EGS – Challenges and Technology Adaptation

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EGS Projects

- Approximately 30 EGS pilot projects since 1974
- Locations include: Australia, France, Germany, Japan, Korea, Sweden, Switzerland, UK, and USA
- Examples of pilot projects that have produced power:
  - Landau (Germany) – 3 MW
  - Soultz-sous-Forêts (France) – 1.5 MW
  - Cooper Basin (Australia) – 1 MW
- Despite availability of heat, EGS underutilized to-date:
  - High capital cost and perceived technical risk

EGS has only seen limited implementation in pilot-scale operations.
EGS Technical Challenges (1)

- **Reservoir Development**
  - Stimulation techniques and technologies to effectively create multiple flow paths between wells
  - Preventing “short circuiting” and temperature decay over time

- **Well Construction and Completion**
  - High capital costs
  - Thermal well design
  - Well Integrity Management

EGS Technical Challenges (2)

• Production Management
  – In-well designs to control injection and production flow paths
  – Reliable artificial lift systems
  – Flow assurance: corrosion and scale mitigation
SAGD aka Reverse EGS

- Thermal heavy oil operations heat the ground with steam to mobilize bitumen instead of recovering heat from the ground
- Well pairs used with flow between injector and producer
- SAGD 180 – 250 °C
- CSS ~ 350 °C
- Equipment and practices may be adapted to EGS

thermal well design approaches and equipment could improve the safety, reliability and efficiency of EGS operations.
O&G Technology Adaptation for EGS

- Expertise and new technologies developed for SAGD and unconventional production
  - Multi-lateral wellbores
  - Multi-zone hydraulic fracturing
  - Thermal well casing design
  - Thermal completion equipment
  - Downhole flow control devices
  - High temperature pumping systems

- Potential to adapt these for EGS
• Drilling costs
  – Directional drilling may enable horizontal wells, multi-lateral completions may reduce costs

• Increased reservoir contact
  – Multi-stage hydraulic fracturing may increase the connected reservoir contact for injected fluid

More efficient well designs could reduce costs and increase efficiency
Thermal Well Design

• Well Reliability
  – Improved well design leads to reduced risk and improved economics

• Thermal Well Design
  – Temperature differentials may result in plastic deformation and strain localization in cemented casing
  – Use of post-yield, strain-based design approaches recommended
  – Casing selected to provide favorable post-yield characteristics (not elastic capacity)

• Thermal Casing Connections
  – Procedures such as ISO/PAS 12835:2013 suitable for qualifying geothermal casing connections
  – Use of qualified thermal connection designs may enhance well integrity
Well Construction and Completion (1)

• Casing Design
  – $\Delta T$ may result in plastic deformation and strain localization
  – Use of post-yield, strain-based design recommended
  – Material selected to provide favorable post-yield characteristics (not elastic capacity)

• Casing Connections
  • Use of qualified thermal connection designs may improve well integrity
  • Evaluation protocol used to qualify casing connections up to 350 °C

Casing connection qualification procedures help to ensure well integrity

Source: C-FER Technologies | www.cfertech.com
Well Construction and Completion (2)

- Thermal Wellheads
  - Novel completion designs used for thermal oil wells have been applied to geothermal wells
  - Streamlined workover operations

- Thermal Cement
  - Alternative thermal well cements
  - Improved cement placement procedures

- Vacuum Insulated Tubing (VIT)
Production Management (1)

- Downhole Flow Control Devices (FCDs)
  - Could be placed on EGS injector and/or producer well(s)
  - Reduce short-circuiting by managing flow rates and pressures
  - Provide the ability to shut-off regions

Source: Vachon et al. | SPE Paper 174416

Well completions with FCDs can be custom designed to minimize EGS short-circuiting
• Artificial lift
  – Lineshaft Pumps (LSPs) are commonly used but may limit well design options
  – High temperature Electric Submersible Pumps (ESPs) may enable new Hz developments
  – ESPs currently operating at up to 250°C for thermal O&G operations

Reliable pumps capable of operating in directional wells would allow optimized well designs