Developing Geothermal Energy in O/G Plays

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http://smu.edu/geothermal
Geothermal Energy Categories

Direct Use
- Space Heating
- District Heating
- Greenhouse Heating
- Industrial/Agri Drying
- Aquaculture

Electricity
- Binary Fluids (165 – 300°F)
  - Coproduction
- Hydrothermal > 300°F
- EGS > 300°F
  - Sedimentary Basin
  - Hot Dry Rock

Paul Brophy, DOE Webinar, 2012
Geothermal Energy Today

Geothermal power plants provide electricity for over 2 million homes in Western U.S. 300 cities are within 5 miles of a known geothermal resource.
Calculating temperatures at various depths

6.5 km (21,300 ft) Temperature Map

3.0 km (10,000 ft)

10 km (33,000 ft)

Google.org/egs  2011 SMU funded research
Geothermal energy potential in United States

Based on SMU Geothermal Lab research for Google.org/EGS

10 times the installed capacity of coal-fired power plants
Geothermal energy potential in Texas
Estimating temperatures from oil/gas BHT

12,000 feet depth
Uncorrected temperatures

Geothermal energy potential in Texas

Based on research by Bruce Cutright of UT Austin, BEG:

AAPG defines a "Giant" oil field
= > 500 million barrels of oil.

Using this definition ...

the Wilcox and Frio Fairways have the equivalent of
3,100 "Giant" oil fields remaining
in extractable thermal energy (brine + methane)
## Comparison of Geothermal with others

<table>
<thead>
<tr>
<th>Beneficiary</th>
<th>2010 Net Generation (Billion kW)</th>
<th>Total Subsidies in M of $2010</th>
<th>Cost in $ of subsidies per MW hours generated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1,851</td>
<td>1,358</td>
<td>$0.73</td>
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<tr>
<td>Petroleum</td>
<td>1,030</td>
<td>2,820</td>
<td>$2.74</td>
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<tr>
<td>Nuclear</td>
<td>807</td>
<td>2,499</td>
<td>$3.10</td>
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<tr>
<td>Renewables*</td>
<td>425</td>
<td>14,674</td>
<td>$34.53</td>
</tr>
<tr>
<td>Hydro</td>
<td>257</td>
<td>216</td>
<td>$0.84</td>
</tr>
<tr>
<td>Geothermal</td>
<td>16</td>
<td>273</td>
<td>$17.06</td>
</tr>
<tr>
<td>Biomass</td>
<td>57</td>
<td>1,117</td>
<td>$19.60</td>
</tr>
<tr>
<td>Solar</td>
<td>1</td>
<td>1,134</td>
<td>$1,134.00</td>
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<tr>
<td>Wind</td>
<td>95</td>
<td>4,986</td>
<td>$52.48</td>
</tr>
</tbody>
</table>

*EIA.gov website for data
It takes longer than expected for initial projects

Items to Consider

- Geopressure
- Legal Regulations
- Assess Resources
- Gov/Private Leases
- RECs/Tax Credits
- Oil & Gas Wells
- Producing Water
- Abandoned Wells
- Public Information
- Power Plant Eng.
- -Turbine
- -Cooling Methods
- Economics
- Transmission Lines
- Injection Wells

SMU Geothermal Laboratory
Technology = Binary or Screw Technology
Geothermal energy categories
Coproduction with o/g production

- Hot water ~180°F mixed with o/g
  - (164°F in Alaska, 250°F in Gulf Coast)
- US produces ~25 b. bbl/yr of water
- Binary technology
- Infrastructure already exists
- Electricity for field use or sold to grid
- Extends the life of fields and keeps jobs in the industry

Demonstration: RMOTC Casper, WY ORMAT Technology 250 kw
Geothermal energy categories
Coproduction with o/g production

Jones CO. Mississippi Demo (June-Oct 2011)
Denbury Resources - well
Gulf Coast Green Energy – RPSEA Project
~23 kw from 4100 bbl/day @ 204°F

Near the Laurel field wellhead, the hot water supply line was bypassed through ElectraTherm’s ORC in a simple three way valve configuration to not to interfere with production. The base load electricity was utilized on site to keep all the electricity “inside the fence.” The power generated displaced the $.098/kWh utility price.


