Unconventional Geothermal Energy and the US Energy Supply

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The Future of Geothermal Energy

- We must introduce uncertainty in the necessity of a coal and nuclear future!

- We must emphasize systems analysis in planning the energy future (the real costs and impacts must be considered)!

- We must consider nationwide market penetration

- We must have several 10’s of MW of unconventional geothermal energy on line by 2010

- Definition of EGS-What should we be talking about?
The MIT Report: Source of Data and Methods of Analysis

- The analysis is described in the MIT report (also Blackwell, Negraru, and Richards, 2007)
- Regional Study-compare Great Basin Study-based on detailed geology
- Data gaps
- Unknowns-basement geology
Temperature at 6 km (18,000 ft) from Blackwell, Negraru & Richards (2007)
Estimated total geothermal resource base and recoverable resource given in EJ or $10^{18}$ Joules.
Example: High temperatures in sediments

A large area in NE Nevada has high temperatures at about 10,000 ft in high permeability sedimentary rocks.

Locations of NE Nevada Oil Wells (+)

Locations for comparisons between TD curves and SMU Correction

Heat Flow Contours (with 20 mW/m^2 intervals)
Examples of Data Gaps

- Illinois Well
- South Dakota Aquifer anomaly
- West Virginia/Penn. shale gas plays
3 km Depth Temperatures
Geothermal systems not included

Based on Geology and Heat Flow
Based on Surface Temp. & Heat Flow

Comparison of 5’ and 2.5’ resolution with geological detail
Examples of Thermal Data Set Coverage in Eastern US

Map from the Geothermal Map of N. America, 2004
Example of basement geological map that can be matched to thermal mapping results

Precambrian Basement Map of Colorado by P.K. Sims, Viki Bankey, and C.A. Finn
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The Future according to TXU?
14,000 MW Coal & Nuclear
Modified in early 2007
Installed Capacity -- 980,000 MW (EIA)

Texas has 10% of installed capacity!
Types of Resources

- Coproduced
- Geopressure-Gulf Coast/East Texas
- Tight gas sands-Pieance Basin/Wattenburg Field
- Thick Sediments in high heat flow areas
- Basement EGS
- Hydrothermal Margins
Location of Texas Geothermal Resources

AAPG 1972 Oil/Gas Well Database
Interpolated Depth to 250°F

The Hill Country area does not have enough data for accuracy.

Dots are well locations.

Geopressure Fairways

Location of Texas Geothermal Resources
Actual Gas Field Conditions

* Wells with BHT’s over 300 °F at 15,000 ft or less, and often geopressure

* Many existing wells

* Water from one well or adjoining wells

* Existing infrastructure of power lines, roads, pipelines, etc.

* Possibility of continued stripping of gas and oil in otherwise non-economic wells
Direct Costs to Develop an Oil & Gas System

* Build mini power plants
* Re-complete some wells to increase flow
* Minor surface infrastructure upgrades (i.e., insulating pipes)
* Chemicals added to prevent precipitates
* Reinjection Well
Location of sedimentary EGS, geopressure, coproduction
Geopressure may be the most cost effective to develop on a large scale in a short time.


Schematic cross section, central Texas Gulf Coast, showing relationship among major growth faults, expansion of section, sand depocenters, and top of geopressure (after Bebout and others, 1982).
Specific sedimentary basin examples

Freestone Co., TX
Corrected BHT Gradients
°Ckm⁻¹ = 33.5
°F100ft⁻¹ = 1.84

Duval Co., TX
Temp. Log Gradients
°Ckm⁻¹ = 34.4
°F100ft⁻¹ = 1.89

Duval County, Texas
(See Above Inset)

Watenberg, CO
Pieance Basin, CO
Tight Gas Sands

- Hard, abrasive rock
- Mild geopressure
- Low natural permeability
- Temperatures of 150 to 225 °C
- Fracture treatments & horizontal wells
- Limited reservoir uncertainty
OVERTON FIELD, EAST TEXAS
(COTTON VALLEY TIGHT GAS SANDS)
Learning Curve Example (Kuuskraa, 2006)

- Reduced drilling time by 50%.
- Increased initial production by three fold.
- Increased EUR per/well by 60%.

Improved Drilling and Production Results

- 2001 Avg - 35 Days
- 2002 Avg - 27 Days
- 2003 Avg - 24 Days
- FINA Avg - 55 Days
Figure 4 Example of fracture treatment map in vertical well from core area of Barnett.

Figure 6 Plan View Fracture Map of Typical Uncemented Barnett Treatment with Fracture Structures Illustrated.

Figure 7 Side View Fracture Map looking normal to un cemented lateral of Barnett treatment with Fracture Height confined to Lower Barnett only. Events shown are for 2 fracture stages. Stage 1 treatment, (filled diamonds) appears to have grown slightly higher than Stage 2 (open diamonds).

Figure 16 Cumulative Frequency distribution, average production rate normalized by length of horizontal section.

Figure 18 Cumulative length of individual fracture segments correlates to improved well productivity.

Criteria for Focus Areas

- Resource quality and/or characteristics
- High CO2 producing states
- High energy usage areas
- Transportability of technology developed
Research Priorities

• Focus on unconventional systems
• No drilling research for 5 years
• No focus on hydrothermal margins for 5 years (too long for large scale & too limited in area)
• Scalable resources in unconventional areas in power and/or CO₂ needy areas
• Locating sweet spots/demonstration areas
• Large scale fracture and fluid circulation experiments
Resource studies: Unconventional Geothermal Energy

- Coordinated studies with clear specifications (state or area based)
- Extensive thermal logging of deep wells
- Develop thermal expertise
- Lithology as function of depth and position
- Lithology of basement
- Some heat flow drilling on geophysical anomalies
- Require digital reporting of BHT
- Outline and characterize 100 MW’s of sites country wide