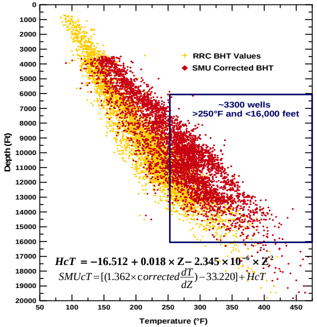
Geothermal Potential of Texas East of I-35E

David Blackwell, Maria Richards, Patrick Stepp
Geothermal Laboratory
Huffington Department of Earth Sciences
Southern Methodist University

Data was collected from Log Headers: logged depth intervals, Bottom Hole Temperatures (BHT), elevation (KB), TSC, using the available scanned logs from the RRC.

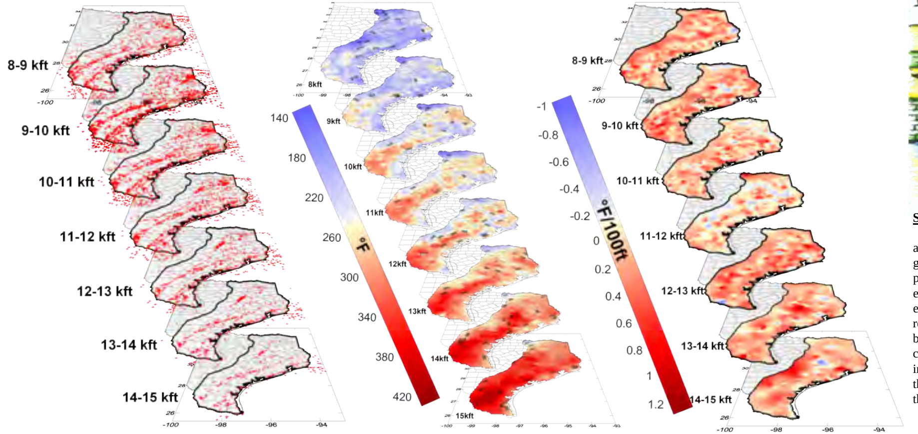
Example of log headers and temperatures from Texas Railroad Commission (RRC) Data for Districts 1- 6



BHT's are corrected in a two step process.

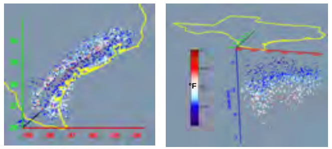
1st a Harrison Correction (HcT) is applied. This gives only a general correction for values deeper than 4000 ft. At SMU we found that depending on regional differences in geology the gradients over corrected in the cooler areas and under corrected for warmer areas. Thus a 2nd linear correction was applied (SMUcT).

Corrected Temperature Data, Contoured Temperature, and Gradients

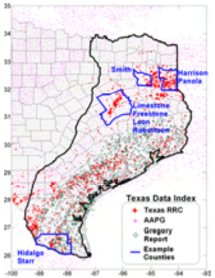


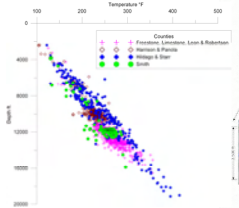
Above, the first figure shows the approximate depth where a particular bottom hole temperature (BHT) measurement was taken. The second figure is contoured from the BHT data after applying Harrison and SMU corrections. The third figure is the temperature gradient. These interval gradients were calculated using the difference between gridded temperature data from the center figure.

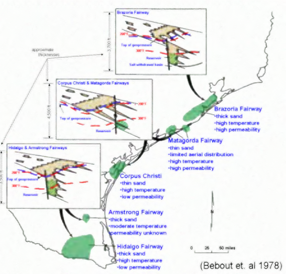
Unprocessed data provided by the 1980 Gregory Report



Highlighted Counties are chosen for Review



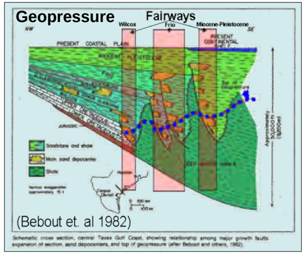


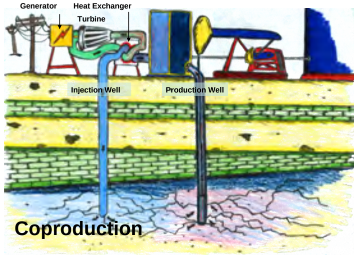


Geopressured Geothermal- Gulf Coast

USGS Circulars 726 and 790 (White et al., 1975 and Wallace et al., 1979) discuss extensively the resource base for geopressured geothermal resources (including dissolved methane) in the Texas and Louisiana Gulf Coast. Since those analyses, extensive evaluations have been carried out (Gregory et al., 1980, and John et al., 1998 for example).

