GEOTHERMAL RESOURCES IN LOUISIANA

by

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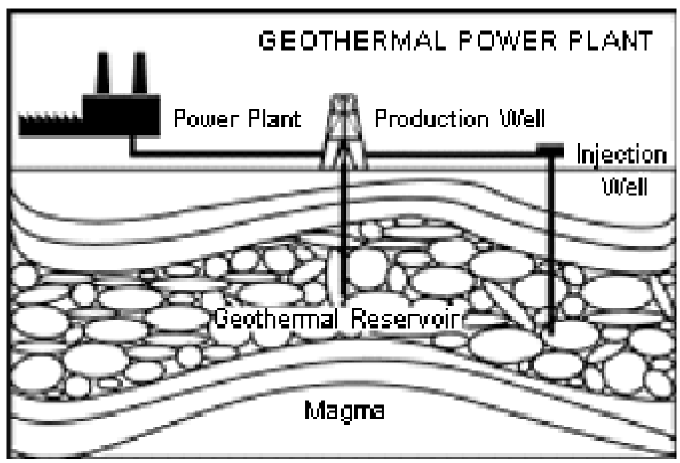
The Earth's temperature increases with depth, reaching more than 4200° C (7600° F) at its core. At great depths, temperatures become high enough to melt rock, forming magma. Some magma rises to the surface through fractures as lava, but most magma remains below the earth's crust and heats the surrounding rocks and subterranean water. Some of this water makes its way to the surface as hot springs or geysers. When this hot water and steam is trapped under a layer of impermeable rocks, it is called a *geothermal reservoir*. These reservoirs can potentially be tapped for electricity generation or direct use by release through a steam turbine. Figure 1 is a diagram of this process. In Louisiana, dissolved hydrocarbon gases commonly increase the energy available from this resource.

Louisiana has some geothermal potential. The temperatures, at 4 km (13,123 ft.), ranges from less than 158° F to over 300° F in North America. Louisiana has some areas along the Arkansas and Texas borders at the high end. Well logs from the coastal plain show temperatures around 160° F, at depths of 4.6 km (15,000 ft.), along most of Louisiana's coast. This is hot enough for energy production, but there are two problems: drilling cost and ground subsidence.

If the drilling has already been done for hydrocarbon production, then one problem has been eliminated. Table 1 shows the potential power production just for "produced" water from oil and gas wells in the south. Additional power could be produced by injecting water into the earth at one point (injection well) and removing the

Figure 1. Schematic of Geothermal Power Plant Production and Injection Wells



Source: U. S. Department of Energy (http://www.eia.doe.gov/kids/energyfacts/sources/renewable/geothermal.html/22 March 2005)

Table 1. Geothermal Power from Existing Gulf Coast Hydrocarbon Production

State	Yearly total processed water, bbl	Processed water cut, %	Water production 1000 gpm	Statewide power at 210?F MWs	Statewide power at 400?F MWs
Alabama	203,223,404	95.1	15.4	7.0	37.8
Arkansas	258,095,372	97.2	20.0	9.1	49.1
Florida	160,412,148	97.2	12.5	5.6	30.5
Louisiana	2,136,572,640	95.2	162.5	73.6	398.0
Mississippi	592,517,602	96.7	45.8	20.7	112.1
Oklahoma	12,423,264,300	99.5	986.6	446.7	2,416.4
Texas	12,097,990,120	96.8	935.1	423.3	2,290.2
Total			2,177.8	986.0	5,334.1

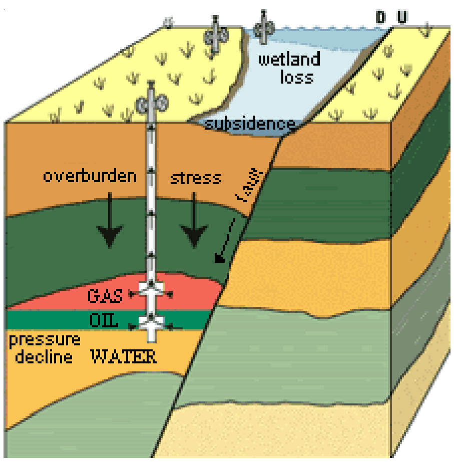
Source: "Geothermal Electric Power Supply Possible from Gulf Coast, Midcontinent Oil Field Waters," *Oil & Gas Journal*, Jason McKenna, U. S. Army Engineer research Center, Vicksburg, MS; David Blackwell, Southern Methodist University, Dallas, TX; and Christopher Moyes & P. Dee Patterson, Moyes & Co. Inc., Dallas, TX; September 5, 2005, Pg., 39.

heated water at another point. Production companies could use it to supply power for pumping and re-injection of the produced water.

