TERMO WP 2.3 Distributed Cold Storages in the District Cooling System

Viktoria Martin, Saman Nimali Gunasekara
viktoria.martin@energy.kth.se; saman.gunasekara@energy.kth.se

30-01-2019
### WP 2.3 Time Plan (2018-2020)

<table>
<thead>
<tr>
<th>Distributed cold storages in the District Cooling (DC) system</th>
<th>2018 April-Dec</th>
<th>2019 Jan-Jul</th>
<th>2019 Aug-Dec</th>
<th>2020 Jan-Jul</th>
<th>2020 Aug-Dec</th>
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<tbody>
<tr>
<td><strong>2.3.1 System description and method</strong> - a knowledge compilation on distributed cold storages in the DC system</td>
<td>Apr</td>
<td></td>
<td>Jul</td>
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<td><strong>2.3.2 Techno-economic performance evaluation:</strong></td>
<td></td>
<td>Oct</td>
<td></td>
<td>Jun</td>
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<td>a) Comparison of the cold storage alternatives</td>
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<td>b) Optimization of the operating strategies</td>
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<td><strong>2.3.3 Benefit analysis</strong> (the avoided power in MW at peak load and the avoided consumption MWh peak load/day)</td>
<td></td>
<td>Nov</td>
<td>Aug</td>
<td></td>
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<td><strong>2.3.4 Reporting and communication – 'Generalizability' in focus</strong></td>
<td>Dec</td>
<td>Jan</td>
<td>Nov</td>
<td>Dec</td>
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Distributed Cold Storages in the DC system: KTH Termo WP 2.3

30-01-2019
KTH WP 2.3: Activity Overview

1. System description & method:
   1. a. SOA analysis: DC & distributed cold storages (& power-to-cold) in Sweden
   1. b. International inspirations for cold storage

2. Techno-economic performance evaluation
   2 & 3 a. Case-study system analysis of Norrenergi AB’s DC-system
   2 & 3 b. Choose and learn suitable software tools for this DC-system study
   2 & 3 c. Benchmark, then compare & optimize the DC system with the integration of cold storages & other options
   2 & 3 d. Overall performance analysis
   2 & 3 e. Results analysis in the overall Swedish context

3. Benefit analysis

4. Reporting & communication
   • Reports
   • Workshops
   • (IEA Annex meetings)
   • International conferences
   • Journal publications

Distributed Cold Storages in the DC system: KTH Termo WP 2.3
KTH: Ongoing Activities - SOA analyses

• With the help of a master’s students project (Sep-Dec 2018):
  o *Distributed Cooling and Cold Storage in Sweden: The Current State and Potential for Improvements with International Cold Storage Inspirations*
  o **Literature study, Other channels** (e.g. interviews)
    Norrenergi AB, Göteborg energi, Hässleholm miljö, Halmstad energi och miljö, (Energiföretagen), …
  o *Eurotherm #112 conference* (abstract accepted)

• Meeting Sven Werner (late-2018)
  o Information, sources on DC as in overall

Questions to the DHC companies:
• Daily cooling consumption (supply) profile?
• Annual cooling consumption (supply)?
• Used types and shares of cold production technologies?
• Electricity consumption for cooling production?
• Cold storage types, capacities, utility?
• Renewable energy production onsite, coupling with the DC?
KTH: Ongoing Activities - Software tools

- BoFit (DHC-system modelling) & PandaPower (electrical system modelling) via a course
- Priority on BoFit- have started with the Norrenergi’s DH system modelling for the course
- Continuation towards the DC system as the next step
SOA Analysis
Highlights and Way Forward
The potential demand for DC in Sweden is estimated to be 2-5 TWh (Tullin, 2016)

Source: Energimyndigheten, 2017
Technologies

District Cooling (DC)

- Lakes, sea, rivers...
- Free Cooling
- Cold Storage (water)
- For peak demand
- Absorption Chillers
- Compression Cooling
- Refrigeration Heat Pumps
- Heat from Heat Pumps return
- Electrically-driven

Distributed Cold Storages in the DC system: KTH Termo WP 2.3
Shares of Technologies to produce DC by all Producers in Sweden in 2013


Distributed Cold Storages in the DC system: KTH Termo WP 2.3

770 GWh (2013)
# Cold Storages

## Cold Water Storages

**Stockholm exergy:**
- 50,000 m$^3$, 55 MW, 0.4 GWh rock cavern storage (Hornsberg)

Old rock caverns used for oil storage, e.g. in Stockholm
- a feasibility study, Alfasfos 2017 - stratified/non-stratified storage

### Other built storages
- **Norrenergi:**
  - Solnaverket - 7000 m$^3$, plans to add 15,000 m$^3$ to Sundbybergverket
- Other built storages...

## Ice/Snow Storages

**Sundsvall seasonal snow storage**
- 70,000 m$^3$ (by 2011)
- 480 MWh

**Industrial ice storages**
- (electrically-driven chillers)...

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**Examples**

### Natural caverns

Old rock caverns used for oil storage, e.g. in Stockholm

### Other built storages

- **Norrenergi:**
  - Solnaverket - 7000 m$^3$, plans to add 15,000 m$^3$ to Sundbybergverket
- Other built storages...
International Examples - inspiration

Climaespaço, Lisbon
- Partially-underground chilled water storage tank, 15,000 m³ (from tri-generation plant, 35 MW cooling)
  - Less requirements of insulation

The Pearl of Qatar
- Electrically driven chillers, 457 MW cooling capacity
  - But can use water of poor quality (including sewage water)

JR Central Nagoya Train Station DHC
- Ice storage of 49 MWh
  - Peak shaving using night-time cheap electricity
  - Adapted to scarce space limitations by design
Way forward - SOA

• Further **collection of data on DC and cold storages** in Sweden
  • Reaching out 😊 to involved actors by emails, calls… → interviews
  • A workshop at KTH → ~April-May 2019
Way forward - Optimization Work

- Modelling & Optimization of the Norrenergi AB’s DC system
  - Modelling the existing DC system (using BoFit)
  - Benchmark the obtained results against existing data
  - Optimization of the grid for e.g. various cold storage scenarios
  - Feasibility of e.g. power-to-cold and other concepts integration and optimization
Discussion

• Cold storage solutions
  • Besides cold water & ‘expensive’ ice?

• Power-to-cold?

• Other?

• Interest in taking part in the SOA data collection?

• Reflections?

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