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Questions to Consider Before Starting a Geothermal Venture



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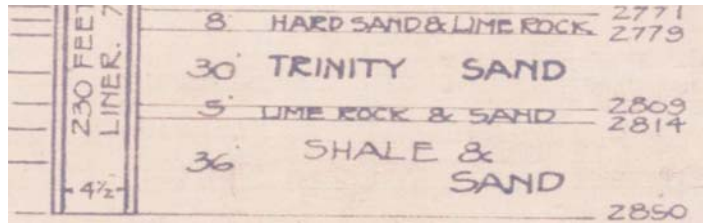
Executive Summary

The mission of the **SMU Geothermal Laboratory** is to promote and encourage research, education, and investment in the field of geothermal energy.

The purpose of this document is to give those interested in developing geothermal resources and undertaking business ventures in the geothermal field an aid in the form of a basic checklist of things that should be considered when engaging in such a venture, in order to increase the probability of project success.

In any geothermal project there are four main areas that need to be considered in order to evaluate the potential success of the project. In the following pages we will expand on the specific questions that should be answered in the various analyses necessary for developing a geothermal project. These areas include:

- | | | |
|------|-------------|---|
| i. | Geologic | <i>Does the resource exist?</i> |
| ii. | Legal | <i>Can the resource be legally harnessed?</i> |
| iii. | Engineering | <i>Can the resource be efficiently harnessed?</i> |
| iv. | Financial | <i>Can the project be financed?</i> |



Geologic Investigation

“Does the resource exist?” This is the starting block for any geothermal venture, simply because you need to identify a geothermal resource and its characteristics before you can develop it.

What is the geology of the area?

- Geologic structure of the area
- Stratigraphic column and cross sections
- Are any local well logs available?
- Is seismic information available?
- Is a chemical analysis of the fluids available?

Does the geothermal resource exist?

- Where, at what depth, in what formation?
- What is the temperature, pressure, formation thickness, and flow rate of the resource?
- What is the estimated size and producing potential of the formation?
- Do you expect natural gas to be saturated in brine? If so what is the gas/brine ratio?
- Is it saturated, super saturated? What portion of the gas do you expect to extract?

Are there geological risks involved?

- Seismic, karsting, fault, or other geologic factors that may present a risk to wells and production.
- What is the produced water chemistry, i.e., amount of total dissolved solids, pH, mineral content?
- What is the likelihood of cooling the formation?
- Would field “rotation” help to mitigate cooling?

Is the resource sustainable on a long term basis?

- Does the resource replenish itself naturally, or is injection into the original formation necessary?
- Where should an injection well be located as to not thermally impact the reservoir?
- How long is the reservoir expected to sustain production rates, 10, 20, 30, 100 years?

Where will the produced fluids be dispensed?

- Into what ground formation?
- At what depth will the fluid be reinjected?
- What is the chemistry of the formation that is being injected into?
- What is the risk posed by production fluid chemistry?
- What’s the size of the disposing formation?
- Are there geological risks related to disposing into this formation?
- Can the spent fluids be used for secondary recovery?

Will coproduction of hydrocarbons and geothermal fluids from the same well occur?

- Is there oil, gas, or both in the production formation?

Legal Investigation

“Can the resource be legally harnessed?” Legal issues often become some of the greatest obstacles in the development of many geothermal ventures. A thorough legal analysis will clearly identify potential issues with the site, amount of power produced, or other issues that could pose serious threats to the project. In the United States, the highest quality geothermal fields, such as in Yellowstone, are closed to all development.

What are the governing bodies of the area?

- Federal, State, Local
- Geologic (Ex. Texas Railroad Commission)
- Environmental (Ex. EPA)
- Utility companies?
- Lobbyists, etc.

Is the resource in an area that can be developed?

- What state, county, city permits are needed?
- Can you drill/inject in this area?
- What zoning laws exist that threaten the project? Noise bans, visible emission bans, aesthetic rules and regulations?
- What protocols are required in order to legally produce and sell power in your area?
- What is the interconnectivity charge to load your power onto the grid?

How do you get the rights to the resource?

- It is important to note that in the state of
- Texas geothermal waters are considered a “mineral” and are subject to Texas mineral laws.
- Who owns the mineral rights?
- Who owns the surface land rights?
- How much will it cost to get the rights?

What environmental rules exist that could benefit/ threaten your project?

- Do any tax credits, stimulus packages, or other incentives exist that your project could benefit from?
- What environmental protocols exist regarding drilling and fluid reinjection?
- What environmental protocols exist regarding emissions? (Note that Texas’ geothermal resources are most efficiently harnessed by binary power plants, which give off no emissions.)

What hydrocarbon rules exist that could impact your project?

- Are there any tax benefits from producing both hydrocarbons and geothermal energy from the same well site? (Such as the Texas House Bill 4433.)



