
Lusail City is located north of Doha in Qatar. When finished, it will provide first class living, working and entertainment areas for more than 200,000 people.

Lusail

General Information On The Project

- Capital Cooling, in partnership with Marafiq Qatar is developing and building the largest District Cooling system in the world.
- The project has a budget of over 2 bn €
- The District Cooling system will cover the 12 areas in which the new city of Lusail has been divided. The first phases were initially planned to be operational in 2012. Operations with temporary solutions started in 2013.
- The planned district cooling system capacity is 1940 MW.
- Capital Cooling has carried out:
  - Business Management & Project Management
  - Investment and Supply Management.
  - Risk Management
  - Technical analysis and advice

Benefits from project

- The district cooling system in Lusail will reduce 50% of the CO₂ emissions that would come from conventional chillers. This would have amounted to 2 400 000 ton CO₂ annually.
- Reduce the need of new power stations by 50% plus less capacity on new power grids
Technical is only one of issues for DC business

FINANCE
ORGANISATION

RISK
MANAGEMENT

TECHNIQUE
MARKET

RESCUE - REnewable Smart Cooling for Urban Europe
(IEE/11/977) / Duration: 01/06/2012 - 30/11/2014
Technical subjects for today

TECHNOLOGY
1. System architecture
2. Production
3. Distribution
4. Energy Transfer Stations
District Cooling system

Sourcing: “free/natural” cooling or Waste heat

Production: Chillers/heat-pump Absorption

Distribution

Cooling installations

ETS
Production technology

- There is no “one solution”
- Use low primary energy that otherwise would be wasted
- Utilize natural sources
  - Air – Water: Sea, lake, rivers, ground water
- Waste energy from industry, CHP
- Absorption chillers
- Heat pumps
- Electrical chillers
Agenda

- Product quality
- System architecture
- Plant location
- Distribution
- Temporary solutions
- Energy Transfer Station
- Permits
Water cooling

- Very high chiller COP is possible when the condenser temperature is low. Particularly with VFD (variable frequency drive) at part load.

- Note SSEER not COP, example individual

<table>
<thead>
<tr>
<th>Chiller system</th>
<th>2.1 – 5.6</th>
</tr>
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<tbody>
<tr>
<td>According to supplier (COP)</td>
<td></td>
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<tr>
<td>Real system (EER)</td>
<td>0.7 – 2.8</td>
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</table>
Natural cooling

- **Example river northern Europe**

- **River possible in Paris, Vienna, Gothenburg, Gävle, Halmstad...**
- **Permissions, will the effluent water temp affect the river?**
  - Answer, permit will set max temp and max $\Delta T$
  - Flow in "once-through" water pipes small compared to the river
  - Impact between sunny and cloudy day 10 to 100 times bigger

Intake in Gothenburg

![Graph showing water temperature over months](image)
Natural cooling – Lakes, Sea

Sea water in Stockholm

Ouderkerkeplas – Lake in Amsterdam 40m deep. (Man made)

Knowledge of the thermocline in lakes essential

- Lake “shifts” between seasons
- Measurements (lots)
- Bottom and surface intakes?
- Benefits – helping nature by mixing water a bit between areas
Lake water pipes in PE
Heat pumps in Helsinki DHC Katri Vala plant

DHC 5 Heat pumps, treated sewage water
60 MW cooling and 90 MW heating
Absorption chillers

- Supplied by DH and not electricity
- Local at end-users:
  - No DC pipes needed
  - Absorption chiller need higher supply temp
  - Less low temp waste on DH in summer
  - Damage $\Delta T$ on the DH system
    - 2-stage ABS, more expensive
  - DH customer connection pipes could become bottle-necks
  - Need redundancy at customer’s site
  - Harder to sell DC without the benefits
  - Cooling towers of roof tops, very large due to the COP=0.7-0.8

- Absorption at DC plant, Helsinki 10x3.5MW
  - Better supply temp, 85°C
  - Possible mix of production, chillers, natural
  - Still need cheap production, low COP
Heat price for absorption

- Heating price over 2-3 €/MWh (1.5-2.5 GBP/MWh) => No ABS
- Extend CHP when no heat need, value of electricity incl. subsidies systems
Benefits with DC

• DC offer must be attractive:
  • Price
  • Performance
  • Simplicity - ETS
  • Low environmental impact
    • Low use of primary energy sources (PES)
    • Sustainability

• If it also has added values it is a bonus!
  • Free floor space
  • Beautification of buildings (No “wall rattlers” – split units with dripping condensers etc..)
  • No refrigerant in building
  • Avoid O&M contracts on chillers
  • No noise from compressor motors
  • No cooling towers on roof-tops
Distribution pipes

Many types of pipes for DC

Pressure level 6, 10 or 16 bar system.

