Engineering Geothermal Systems in Oil and Gas Reservoirs

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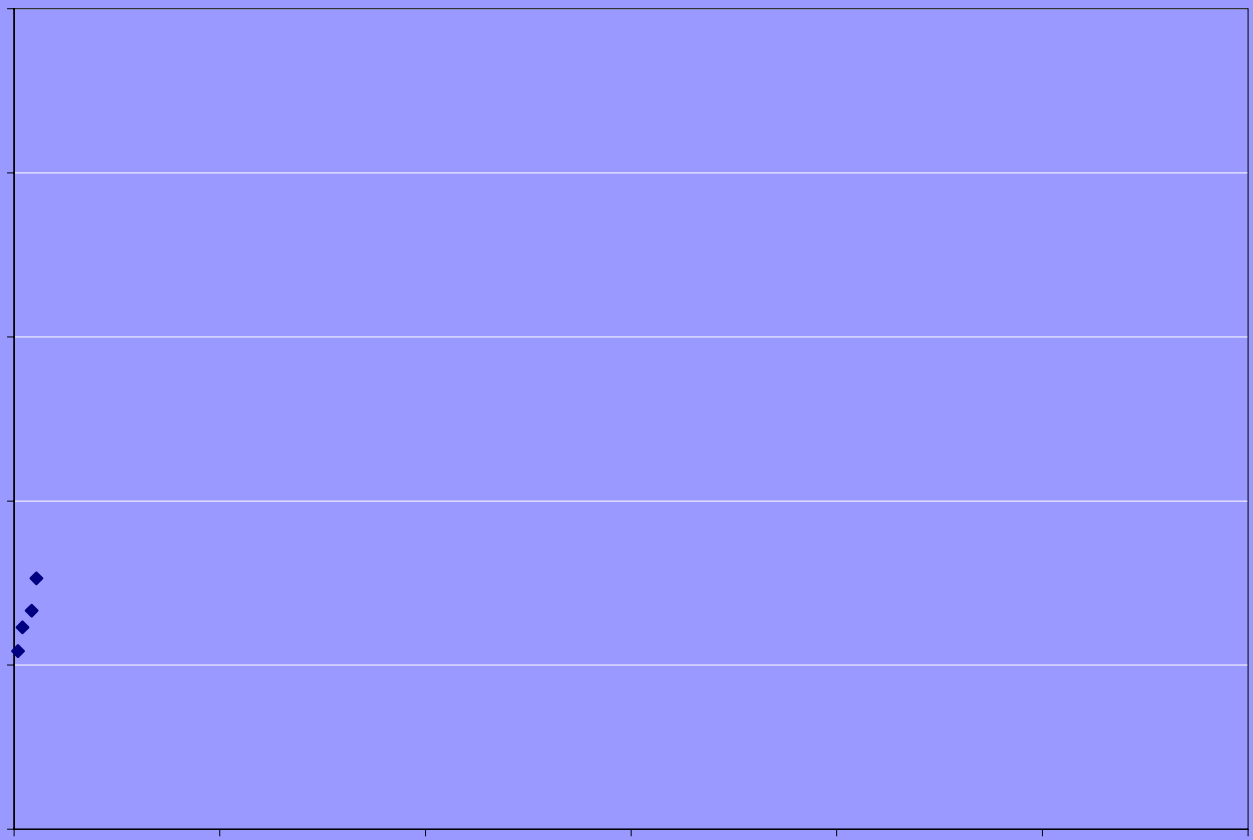
Energy from the Earth's Heat

- Hydrothermal systems
  - Naturally high permeability
  - Can be developed without stimulation
  - Usually at shallow depths <3 km
- Conductive heat energy

The Geothermal Resource in Oil and Gas Settings

Size of the Resource

Supply of EGS Power at Cost

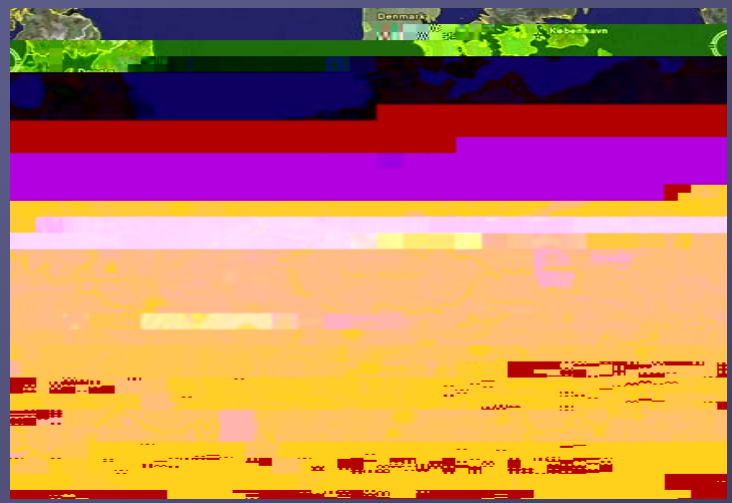


EGS in Oil Fields

- Oil and gas wells provide data for geothermal development

EGS in Oil Fields

- Europe
  - Soultz
  - Landau
  - Grosse Schönebeck
  - Unterhaching
- Australia
  - Cooper Basin
  - Paralana GreenEarth Energy
  - Hot Rock Ltd
  - Geogen VictoriaT
  - Torrens Energy Ltd
  - Granite Power



