CEUs for this workshop

Be sure to scan the QR for Tuesday, Wednesday, and Thursday workshops to get points towards your IGSHPA certification CEUs.
Inclined vs. Vertical Bores

Optimized Heat Exchanger

→ Less wells
→ Less horizontal piping
→ Less site impact
→ Preservation of real estate
→ Flexible construction planning
→ COST EFFICIENCY!
What is the theoretical difference?

*Presented at European Geothermal Congress 2022 | Berlin, Germany | 17-21 October 2022

Vertical

Inclined

Figure 15: Profile mapping of temperatures in the ground for vertical (top) and inclined wells (bottom) probes, after 25 years of heat extraction for 1800 hours per year.
What is the modeled difference?

### Less Wells
- Vertical: 24 wells @ 20ft spacing
- Inclined: 21 wells @ 50ft spacing
- 500ft TVD

### Less Piping
- 1,244 ft piping
- 280 ft piping

### Less Site Impact
- 10,500 sqft impact
- 500 sqft impact

-13%  
-78%  
-95%

*Not to scale*
What are the challenges of inclined?

Well Trajectory
- Property Boundaries
- Subsurface Infrastructure
- Bore Collision
- Thermal Capacity

Borehole Integrity
- Hole Collapse
- Stuck Pipe
- Drag Forces
- Casing Seal

Loop + Tremie Insertion
- Drag
- Pushing Pipe
- Pipe Buckling
- Pipe Collapse

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Eversource Energy
Networked Geothermal Pilot
Framingham, MA
Project Summary

First Public Utility Community Geothermal Project in US!

- 1-mile-long ambient loop
- 90 bores (3 fields)
- 37 Buildings (commercial, multifamily, single homes)
- 140 utility customers
Inclined vs. Vertical Design & Construction

Highlights

- Bore reduction:
  - 60 vertical to 35 inclined
- Site impact:
  - Construction during ongoing community college operations
### Site Work

<table>
<thead>
<tr>
<th>Vertical Drilling</th>
<th>Delta</th>
<th>Incline Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>34k SQFT</td>
<td>-1600%</td>
<td>2k SQFT</td>
</tr>
<tr>
<td>1.4k CY</td>
<td>-250%</td>
<td>0.4 CY</td>
</tr>
<tr>
<td>877 TON</td>
<td>-1654%</td>
<td>50 TON</td>
</tr>
</tbody>
</table>

**Vertical Drilling Delta Incline Drilling**

**Site Work**

![Site Work Image 1](image1.png)

![Site Work Image 2](image2.png)
## Lateral Piping

<table>
<thead>
<tr>
<th>Vertical Drilling</th>
<th>Delta</th>
<th>Incline Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.3k LF</td>
<td>-279%</td>
<td>1.4k LF</td>
</tr>
<tr>
<td>584 JOINTS</td>
<td>-214%</td>
<td>186 JOINTS</td>
</tr>
</tbody>
</table>

*Images depict installation of lateral piping and drilling techniques.*
## Indirect Costs

<table>
<thead>
<tr>
<th>Vertical Drilling</th>
<th>Delta</th>
<th>Incline Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/week site maintenance</td>
<td>100%</td>
<td>0 days/week site maintenance</td>
</tr>
</tbody>
</table>
Thank you!

Dmitry Kuravskiy  
US Drilling Operations Lead  
781-428-1982  
dkuravskiy@celsiusenergy.com

Dominic J. Montalbano  
Strategic Development Manager  
508-926-4437  
DMontalbano@rhwhite.com