- PE un-insulated
- GRP un-insulated
- PE coated steel pipes (same as for gas pipes in steel)
- Pre-insulated PUR on steel pipes in HDPE casing
  - Same type as for DH
  - Less insulation thickness series
  - Concern is not energy losses (Ground temp and DC temp are low in UK/SE)
  - Low demand periods – Stand still water – Supply temp
Distribution pipes

On DC the pipe DN is much larger than on DH.
Design temperature difference only $\Delta T=10^\circ C$ (DH, $\Delta T=50^\circ C$)
⇒ Pumping 5 times more water for the same capacity!
⇒ Pipe investments are naturally high in DC projects
⇒ Smart production with less primary energy use needed

DN600 for DH
150-200 MW

DN600 for DC
25-30 MW

From Stockholm
Distribution pipes

Standard EN253 is a comprehensive standard developed for DH
Applicable for DC
Certification: manufacturing, fitters

Lots of linked normative standards

Friction fixation – Bonded pipes (Sandwich)
Thermal expansion low, stress on steel material below limits
Electro welded casing joints

- Pressure tested before foaming
- Minimize human influence
- Stored info on joint quality
- Safest with risk of rain or ground water

Alternative is shrink joint
Thermal memory
Heat with gas flame
Isolation valves

Friction fixation – Bonded pipes
Pre-insulated isolation valves
Valve then a part of the pipes
Operation with spindle extension or hydraulic
No valve chambers
Surveillance system

Leak detection on-line from control room or supplier

For DH – Resistance between inner pipe and wire

Wet foam change the resistance

Exact d (mm) distance important or measurement fault (many joints)

Moist travels to coldest surface

Some water initially in the foam

3DC - measure impedance between wires

Not only on steel pipes anymore
Not only the ETS – customer installations

- Develop Technical Requirements
- Include the cooling systems in buildings
- No system performs better than the secondary side return temperature
- Prepare for $\Delta T$ improvement program
- Ownership of ETS
Heat exchangers

- Direct connection – No HEX
  - Better return temp
  - Same water as in the customers building’s cooling systems
  - Water quality issues
  - Leakages will disturb all customer
  - DC net is a huge water storage, can cause swimming pools in basements

- Indirect connection – with HEX
  - More robust design
  - Temp loss in approx. 0.5-1°C

- Consider pre-fab of Energy Transfer Stations
  - On a skid, transport openings
  - Brazed plates, no gaskets
  - Flushing and fouling
  - CIP (Cleaning In Place)
  - Low O&M
System architecture

- Smart mix of production options - Optimization

![System Architecture Diagram]

- DC grid
- Cooling water
- Optimization of production options
### Energy balance

#### Climatic data

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</thead>
<tbody>
<tr>
<td>Temp.</td>
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<td>-5</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
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<tr>
<td>Humidity</td>
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<td>60</td>
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<td>80</td>
<td>90</td>
<td>100</td>
<td>110</td>
<td>120</td>
<td>130</td>
</tr>
</tbody>
</table>

#### Demand profile

- **Customer demand**
- **Production**

#### Durability diagram

- Production

#### System architecture

- District cooling
- Heat recovery system

#### Availability of sources

- **Electricity cost**
- **Heat cost**
- **Water cost**

#### Energy balance

- **Distribution of production**

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System design

Selection of main equipment configuration
Pump configuration
Pressure drops
Pipe design
Temperature loss
Pressure class selection
Material selection
Electrical configuration (Power supply)
Operation and maintenance costs

- Electricity
  - grid cost
  - energy cost

- Thermal heat
  - Water/steam
  - Cost per month/season/outdoor temp

- Limitation of ABS operation
- Optimum chiller change over
- Water and sewage cost
- Organisation/Personnel cost
System architecture

The production reference should describe the most economical solution that can be accomplished

- Natural (Free) cooling
- Electrical chillers
- Absorption chillers
Project management important

- Income - Price your product right – Customers alternative
- Initial failures hard to recover

![Graph showing dramatic impact on cash flow with 12 year pay-back delay.

Reference case vs. 10% higher investments and costs and 10% lower revenues + delays.]
District Cooling in Växjö

- 60 000 people in city centre
- District heating since 1970
- Biomass CHP – #1 in 1997
- New CHP#2: 38 MW,el / 62 MW,heat
- DC customer demand in 2012 – 13 MW
- DC potential 25 MW & possible expand to 35 MW
DC potential in the city of Växjö in Sweden
FINAL MESSAGE – System-knowledge essential plus utilize synergies DC & DH

Thanks for the attention!

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