Resource Development

- Scenario 2 – Drill New Wells
  - Benefits
    - Large size borehole can be drilled to maximize flow rates and accommodate a pump
    - Well can be completed in hot water zones
    - Temperature vs. Depth can be optimized
    - Water already stored in sedimentary rocks
    - Can be drilled to reach higher temperatures in underlying crystalline rocks
  - Drawbacks
    - Deep wells can be very expensive
    - Drilling risk must be considered
    - May not have data in target zone

Enhancing Permeability in Oil Fields


Flow Profile & Significant Fracture Apertures
Openhole GPK-3 (4500 m - 5020 m)
Flowrate (l/s)
0
10
20
30
40
50
60

Economics of EGS in Oil Fields

- Scenario 1 – Wells of opportunity assumptions
  - Depleted oil field with 1000 psi overpressure
  - Wells 12,000 ft deep with 5” completion
  - Temperature 300°F
  - Build 50 MW plant -$110,000,000
  - Need 117 wells!
  - Competed above primary hot water reservoir

Economics of EGS in Oil Fields

- Scenario 2 – Drill new wells assumptions
  - Dry holes in area of soft geopressure ~1000 psi overpressure
  - Wells 12,000 ft deep with 9 5/8” completion
  - Temperature 300°F
  - Build 200 MW capacity – 30 wells for $190,000,000
  - 200 MW binary plant for $220,000,000
  - Drill and complete with screen and gravel pre-pack
  - Stimulate to achieve higher flow rates
  - Pumped with 700 HP motor
  - Maximum flow rate - 1500 gpm
  - Cost of Power – 8.07 ¢/kWh

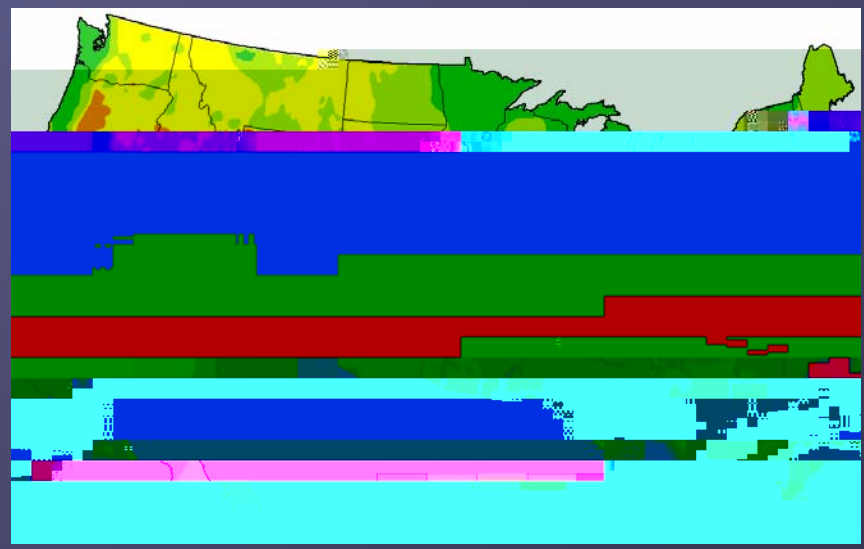
Reality Check EGS

What would need to happen to make EGS a reality?

- Â Reduce the cost of power through technology improvement and learning by doing
  - Increase flow rate per producer by improving stimulation methods
  - Reduce drilling cost by reducing number of casing intervals, improving rate of penetration and reducing risk
  - Improve conversion efficiency
- Â Identify high temperature oil fields with potential for high volume water production
- Â Develop a commercial project with DOE/industry in at least two areas with different geology

Reaching the Goal

- To get 1000 MW of EGS power on line we need:
  - 1 well in 3 months, average 5 MW per well
  - 16 rigs drilling for three years
  - 4 sites with 250 MW potential
  - Identify fields with declining production and large numbers of wells that can be recompleted.
  - Identify large areas of uniform hot rock at reasonable depth from O&G drilling data
  - Use hot oil/gas fields to get data and starting points for projects



Technology gaps and barriers

- Need reliable methods to increase the fractured heat exchange area without inducing felt seismic events or making short circuits
- Need to divert stimulation to zones that have been less affected
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Future Work to Overcome Gaps and Barriers