Newberry Volcano EGS Demonstration
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EGS Demonstration Projects

This presentation does not contain any proprietary confidential, or otherwise restricted information.
Project Location

- Northwest flank of Newberry Volcano, Deschutes Co, OR
- Geothermal leases held by Davenport Newberry LLC
Project Overview

• Timeline
  o Phase I – May 2010 to Feb 2011
  o Phase II – Feb 2011 to Nov 2012
  o Phase III – Nov 2012 to May 2013
  o 1% complete

• Budget
  o Total project funding $43.8m
  o DOE share $21.4m
  o Awardee share $22.4m
  o Funding for FY10 $ 4.1m

• Barriers
  o Institutional
    • Drilling cost – minor grant share for new wells, no share for existing wells
    • Permitting – lack of EGS/induced seismicity policy, minimal support against opposition
  o Technical
    • Many of the technical EGS development barriers cited in the Multi-Year Plan will be encountered and/or addressed (e.g. B, C, D, E, F, G, H, I, J, L, M, P)

• Partners
  o Davenport Newberry LLC
    Doug Perry
    Todd Jaffe
  o Temple University
    Nick Devatzes
  o U.S. Geological Survey
    Steve Hickman
  o Lawrence Berkeley National Lab
    Jonny Rutqvist
  o University of Utah / EGI
    Pete Rose
  o Texas A&M
    Ahmad Ghassemini
  o University of Oregon
    Emilie Hooft
  o Foulger Consulting
    Gillian Foulger
Project Management and Tools

AltaRock Project Team
Susan Petty – Principal Investigator
Will Osborn – Project Manager
Todd Jaffe – Permitting
Adrian Foley – Public Relations
Joe Iovenitti – Geology
Trenton Cladouhos – Stress Analysis
Laura Nofziger – Stimulation
Ben Larson – Geochemistry
Daniel Bour – Zonal Isolation

Technical Advisory Committee
Doug Perry (Davenport Power)
Dave Blackwell (SMU)
Louis Capuano (ThermaSource)
Bill Livesay (AltaRock)
Al Waibel (Columbia Geoscience)

Specialized Tools
AltaStim
TOUGHREACT / TOUGH-FLAC
Chemical Diverters
Mechanical Diverters
Single-Well Test Methods
Quantum Dot Tracers
Distributed Temperature Sensing
Fabry-Perot Pressure Transducer
Borehole Televiwer
Open-Hole Isolation Methods
Expandable Liner Hanger
MSA / Tilt Meters
Project Objectives

To demonstrate the development and operation of an Engineered Geothermal System

- Site and resource investigation
- Stimulation of existing well to create geothermal reservoir
- Production well drilling and completion
- Testing of well productivity and reservoir characteristics
- Conceptual modeling of commercial-scale EGS wellfield and power plant

Primary Goals

- Create EGS fracture network around existing borehole
- Drill two production wells into mapped fracture network
- Produce single-well mass flow rate of 75 Kg/s (595 kph)
Pre-Stimulation 2010 - Spring 2011

• Pre-Stimulation
  – Site and wellbore readiness
  – Site preparation
    • Sump, well pad, roads
    • Water wells

• Stimulation Plan
  – Geoscience review, lab studies, LiDAR
  – Initial Microseismic Array ("MSA") - design, install, monitor
  – Injection well
    • Conduct integrity test
    • Measure baseline (pre-stimulation) injectivity
    • Geophysical logs
• Public Outreach
  – Multimedia presentation of project plan
  – Permitting and planning meetings
  – Public interaction through various media outlets

• Permitting
  – Notice of Intent (exploration, operation, drilling)
  – Groundwater use
  – Surface MSA installation and monitoring (complete)
  – Strong motion sensors
  – Underground injection
  – MSA calibration
  – Subsurface MSA sensors and telemetry
  – Stimulation
  – Drilling
  – Testing
  – Induced seismicity and Seismic Hazards Evaluation
  – Environmental Assessment