Engineering Investigation

“Can the resource be efficiently harnessed?” Once the geologic resource is well understood, it becomes essential to find the most efficient way of harnessing its full potential in order to maximize plant output as well as financial gain.

What type of plant design and system is best suited for harnessing the resource?

- Dry steam, flash steam, or binary plant?
- Will the temperature, pressure, and fluid flow rate of my reservoir be able to support one of these plants?
- Can absorption chillers or geexchange units be incorporated?
- What diameter wells/ pipes do I need to produce my desired amount of energy?
- How many wells do I need to obtain my desired fluid flow rate to maximize power plant output?
- What insulation is needed in order to most efficiently transport the heat?
- What material should my casing/ pipes be made of to avoid corrosion, scaling, or other impurity related issues?

To what extent is reservoir engineering required in your resource?

- Do you need to fracture the formation in order increase production?
- Does your reservoir require fluid injection such as an enhanced geothermal system (EGS)?

What working fluids will be involved in the plant operations?

- What refrigerants will be using in the binary systems?
- How much cooling fluid is needed and where will it come from?
- In the wells, pipes, and plant systems, what chemicals will be used to eliminate issues of scaling?

What systems will be required to run the plant?

- What electrical, computer, etc. systems are required in order to run the plant at its highest efficiency?
- What personnel will be needed to run the plant?
- What backup/ emergency systems will be installed in the case of a malfunction?
- What parameters will be collected on a regular basis?

How will I transport the energy from the plant to the desired market?

- What infrastructure is available to do this?
- Where is the closest utility transfer station?



Financial Investigation

“Can the project be financed?” Answering this question will be the true make or break of any business venture. If the numbers don’t make sense, then the project won’t make sense. Even in the case of green energy projects, there is no exception.

Opportunity Analysis

- Who will you sell the energy to?
- What is the most profitable target market for your power generation— selling to the grid, distributed energy, coproduction, a combination of each?
- If gas is produced, will it be sold to a pipeline, used in a fuel cell, or in a turbine?
- How much energy is needed to satisfy the site demand?
- What are the resources already available?
- How can I maximize my profit from these resources?
- Can a Power Purchase Agreement be secured? At what price, for how many years?
- Who is the competition?
- What is the price to beat of the competitor?
- How will this project be financed (debt/equity)?
- What is the source of capital?
- What is the cost of capital?
- What financial risks are associated with the project?
- Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis is recommended.
- What is the anticipated performance of the plant?
- Note, that for coproduced systems these questions need to be addressed for both the geothermal and hydrocarbon production.

Profit Analysis

- What is the estimated Cost of Capital for the project?
- Where will the funding from the project come from?
- What is the Net Present Value for the Project?
- What is the Future Value of the investment?
- What is the Required Rate of Return for the project?
- What discount rate is being used to account for risk.
- How many years does the project need to be in production to produce the required rate of return?
- How dependent are the estimates based on commodity prices.
- What is the effect of raising or lowering commodity prices?
- Are there government incentives or subsidies that may affect the outcome of these calculations?
- What is the potential for “cap and trade”/ carbon-credit earnings for this project, and how does this effect the calculations?
- Note that given a coproduction site, include the earnings from hydrocarbons should be included in the calculations.
- How much do I expect to make from the project?
- What is the projected timeline for the project?
- What are the risks associated with not being on schedule? Expenses, legal ramifications, etc.
- Given the calculations, the expected budget, and the potential payback, does the project make financial sense?

Financial Investigation, cont.

Cost Analysis

What are the exploration and development costs?

- Seismic surveys, well logs and data, geologic analysis, chemical analysis of geothermal fluids, etc.
- Short and long term flow tests, disposal and/or reinjection tests
- What are the drilling costs? What are the costs for the drill rig, well fracturing, personnel, casing, etc.?
- Is it possible to recomplete an existing well?
- What is the cost to recomplete a well?
- What is the estimated lifespan of a well?
- Production well (new): drilling costs, casing costs, emplacement of the wellhead, preparing the site for power plant installation.
- Production well (existing): work-over costs of well, perforation of casing, formation fracturing.
- Injection well designed and drilled to necessary depth, casing, injection pump, etc.
- What are the development costs for infrastructure on and off site?

What are the legal costs?

- Legal costs associated with zoning, siting, drilling permits and mineral right procurement.
- Legal costs associated with rules and regulations of how to properly case and prepare a well for production use.
- What are the permitting costs and procedures? (In Texas see Oil & Gas Permits from the Rail Road Commission Website

<http://www.rrc.state.tx.us/licenses/og/index.php>

- Purchase (or design and manufacturing) of the power plant, shipping, and installment costs.
- Connection of pipes to other necessary infrastructure to the plant (separator, injection well, rock muffler, etc.).
- What are the installation costs related to equipment, transmission wires and cables, cost of machinery, and personnel to install and test run the plant.
- Connection to gas pipeline. Will the gas need to be cleaned or pressurized to meet pipeline requirements.
- What are the production costs?
- Taxes and interconnection tariffs cost of day-to-day plant operation, obtaining personnel, operational research to make the plant most efficient, etc.
- What are the operation and maintenance costs associated with running the plant?
- Costs of routine yearly maintenance and monitoring, chemicals for injection and to prevent scaling and corrosion?
- What is the total budget for fully developing the resource, completing project, and running it over a specific time frame.