Produced water may contain natural gases that can be separated if the fluid is depressurized. These gases can be used separately or to add heat energy to the liquid. If the geothermal fluid is depressurized to release the gases, then it must be re-pressurized to the original level to re-inject it back into the ground. Some, but not all, of the energy can be extracted from the expanding gases for the re-pressurization. Releasing the gases from the fluid will also remove some of the heat energy (cool) from the liquid remaining. The hydrocarbons can be removed by chemical means which add cost, but do not have these penalties. The world's first hybrid (organic Rankine/gas engine) geopressure-geothermal power plant was operated at Pleasant Bayou, Louisiana, using both the heat and the hydrocarbons of a geopressured resource.

As illustrated in Figure 2, if geothermal fluids are withdrawn from a reservoir and not re-injected, it permits soil formations at the site to compact, leading to ground subsidence at the surface. Ground subsidence can affect the stability of pipelines, drains, and well casings. It can also cause the formation of ponds and cracks in the ground and, if close to a populated area, it can lead to instability of buildings.

Figure 2. Graphic of How Extraction May Induce Subsidence



Graphic courtesy of *U. S. Geological Survey*

Oil and gas deposits lie in underground cavities along with formation water, so when the deposits are sucked out through wells, the land sinks to fill the now-empty hole. This is especially noticeable where there are nearby faults.

The liquids exist in the voids of the sand and gravel beds that underlie much of the Gulf coast. When the liquids are removed the rocks shift and compact due to the weight of the soil above. The lowering of land surface elevation from this process is permanent. Pressurizing water sufficiently to "lift" thousands of feet of earth is not economically feasible. This effect is local in nature, generally affecting only a small geographical area.

Little is currently known about how to prevent or mitigate subsidence effects. Fluid re-injection can help, but its effectiveness depends on where the fluid is re-injected and the permeability conditions in the field. Typically, re-injection is done at some distance from the production well to avoid cooling the production fluid and may not help prevent subsidence.

The Mississippi River delta plain is subject to the highest rate of relative sea-level rise (>3 ft per century) of any region in the Nation largely due to rapid geologic subsidence. Subsidence impacts the socio-economic infrastructure of south Louisiana placing the communities and infrastructure at risk of being inundated by the rising sea.

Compounding the subsidence problem is the forecast that the world's oceans will rise over the next century due to global atmospheric warming. Together the rising sea and subsidence accelerate coastal erosion and wetland loss, increase flooding, and increase the extent and severity of storm impacts.

Impacts of Subsidence and Sea-Level Rise
The effect of subsidence on coastal environments of Louisiana varies from direct lowering of roads and levees to rapid degradation of marsh vegetation and soils. Land subsidence causes many problems including: (1) changes in elevation and slope of streams, canals, and drains; (2) damage to bridges, roads, railroads, storm drains, sanitary sewers, and levees; (3) damage to buildings; and (4) failure of well casings.

As the land subsides and the rate of sea-level rise increases, coastal marshes submerge and are transformed to open water exposing the more populated part of the state to the full effect of hurricanes. Levees are necessary to protect the developed areas from flooding, as in New Orleans.

Risk Assessment

Current pressures for balanced energy, land and water management, concerns about natural disasters, and protection of environmental quality demand scientific information. However, there are often no clear, unequivocal answers to land-use and environmental issues due to the uncertainties in the scientific information and the need to consider economic, political, social, and aesthetic values[1].

Geothermal resources can be over-produced as reported from *Renewable Energy Trends 2003 With Preliminary Data For 2003*, July 2004 (Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, U.S. Department of Energy, Washington, DC 20585).

> "Geothermal generation dropped 9 percent between 2002 and 2003. The majority of geothermal generation comes from 21 plants at The Geysers field in California, one of the largest geothermal fields in the world. <u>Production at The Geysers fell sharply about 10 years ago because of a decline in underground pressure</u> to produce steam. As a result, The Geysers, which have a total rated capacity of 1,650 megawatts (mw), are currently achieving (according to industry measurements) an average annual net capacity of only 862 mw.
>
> The Santa Rosa Geysers Recharge Project, which became operative in December 2003, is designed to enhance steam production and produce 85 mw of additional generating capacity from this field by pumping about 11 million gallons of tertiary-treated wastewater daily into The Geysers geothermal reservoir. The wastewater comes from the Santa Rosa regional sewage treatment plant and other cities through a 41-mile underground pipeline. The project also mitigates a major wastewater disposal problem. The project's final cost was just over $200 million or $2,400 per kilowatt."