• Go/No-Go
Injection Well Stimulation
Spring-Summer 2011

• Preparation for Stimulation
  – Ongoing site maintenance
  – Materials procurement
  – Installation of subsurface sensors and telemetry

• Injection Well Stimulation
  – Rig mobilization
  – Wellhead installation
  – First stimulation
  – Zonal isolation (chemical, mechanical)
  – Additional stimulations and tracer injection

• Flow test
  – Mass flow, temperature, pressure
  – Well bore surveys
  – Chemical composition and tracer recovery

• Production well drilling plan

• Go/No-Go
Production Wells
Fall 2011- Fall 2012

- Drill First Production Well
- Geophysical well logs
- Connectivity test
  - Pump groundwater into injector
  - Test production well and recirculate to injector
    - Mass flow, temperature, pressure, water make-up rate
    - Well bore surveys
    - Chemical composition and tracer recovery
- Stimulate production well, if needed
- Update numerical model and evaluate productivity
- **Go/No-Go**
- Drill second production well
- Conduct multi-well connectivity test
- **Go/No-Go**
Conceptual Modeling and Long-Term Monitoring

- Post-production reservoir response and long-term monitoring
- Update numerical model and evaluate resource potential
- Develop conceptual models
  - Wellfield expansion
  - Power plan design
  - Forecast reservoir performance
  - Estimate capital and operating cost
- Project Reports
  - Drilling, stimulation and test results
  - Reservoir performance
  - Peer-reviewed publications
  - Data posting to National Geothermal Data System
Meeting DOE EGS Program Objectives

Project Scope Meets DOE EGS Demonstration Objectives

- Demonstrate reservoir creation that achieves a flow rate of 20 kg/s by 2015
- Achieve a 10% increase in flow rate for EGS field site demonstration by 2011
- Model the reservoir conductivity at an EGS system demonstration by 2011
- Determine pre-stimulation reservoir flow rate for at least one EGS field site by 2010

Project Tasks Include DOE Essential Elements of EGS Development

Phase I

- Site Selection - surface analysis, well logs and well construction
  - Construct regional geologic model based on existing data
  - Share in Oregon LiDAR Consortium for enhanced surface feature imaging
  - Evaluate two existing full-size bore holes to select stimulation candidate
  - Temple/USGS borehole televviewer to target stimulation

- Reservoir Characterization - downhole instruments and use of data in modeling
  - Install and calibrate surface and subsurface seismometers
  - Texas A&M rock properties
  - LBNL native state THMC model
  - AltaStim stimulation modeling
  - Induced Seismicity and Seismic Hazards Study
Phase II

- **Reservoir Creation** - establish permeability and create and maintain cracks
  - Stimulate injection well using chemical (no rig) and mechanical diverters (rig)
  - Monitor fracture growth using focused MSA
- **Reservoir Validation** - fracture imaging tools
  - Repeat borehole televiewer to assess effects of hydroshearing
  - Inject tracers and execute single-well flow test methods
  - Use distributed temperature sensing to identify flow zones
- **Interwell Connectivity** - tools to ensure that suitable flow path connects wells, such as tracers
  - Conduct two-well and three-well connectivity tests
  - Analyze conservative and non-conservative tracers to assess effective volume, rate, etc.
  - Conduct dual-well stimulation as necessary

Phase III

- **Reservoir Scale-Up and Sustainability** - tools for selecting additional locations for wells, and long-term operation and maintenance of an economic EGS installation
  - Calibrate numerical models with real EGS performance data
  - Forecast reservoir performance over typical plant and field design life
- **Energy Conversion** – suitable energy conversion systems
  - Build conceptual model of commercial-scale power plant and wellfield
  - Estimate capital and operating costs of commercial-scale EGS facility
• **Goal of project:** Improve EGS economics by stimulating multiple zones

• **Technology Development:**
  - Reduce risk by improved fracture mapping and information gather and modeling.
  - Test methods to evaluate the created reservoir
  - Increase our understanding of induced seismicity through better understanding of stresses, natural seismicity and existing faults and fractures