Leveraging Aquifers to Support Sustainable Energy Infrastructure
Aquifer Thermal Energy Storage (ATES)

- Aquifer technology has existed for about 25 years
- Well-established in the Netherlands – over 2,500 projects
- Optimal in climates with cold winters and hot summers
- Requires low groundwater velocity
- No groundwater consumed
- Balanced injection and withdrawal rates
- Heat stored in the aquifer in the summer
- Heat extracted from the aquifer in the winter
ATES – How it Works

- Open loop with separate warm and cold stores
- Seasonal reversal of warm and cold withdrawal/injection
- Hydraulically balanced

Seasonal thermal energy storage enabled by:
- High heat capacity of groundwater vs. aquifer skeleton
- Dynamics of fluid flow in porous media
- Low temperatures, low advection losses
- Hydraulic modeling and management of aquifer
ATES Operating Modes

**Summer Mode**

**Winter Mode**
Hydrogeologic Due Diligence – Ford Site
Hydrogeologic Due Diligence
3D Groundwater Flow Model

Hydraulic Head

St. Peter Aquifer

Shakopee Aquifer

Jordan Aquifer
Regulatory Due Diligence
Ford Site, Saint Paul, MN

• **ENVIRONMENTAL:** Aquifers below the St. Peter sandstone are unlikely to have been affected by anthropogenic contamination from historic land uses at the Ford Site.

• **FEDERAL - Underground Injection Control:** ATES wells are Class V injection wells under the UIC program administered by the US EPA. EPA retains primacy over the UIC program in Minnesota.

• **STATE - MDNR Appropriation Permit:** Groundwater withdrawals > 10,000 gpd require an appropriation permit from the DNR, even for nonconsumptive use.

• **STATE - MDH Groundwater Thermal Exchange Device and Well Permits:**
  • Minnesota Statute 103I.621 – ATES system can be developed; MDH permit required
  • Minnesota Administrative Rules Ch 4725 - Wells and Borings
District Aquifer Thermal Energy Storage (DATES)
Distributed submersible well pumps allow reduced pipe size and cost
Ford Site Redevelopment
Saint Paul

• 135 acre site
• Roughly 5 million square feet of commercial, retail, and residential
• Net-zero carbon goals
• Coordinated discussions between City, land owner, developer, and local utilities
Proposed District Energy System

- About 5,000 GPM aggregate flow
- Heating and cooling site buildings
- Fresh water district energy loop serves the buildings
- Focus on commercial and multi-family residential
- Potential of adding single-family homes
- Phased approach to coincide with site development
- Sets the foundation for net-zero carbon development
Financial Benefits

• Third-party financed – 100% debt financing
• Equivalent first-installed costs for developers
• Lower life-cycle costs for building owners
• Reduced maintenance
• Reduced labor costs
• Smaller building footprint
• Simpler mechanical systems
• Lower tenant energy costs
### Environmental Benefits

**Xcel Current Profile - 881 lbs CO2/MWh**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>EUI Basis</th>
<th>Tons of CO2</th>
<th>% Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as Usual Code</td>
<td>Code</td>
<td>9,261</td>
<td>37%</td>
</tr>
<tr>
<td>ATEs</td>
<td>SB2030 - 80%</td>
<td>5,852</td>
<td></td>
</tr>
</tbody>
</table>

**Xcel 2030 Profile - 521 lbs CO2/MWh**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>EUI Basis</th>
<th>Tons of CO2</th>
<th>% Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as Usual Code</td>
<td>Code</td>
<td>8,543</td>
<td>59%</td>
</tr>
<tr>
<td>ATEs</td>
<td>SB2030 - 80%</td>
<td>3,461</td>
<td></td>
</tr>
</tbody>
</table>
Environmental Benefits

- Differing financial timelines (8-year vs 30-year)
- More complicated cost allocation
- Competing site priorities (affordable housing, infrastructure investment)
- Uncertainty of a new technology
- Inexperienced engineers, architects, and contractors
- Complicating the Developer’s program
- Submetering
Opportunities for Improvement

• More detailed educational materials before the developer is engaged
• Simplified financial models and financing plans
• Eliminate uncertainty
• Match the traditional utilities’ rate structures and billing strategies
• Quickest path to the second system:
  - Install the first
The Silver Lining
Towerside District Energy (Minneapolis, MN)
The Silver Lining
Hillcrest Redevelopment (Saint Paul, MN)
Thank You

Mark Worthington
President
mark.worthington@underground-energy.com

Nina Axelson
Vice President
nina.axelson@ever-greenenergy.com