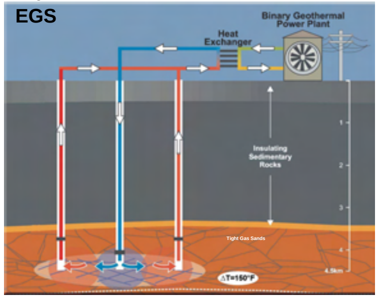
In January of 2007 the Texas General Land Office leased by competitive bid 11,000 acres of state land for geothermal development along the Gulf Coast.





Coproduced Fluids- General, Statewide

There are high volumes of water produced by hydrocarbon production. About 12,000,000,000 bbls (~4,000,000 l/min) of water were produced in Texas in 2002 according to Curtice and Dalrymple (2004). McKenna et al. (2005) estimated an electric power production of over 1,000 MW using this waste water.



Sedimentary Enhanced Geothermal Systems (SEGS)- East Texas Tight Gas Sands

By combining the knowledge of existing reservoirs (areas of known porosity, permeability and fracturing) from the hydrocarbon industry with methods to extract the heat from the geothermal industry, a whole new arena is available for geothermal electrical power production. Geothermal power projects are usually heavily loaded with upfront costs for exploration, reservoir characterization, and well drilling. These are also the biggest risk elements for investors in conventional geothermal projects. The hydrocarbon industry though routinely works with deep wells with known temperatures that are hot enough for use with binary geothermal technology to generate electricity. Because of the known reservoir characteristics and temperature information this form of geothermal development becomes an investment with decreased risk. Through working with projects that use existing oil/gas wells, the biggest risk elements are already known. Thus the focus is has now become how to use the geothermal resource that exists in oil/gas fields to its greatest potential.

References
Bebout, D.G., Loucks, R.G., Gregory, A.R., *Report of Investigations No. 91: Frio Sandstone Reservoirs in the Deep Subsurface Along the Texas Gulf Coast: Their Potential for Production of Geopressured Geothermal Energy*. Bureau of Economic Geology, University of Texas at Austin, Austin Texas, 1978.
Bebout, D.G., Weise, B.R., Gregory, A.R., Edwards, M.B., *Wilcox Sandstone Reservoirs in the Deep Subsurface Along the Texas Gulf Coast – Their Potential for the Production of Geothermal Energy*, Bureau of Economic Geology, University of Texas at Austin, Austin, Texas, 1982.
Blackwell, D.D., Negraru, P.T., and Richards, M.C., *Assessment of the Enhanced Geothermal System Resource Base of the United States*, Natural Resources Research, DOI: 10.1007/s11053-007-9028-7, 2007.
Campbell, R. G., and Hattar, M. M., *Operating results from a hybrid cycle power plant on a geopressured well*, Geothermal Resources Council Trans., 14, 521-530, 1990.
Campbell, Richard G.; Hatter, Mai M.. *Design and Operation of a Geopressured-Geothermal Hybrid Cycle Power Plant: Final – Volume I – February 1991*. The Ben Holt Co.; Pasadena, California, 1991.
Campbell, R.G., Hatter, M.M., *Design and Operation of a Geopressured-Geothermal Hybrid Cycle Power Plant: Final Report – Volume II – February 1991*. The Ben Holt Co.; Pasadena, California, 1991.
Curtice, R.J., and E.D. Dalrymple, Just the cost of doing business, World Oil, 77-78, 2004.
Gregory, A. R., Dodge, M. M., Posey, J. S., and Morton, R. A. 1980. Volume and accessibility of entrained (solution) methane in deep geopressured reservoirs-Tertiary formations of the Texas Gulf Coast, U. S. DOE final Report DOE/ET/11397-1, 361 p.
John, C.J., Maciasz, G., Harder, B.J., *Gulf Coast Geopressured – Geothermal Program Summary Report Compilation: Volume I – Executive Summary*. Basin Research Institute, Louisiana State University. Baton Rouge, Louisiana, 1998.
John, C. J., Maciasz, G., and Harder, B. J. 1998. Gulf Coast geopressured-geothermal summary report compilation, Report DOE/ID/13366-T1-Vol. I-V.
McKenna, J. R., and Blackwell, D. D. 2005. Geothermal electric power from hydrocarbon fields. Geothermal Resources Council Trans., v. 29, p. 283-288.
McKenna, J., Blackwell, D., Moyes, C., and Patterson, P. D. 2005. Geothermal electric power supply possible from Gulf Coast, Midcontinent oil field waters. Oil & Gas Journal, Sept. 5, v. 103(33), p. 34-40.
Papadopulos, S. S., Wallace Jr., R. H., Wesselman, J. B., and Taylor, R. E. 1975. Assessment of onshore geopressured-geothermal resources in the northern Gulf of Mexico basin, in Assessment of Geothermal Resources of the United States-1975, US Geol. Surv. Circular 726, p. 125-140.
Shook, G. M. 1992. An integrated approach to reservoir engineering at Pleasant Bayou geopressured-geothermal reservoir, DOE Technical Report EGG-EP-10557, 48 p.
Wallace Jr., R. H., Kraemer, T.F., Taylor, R.E., and Wesselman, J.B. 1979. Assessment of Geothermal Resources of the United States-1978. In Assessment of geopressured-geothermal resources in the northern Gulf of Mexico basin. Ed. Muffler, L. J. P., U. S. Geol. Survey Circular 790.
White, D. F., and Williams, D. L. 1975. Assessment of geothermal resources of the United States. U.S. Geol. Survey Circular 726.