“..designed for a truck bed to simplify plug-and-play .
Water/fluids are an Important Variable

- Based on $\Delta T$ of 120° F
- 1000 kW = 1 MW
- Baseline for estimation
- Curve will be different based on
  - Machine
  - $\Delta T$

Image from Blackwell et al., 2010
Geothermal energy categories

Coproduction with o/g production

*Coproduction is considered only a starting point …

- Convert shut-in wells to produce hot water and the oil/gas
- Start with an energy well … develop the well from the beginning to use the full pressure, oil/gas and water in the reservoir
- Drilled a dry well? Complete as energy well and produce electricity for other wells in the field.
- Ready to abandon? Will a workover produce enough hot water to transition the well to its next purpose? Can you sell it to a company who wants to drill it deeper?

In 2010,

- # of shut-in wells
  - LA > 34,000
  - TX > 114,000

1. PTTC Network News March 2010
Geothermal energy categories

EGS – Enhanced Geothermal Systems (Large-scale)

- **71,000 – 170,000 EJ** \(10^{18} \text{ J}\)
- Trapped fluids
- Elevated pressures
- Temperatures 200 to 500°F
- Dissolved natural gas

Pleasant Bayou, Texas

- Demonstration power plant
- 1 MW electricity
- Gas/Heat
Geothermal energy categories
EGS – Enhanced Geothermal Systems (Large-scale)

EGS defined broadly as engineered reservoirs that have been stimulated to emulate the production properties of high grade commercial hydrothermal resources. Accomplished through hydroshearing of reservoir area.
Geothermal energy categories
EGS – Enhanced/Engineered Geothermal System

*EGS is where we need to get to for utility scale projects

East Texas/ LA
Haynesville Shale
Sabine Uplift
EGS

North Texas
Ellenburger Limestone
Fort Worth, TX
EGS, Coproduced

Gulf Coast & South TX
Frio and Wilcox
EGS, Geopressure

2004, Blackwell and Richards, GMNA

SMU GEOTHERMAL LABORATORY
How to extend the life of an oil/gas field?
EGS – Enhanced Geothermal Systems or Engineered Systems
Currently experimental in US, Australia, Germany, UK

Based on the shale plays,
Geothermal development in O/G fields is right on target!

US Geothermal Power Goal: 100,000 MW installed in 50 years
Geothermal DIRECT USE applications

A Variety of applications

- **Space Heating**
  - 2,000+ buildings in 17 states

- **District Heating**
  - 20 systems

- **Greenhouse Heating**
  - 44 facilities in 9 states

- **Industrial/Agricultural Drying**
  - 9 facilities in 3 states

- **Aquaculture**
  - 51 sites in 11 states

- **Pavement Snow Melting**
  - OR and WY

Greenhouse Applications

Shrimp Farm, Arizona
Geothermal Heat Pumps & Waste Heat

Start with these easy savings:
Offset before generating new
Use waste heat sources
Create local jobs
Save on carbon footprint
Geothermal: right below our feet
Related links and resources

Presentations from the past five SMU Geothermal Conferences related to developing geothermal in oil and gas fields:
http://smu.edu/geothermal/Oil&Gas/Oil&GasPresentations.htm.


Geothermal potential. Petroleum Review, 6 September 2011, George Lockett looks at the prospect of utilizing North Sea platforms to extract geothermal energy from the oil and gas fields on which the platforms are placed.

Property Rights and Legal Issues:

NREL’s System Advisor Model (SAM) is a performance and financial model designed to facilitate decision making for people involved in the renewable energy industry. https://sam.nrel.gov/

The same technology for geothermal heat extraction is used for waste heat. http://www.heatispower.org/