Many areas of the world are using geopressured water for energy today, notably the Philippines, New Zealand, and Iceland. New Zealand has had significant problems with subsidence. California and Nevada utilize it extensively, but their resource is totally different being relatively shallow and mostly steam driven. They have had little problem with subsidence.

The above reference points out that extracting fluid from the earth has its consequences. Geothermal energy may not be as finite as oil and gas, but it has limits. The question is, "how much is it worth compared to the alternatives?"

We could produce a substantial quantity of energy, but the process accelerates the loss of coastal marshes. We could attempt to mitigate that loss by re-injecting the spent brine, but that will reduce the energy produced, and will eventually degrade the temperature of the resource. We could divert the Mississippi river to build up replacement soil in the marsh at a very high cost, both in money and in the ecology of the marsh.

In his master's thesis, Jeremy Griggs undertakes to evaluate the economics of geopressured reservoirs that exist in coastal Louisiana. With reasonable values for electricity and natural gas he presents a case for some locations to be good prospects, but he doesn't take subsidence into account over the long term. He also outlines areas that still need much work to make the investment more commercially viable. In general, if the site doesn't produce sufficient petroleum products to pay for the work, adding geothermal energy will not make the project economical[2].

Mr. Griggs states that areas needing more work include:

> **"5.4 The Future of Geothermal/Geopressured Brine Energy**
>
> The economic and technical constraints posed in this study delineate a potential range of conditions

where the development of geopressured aquifers may have commercial application. However, these factors also indicate that challenges remain before field development of geopressured aquifers can begin. Five groups emerge that warrant further investigation and could greatly enhance the value of the geopressured/geothermal resource:

1. Reservoir characterization and resource estimation. By refining estimates of rock compaction, shale-water influx, and diagenic (sic) history a more detailed analysis of aquifer drive mechanisms could be determined. The reactivation of the Wells of Opportunity program could refine estimates expected aquifer volumes and aid in quantitatively determining the effects of carbon dioxide and heavier hydrocarbons on methane solubility in brine.
2. Facility optimization and systems analysis. Detailed system analysis and facility optimization could decrease capital cost and operating expense while providing for more efficient extraction of methane. Accurate temperature, flow rate, and facility coupling could provide "fit-for purpose" equipment and significantly reduce expense.
3. High efficiency binary-cycle power plants. Further investigation of Kalina-cycle power plants could provide for a cheap, yet highly efficient, means of extracting thermal energy from geopressured brine… .
4. Detailed economic analysis. Accurate estimation of facility and power plant expense, along with more detailed estimates of drilling cost may provide a more economic opportunity. Commercial potential of geopressured aquifers could increase with the inclusion of dry-hole risk, well replacement cost, and the likely-hood of different development.
5. Legal and political difficulties. The aerial (sic) extent of potentially commercial geopressured aquifers is likely to be in excess of 10 sq. mi. and small acreage landowners could derail the development of this energy source. Mineral law case history is vague concerning the ownership of sub-surface brine [86]. The renewal of federal tax credits and the implementation of severance tax relief and federal loan guarantees could provide significant economic incentive to develop geopressured aquifers ([86] Harrell, T.A.: *Legal Impediments to Geopressured Development – Current Concerns*, in Proceedings, 5th Geopressured-Geothermal Energy Conference, held in Baton Rouge, LA. October 13-15, 1981)."

If energy becomes valuable enough, it is certain that this resource will be exploited. The repercussions of such use will have to be weighed against the need and a decision made. Many east coast states have resources that are less expensive to tap into and have less drastic consequences, but they refuse to tap into them at this time.

Additional information on Geothermal energy and how it works can be found at the Renewable Energy Policy Project (REPP) website (URL: http://www.repp.org/geothermal/index.html), Chapter 1- Introduction, *Geothermal Energy for Electric Power: A REPP Issue Brief*, December 2003, by Masashi Shibaki, Fredric Beck, Executive Editor, Renewable Energy Policy Project; 1612 K St. NW, Suite 202; Washington, DC 20006.

Additional information on the Kalina Cycle Power Plant can be found at URL: http://www.exergy.se/ftp/kalina.pdf
Exergy Study of the Kalina Cycle, presented at the 1989 American Society of Mechanical Engineers (ASME), Winter Annual Meeting, San Francisco, California December 10-15, 1989.

References

1. Kindinger, Jack L., *Subsidence and Sea-Level Rise in Southeastern Louisiana: Implications for Coastal Management and Restoration*, U.S. Geological Survey.

2. *A Re-Evaluation Of Geopressured Geothermal Aquifers As An Energy Resource*. A thesis submitted to the Graduate Faculty of The Craft and Hawkins Department of Petroleum Engineering of Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Science in Petroleum Engineering by Jeremy Griggs, Louisiana State University, August 2004.