US and Texas Contacts

Non-profits Groups Assisting Renewable Development

Geothermal Energy Association

Karl Gawell
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karl@geo-energy.org
www.geo-energy.org
P: 202-454-5264

Geothermal Resource Council

Curt Robinson
P.O. Box 1350
Davis, CA 95617
crobinson@geothermal.org
www.geothermal.org
P: 530-758-2360

Research Partnership to Secure Energy for America (RPSEA)

Michael Ming
1650 Highway 6, Suite 300
Sugar Land, TX 77478
mming@rpsea.org
<http://rpsea.org>
P: 281-313-9555

Texas Renewables Energy Industries Association (TREIA)

Russell Smith
P.O. Box 16469
Austin, TX 78761
rsmith@treia.org
www.treia.org
P: 512-345-6469

Texas Renewable Energy Education Consortium

Sidney Bolfing
3801 Campus Drive
Waco, TX 76705
sidney.bolfing@tstc.edu
www.treec.org
P: 254-867-3206

State Agencies Assisting Renewable Development

Rural Alliance of Renewable Energy (RARE)

Travis Brown
1700 N. Congress Ave. Suite 22
Austin, TX 78701
tbrown@orca.state.us
www.infinitepower.com/rare
P: 512-936-7878

State Energy Conservation Office (SECO)

Dub Taylor
LBJ State Office Building
111 East 17th St., Room 114
Austin, TX 78701
dubtaylor@cpa.state.tx.us
P: 512-463-1931
www.infinitepower.com

Texas Railroad Commission

1701 N. Congress
P.O. Box 12967
Austin, TX 78711
<http://www.rrc.state.tx.us/about/divisions/index.php>
<http://www.rrc.state.tx.us/contact/RRCphonedirectory.pdf>

Drilling Permits for Oil/Gas wells

Lorenzo Garzo
P: 512-463-6751
drillingpermits-info@rrc.state.tx.us

Injection Well Permits

Doug Johnson
P: 512-463-6792
ac@tceq.state.tx.us



***Companies with
Technology Related to
Geothermal Power
Plants***

Pratt & Whitney Power Systems

Michael Ronzello
400 Main Street
East Hartford, CT 06108
michael.ronzello@pw.utc.com
www.pw.utc.com
P: 860-727-2465

ORMAT Technologies, Inc.

Paul Thomsen
6225 Neil Road
Reno, NV 89511
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www.ormat.com
P: 775-356-9029

ElectraTherm Inc.

Richard Langson
3208 Goni Road
Carson City, NV 89706
info@electratherm.com
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P: 775-882-6680

Gulf Coast Green Energy

Loy Snearly
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Bay City, TX 77414
loys@sbcglobal.net
www.gulfcoastgreenenergy.com
P: 888-448-2112

Deluge, Inc.

Brian Hageman
8765 E. Bell Road, Suite 210
Scottsdale, AZ 85260
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www.delugeinc.com
P: 602-431-0566

***Engineering Power
Plant Design***

Power Engineers

3940 Glenbrook Drive
P.O. Box 1066
Hailey, ID 83333
www.powereng.com
P: 208-788-3456

Telios Corporation

Shannon McCall
3535 Travis St., Suite 115
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smccall@teliospc.com
www.teliospc.com
P: 214-774-6199

Reservoir Engineering

GeothermEX

Subir Sanyal
3260 Blume Drive, Suite 220
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www.geothermex.com
P: 510-527-9876

Consultants

Erdlac Energy Consulting

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Midland, TX 79703
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Good Company Associates

Robert King
816 Congress Avenue, Suite
1400
Austin, TX 78701
rking@goodcompanyassociates.com
www.goodcompanyassociates.com
512-279-0751

Geologic Data

**UT Bureau of Economic
Geology**

Daniel Ortuna
Well Log Library
10100 Burnet Road
Austin, TX 78758
daniel.ortuno@beg.utexas.edu
P: 512-471-7139
<http://www.beg.utexas.edu>

IHS Energy

888-645-3282 or 713-840-8282
<http://energy.ihs.com/index.htm>

Drillinginfo, Inc.

P.O. Box 5545
Austin, TX 78763
Sales: 888-477-7667 ext. 1
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<http://www.info.drillinginfo.com>

***For more contacts and
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