Seasonal Thermal Energy Storage

Presented to

Energy Planning for Resilient Communities – Best Practices

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by

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Underground Thermal Energy Storage
= Seasonal Thermal Energy Storage

UTES is a low-temperature geothermal technology

High-Temperature Geothermal
Geothermal Gradient Map

Low-Temperature Geothermal
Shallow Groundwater Temperatures
Underground Thermal Energy Storage (UTES)

Aquifer Thermal Energy Storage (ATES)
- Open Loop (hydraulically balanced)
- Seasonal flow reversal (well-to-well)
- Groundwater storage medium
- Economic efficiencies of scale

Borehole Thermal Energy Storage (BTES)
- Closed Loop (hydraulically balanced)
- Seasonal flow reversal (GHX)
- Soil/Rock storage medium
- Cost Proportional to thermal capacity
ATES for Cooling

Chilled Water Loop
$\Delta T \sim 12^\circ F$

Ambient
Groundwater 50°F

Warm Store ~55°F

Cold Store ~ 41°F
Aquifer Thermal Energy Storage (ATES)
Cross Section Animation – 5 years

https://youtu.be/N1Wg2ygeWj0
Optimizing the Earth Couple

- The role of advective heat transport via groundwater flow is of critical importance in designing an efficient Earth couple.
  - Groundwater flow is dominant heat transfer mechanism.
  - For large (> 150 ton) systems, evaluation of ground conditions is recommended prior to design.
- Seasonal Thermal Energy Storage significantly increases the efficiency of the Earth couple.

<table>
<thead>
<tr>
<th>Earth Couple Design Matrix</th>
<th>Heat Source / Sink</th>
<th>Thermal Battery</th>
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</thead>
<tbody>
<tr>
<td>Application</td>
<td>Conventional GeoExchange</td>
<td>ATES BTES</td>
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<tr>
<td>High Groundwater Flow Rate</td>
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<tr>
<td>Low Groundwater Flow Rate</td>
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<tr>
<td>Aquifer Present</td>
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<tr>
<td>No Aquifer Present</td>
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</tbody>
</table>
ATES Growth in The Netherlands

Source: www.ifdeftechnology.nl/
UTES Financials and Energy Benefits

- BTES well suited for extreme climates with surplus waste heat in summer
- ATES: ~60% savings on cooling energy compared to air-cooled chillers
  - ~80% peak cooling demand reduction
- Findings from Recent ATES Feasibility Study, St Paul, MN
  - 135 ac site; 6.5 M ft²; 3,450 TR; 5,500 gpm; 2-pipe DES; distributed heat pumps
  - Business As Usual is a new, efficient 4-pipe DES with central plant
- Savings vs. BAU:
  - 40% savings in primary energy consumption
  - 35% reduction in CO2 emissions
  - 100% reduction in cooling water consumption
- ATES Financials
  - $33 M CAPEX (inclusive of District Energy System; equal to BAU)
    » $9,600/TR inclusive of DES piping
The Resiliency Case for UTES

- Reduced and manageable power consumption for heating and especially cooling if the grid goes down and islanding is required.
  - ATES direct cooling COP ~25

- Combined with solar PV, UTES is 100% renewable HVAC
  - good connection in cooling mode in time of day

- ATES wells for emergency water supply and firefighting
Where is the climate suitable for ATES?

Annual water-side economizer (free cooling) hours
Where are the aquifers?
Thank You!