Putting It All Together ……

1. Temperature

New Technologies have created a mechanism for generating electricity from lower temperature fluids. Thus the "Geothermal Resource" for Texas has changed from what was depicted in 1982 by Woodruff et al. in the Bureau of Economic Geology study and map depicting Texas Geothermal Resources. The Earth under Texas has not changed, except for thousands of new wells drilled, oil and gas removed, and brine injected into different formations. From the deeper drilling we have increased knowledge of what the temperature is at various depths. Combining the new technologies with improved temperature data, we are able to determine best case scenarios for developing fields. Areas with temperatures of 250°F or more at the shallowest depth are the first factor.

2. Water Flow Rate and Injection Wells

To generate electricity heat needs to be extracted from the produced fluid. Fluid flow rates are on a level of 10,000 barrels per day (300 gpm) or higher. Depending on the technology, the amount of fluid necessary varies still, higher volumes give increased electrical production. In Texas, there is no reporting of the produced water, rather the amount injected. Using the classification of injection wells is one way to determine areas of increased water flow. Generally the higher flow rates are associated with shallow fields (< 9000 ft).

The water being injected is part of the resource calculation since it is injected with the expectation that it will flow through the reservoir again (and again) continuing to extract heat, along with oil and gas reserves.

3. Depth and Pressure

The amount of parasitic load for generating electricity is impacted by pumping needs. Thus deeper depths can be more favorable in areas of high geopressure with no pumping necessary. With out geopressure it becomes increasingly difficult to pump wells below 14,000 ft.

The major geopressure areas are along the Gulf Coast in bands following coastline. Geopressure is a resource in that fluid naturally flows from a well; it has mechanical force that can be used to assist in the reinjection process; and it carries dissolved natural gas. (See example areas of high geopressure to left).

4. Diameter of Well

High fluid flow rates make it necessary for a larger diameter well. An 8" casing is a minimum diameter. Wells that have 10"+casings are preferred.

5. Water Chemistry

There is no fresh water in Texas hot enough to generate electricity. What we have is different amounts of salinity and TDS. The good news is this can be dealt with by the technology and the water is reinjected into similar formations. The bad news is generally the amount of heat available for extraction decreases with increasing TDS.

6. Proximity to Transmission Lines

Today there is increasing consideration for developing distributed energy which reduces the need for cross-country transmission lines. Where there is large scale geothermal development, the closeness to the transmission grid is preferred.