

Appendix 2

Feasibility Checklist for Montana Geothermal Electricity Generation

There are four areas to consider when evaluating the potential success of an electrical power generation project using Montana's geothermal resources:

- 1. Geologic Issues – Does the resource exist?**
- 2. Legal Issues – Can the resource be legally harnessed?**
- 3. Engineering Issues – Can the resource be efficiently harnessed?**
- 4. Financial Issues – Can the project be financed? Does it make sense economically?**

These four areas are discussed in detail below:

1. Geologic Issues — Does the Geothermal Resource Exist?

This is the starting block for any Montana 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?
- ✓ Are any local well logs available?
- ✓ Is seismic information available?
- ✓ Is a chemical analysis of the fluids available?
- ✓ What is the current knowledge of the geothermal resource?
- ✓ Where is the geothermal resource, at what depth, in what geologic 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?
- ✓ Are there geological risks involved?
- ✓ Seismic 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, and mineral content?
- ✓ What is the likelihood of cooling the formation when it is pumped?
- ✓ Is the geothermal 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?
- ✓ 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?
- ✓ Have you reviewed all relevant geologic and water resource records from Montana agencies, including DEQ, MBMG, and DNRC?

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2. Legal Issues — Can the Geothermal 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 National Park, are closed to all development.

- ✓ Is the resource in an area that can be developed?
- ✓ What Montana state, county, and city permits are needed?
- ✓ Can you drill/inject in this area?
- ✓ What zoning laws exist that could impact the project?
 - noise bans,
 - visible emission bans,
 - aesthetic rules and regulations?
- ✓ What are the governing bodies of the area?
 - Federal, tribal, Montana, local
 - Utility company service territories
- ✓ 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?
- ✓ 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 or threaten your project?
- ✓ Do any tax credits, stimulus packages, or other incentives exist that your project could benefit from?
- ✓ What are the environmental laws regarding drilling and fluid reinjection?
- ✓ What are the environmental laws regarding air emissions?
- ✓ What hydrocarbon rules exist that could impact your project?

3. Engineering Issues — Can the Resource be Efficiently Harnessed?

Once your chosen geothermal resource in Montana is well understood, you need to find the most efficient way of harnessing its full potential in order to maximize power plant output as well as economic return.

- ✓ What type of plant design and system is best suited for harnessing the resource?
(Dry steam, flash steam, or binary power generation plant?)
- ✓ Will the temperature, pressure, and fluid flow rate of my reservoir be able to support one of these plants?
- ✓ What diameter wells and 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 to increase production?
- ✓ What working fluids will be involved in the plant operations (including refrigerant fluids if using a binary turbine system)?

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3. Engineering Issues — Can the Resource be Efficiently Harnessed? – continued

- ✓ 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 electrical, computer, and other 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?
- ✓ How will I transport the energy from the plant to the desired market?
- ✓ Where is the closest utility transfer station?

4. Financial Issues — Can the Project be Financed?

Answering this question will be the true “make or break” test of your Montana geothermal power generation venture. If the budget numbers don’t make sense, then the geothermal project won’t make sense.

Opportunity Analysis

- ✓ Who is going to buy your energy?
- ✓ What is the most profitable target market for the generated power: selling to the grid, distributed energy, coproduction, a combination?
- ✓ If gas or oil is produced in a coproduced well, will it be sold to a pipeline, used in a fuel cell, or used in a turbine?
- ✓ How much energy is needed to satisfy the energy needs of the binary generator?
- ✓ Can a Power Purchase Agreement be secured? At what price, for how long?
- ✓ 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?
- ✓ What is the anticipated plant performance?

Profit Analysis

- ✓ What is the estimated Cost of Capital?
- ✓ Where will the funding come from?
- ✓ What is the Net Present Value?
- ✓ What is the Future Value?
- ✓ What is the Required Rate of Return?
- ✓ What discount rate is 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 that may affect the calculations?
- ✓ How much do I expect to make from the project?
- ✓ What is the project timeline?
- ✓ What are the risks associated with not being on schedule?
- ✓ Given the calculations, the expected budget, and the potential payback, does the project make financial sense?
- ✓ Is there a potential for “cap and trade”/carbon-credit earnings for this project?
- ✓ Can you include the earnings from oil/gas sales if using geothermal energy from existing oil/gas wells?

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4. Financial Issues — Can the Project be Financed? – continued

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.?
- ✓ Can you recomplete an existing well?
- ✓ What is the cost to recomplete a well?
- ✓ What is the lifespan of a well?
- ✓ New production well: drilling costs, casing costs, emplacement of the wellhead, preparing the site for power plant installation.
- ✓ Existing production well: 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 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?

What are the development costs for infrastructure on and off site?

- ✓ 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, sound muffler, etc).
- ✓ What are the installation costs for equipment, transmission wires and cables, cost of machinery, and personnel to install and test run the plant?

What are the production costs?

- ✓ Taxes and interconnection tariffs?
- ✓ Cost of day-to-day plant operation, obtaining personnel?
- ✓ 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 the project, and running it over a specific time frame.

Adapted from “Questions to Consider Before Starting a Geothermal Venture,” by Maria Richards, Southern Methodist University, 2009. www.smu.edu/geothermal