## ENERGY CONVERSION EVALUATION

<table>
<thead>
<tr>
<th>Feature</th>
<th>Ormat</th>
<th>Pratt &amp; Whitney</th>
<th>Deluge</th>
<th>Recurrent</th>
<th>Electratherm</th>
<th>Calnetix</th>
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</thead>
<tbody>
<tr>
<td>Output (kW)</td>
<td>350</td>
<td>430</td>
<td>1750</td>
<td>845</td>
<td>235</td>
<td>550</td>
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<tr>
<td>Net kW</td>
<td>300</td>
<td>407</td>
<td>1487.5</td>
<td>750</td>
<td>191</td>
<td>495</td>
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<tr>
<td>Footprint (sq. ft.)</td>
<td>420</td>
<td>2800</td>
<td>124</td>
<td>3406</td>
<td></td>
<td>100</td>
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<tr>
<td>Remote operation</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td>yes</td>
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<tr>
<td>Cooling</td>
<td>air</td>
<td>air</td>
<td>not provided</td>
<td>not provided</td>
<td>Forced air</td>
<td>Forced air</td>
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<tr>
<td>No. machines</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>2</td>
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<tr>
<td>Working fluid</td>
<td>R245fa</td>
<td>R245fa</td>
<td>liquid CO₂</td>
<td>H₂O &amp; NH₃</td>
<td>R245fa</td>
<td>R245fa</td>
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<td>Delivery</td>
<td>10 mos</td>
<td>4 mos</td>
<td>4 to 7 mos</td>
<td>10 mos</td>
<td>4 mos</td>
<td>9 mos</td>
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<tr>
<td>Cost</td>
<td>$1,600,000</td>
<td>$1,175,000</td>
<td>$4,165,000</td>
<td>$1,926,500</td>
<td>$965,665</td>
<td>$1,475,000</td>
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<tr>
<td>Extra Infrastructure</td>
<td>none</td>
<td>Building</td>
<td>Building</td>
<td>Building</td>
<td>Building</td>
<td>none</td>
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<tr>
<td>Extra costs for cooling</td>
<td>0</td>
<td>$565,000</td>
<td>$350,000</td>
<td>$565,000</td>
<td>$250,000</td>
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<td>Warranty</td>
<td>1 yr.</td>
<td>1 yr.</td>
<td>1 yr.</td>
<td>1 yr.</td>
<td>ext 5 y., included</td>
<td>18/12</td>
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<td>Outdoor/Indoor</td>
<td>Outdoor</td>
<td>Indoor</td>
<td>Indoor</td>
<td>Indoor</td>
<td>Indoor</td>
<td>Outdoor</td>
</tr>
</tbody>
</table>

Gosnold, 2011 Presentation at SMU Geothermal Energy Conference
# ENERGY CONVERSION EVALUATION

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<th>Calnetix</th>
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<tbody>
<tr>
<td>Output voltage</td>
<td>480</td>
<td>480</td>
<td>480</td>
<td>480</td>
<td>480</td>
<td>350-500</td>
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<td>Shipping</td>
<td>we pay</td>
<td>yes</td>
<td></td>
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<td>we pay</td>
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<tr>
<td>Performance guarantee</td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Insulation for HE and Pipe</td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connection to grid</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Transportation to site</td>
<td>yes</td>
<td>yes</td>
<td>unknown</td>
<td>unknown</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>Special</td>
<td>no pad req.</td>
<td>Turnkey install.</td>
<td>pad req.</td>
<td>no pad req.</td>
<td>pad req.</td>
<td>no pad req.</td>
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<tr>
<td>Infrastructure</td>
<td>$10,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$10,000</td>
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<tr>
<td>Total Cost</td>
<td>$1,610,000</td>
<td>$1,800,000</td>
<td>$4,575,000</td>
<td>$2,551,500</td>
<td>$1,275,665</td>
<td>$1,485,000</td>
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<tr>
<td>Cost per kW</td>
<td>$5,367</td>
<td>$4,423</td>
<td>$3,076</td>
<td>$3,402</td>
<td>$6,679</td>
<td>$3,000</td>
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<tr>
<td>Yearly sales $.05/kWh</td>
<td>$124,912</td>
<td>$169,464</td>
<td>$619,356</td>
<td>$312,280</td>
<td>$79,527</td>
<td>$206,105</td>
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<tr>
<td>Years to cover investment</td>
<td>12.9</td>
<td>10.6</td>
<td>7.4</td>
<td>8.2</td>
<td>16.0</td>
<td>7.2</td>
</tr>
</tbody>
</table>

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