Geothermal Energy

Why do we need it?
Where do we get it?

Ashley Johnson
Geothermal Energy

- What is Geothermal Sourced Energy?
- Why Geothermal Power
- Drilling for Geothermal Power
- Research Challenges
  - Elastomers
  - Bits and Materials
- Conclusion
Geothermal sources and applications

**Shallow Sources**
- Shallow-borehole heat exchangers
- Heat extraction from ambient rock formation

**Intermediate Sources**
- Hydrothermal systems
- Water circulation through stimulated fractured rock

**Deep Sources**
- Hot dry rock

### Application

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<tr>
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<th>Product</th>
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<tbody>
<tr>
<td>District heating</td>
<td>Hot fluid &lt;50 degC</td>
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<td>Closed/open loop</td>
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<td>Vertical borehole arrays or aquifer</td>
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<td>– seasonal thermal storage</td>
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<td>Solar influx or active recharge</td>
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<tr>
<td>Direct heating</td>
<td>Hot fluid &lt;100 degC Soluble minerals</td>
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<td>- domestic, industrial</td>
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<td>Low grade heat</td>
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<td>Produced water, abandoned wells</td>
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<tr>
<td>Power generation</td>
<td>Electricity Soluble minerals</td>
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<td>- Direct steam</td>
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<td>- Binary cycle</td>
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Why Geothermal Power

- Renewable Energy vs Reactive Power
- Inland Empire Energy Centre - Closure
- Effective Load Carrying Capacity
- Durable Base Load
  - Critical for Grid Stability
Geothermal Power – Heat to Electricity
Conductive Lode

- Identify the Conductive Path
- Penetrate the Lode
  - Granite – Challenging drilling
- Drill to Target
  - Break Rock (not tools)
  - Deliver Power
  - Steered Hole
- Map Permeability
  - Characterise formation
- Temperature 220 °C
Drilling – Cutting Rock

- Shear Cutter Cutting
  - Unconventional Shale – 150 m/hr, 5 km
  - Granite 1 m/hr, 20 m

- Impact Hammer Drilling
  - Efficiency
  - Failure Mechanism
Fundamental Cutting Performance
Steering the Bit

- Selectively Push the Bit
  - Hydraulically driven
  - Moving Pistons

- Environment
  - 220 + °C
  - 70 MPa
  - 10 MPa (Differential)
  - Water, Oil, Solids
Mechanical Power at Bit

- Mechanical Power Transmission
  - Torque through 5,000 m rotating pipe
- Hydraulic Power + Motor
- Mono Motor

- Elastomer Challenge
  - Chemical Stability
  - Thermal Stability
  - Mechanical Deformation
  - Abrasion
Characterise Formation

- Lithology
- Permeability
- Resistivity
- Electrical Isolation
- Abrasion Resistant
- Temperature, Pressure
- Electronic Board Stability
Common problems requiring well intervention

- High to Ultra-high reservoir temperature
- Typically within the 200-300+ °C range
- Corrosion (reservoir and occasionally top hole)
- CO$_2$ and H$_2$S corrosion
- Pitting, galvanic, crevice
- Scaling
- Silica, Calcium carbonate, and heavy metal Sulphide salts
Scale Removal

- Mineral Scale Removal – No Ductile Steel Damage
- Abrasive Jetting
  - Shape, Hardness, Density, Fracture Toughness, Toxicity
- Sterling Beads
Geothermal Power

- Critical Enabler for Sustainable Power Systems
- High Temp Fluid Flow
- High Permeability Formation Conduit
- Challenging Environment
  - 220 °C, 60 MPa, Water, Oil, Solids, Corrosive
- Hydraulic, Electronics, Mechanical, Materials Systems