DEVELOPMENT OF GEOTHERMAL DIRECT-USE PROJECTS

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INTRODUCTION

- Direct-use geothermal provides heat and/or cooling to buildings, greenhouses, aquaculture ponds and industrial processes.
- Need to match the resource with the needs of the user to be successful.
- Each project is unique!!!
- Each project needs a “hero” or “champion”!!!
INTRODUCTION 2

• Development of a project should be approached in phases to minimize risk.
• Size of the project determines the amount of exploration and development that can be economically justified.
• For a single home – the risk is high with minimum information economically obtained.
• Larger projects can justify more investigations and resource characterization, thus reducing the risk (i.e. district heating and industrial applications) - feasibility study appropriate.
Proposed well

Levels of exploration and reservoir confirmation
INTRODUCTION 3

• PROJECT PHASES:
  – What do you know about the resource??
  – Determine the market or use, and if economically feasible
  – Identifying and securing rights to the resource
  – Permitting, financing and environmental impact
  – Exploration (geology, geochemistry, geophysics, drilling & reservoir engineering)
  – Preliminary and conceptual design of the direct-use projects during exploration
  – Once resource is known – Final design
    • Equipment selection
    • Costs including O&M
  – Construction and operation
SELECTING THE USE

• “I have this resource, what do I do with it?”
• Answer:
  – What is the temperature and flow rate?
  – What is the chemistry of the resource?
  – What are the potential markets and income?
  – Do you have the experience or can you hire it?
  – Do you have the financing – ROI ok?
  – Do you own or can you lease the resource?
Geothermal Energy Uses

Typical uses of geothermal energy at different temperatures:

- **700°F (371°C)**: Flash & Dry Steam Geothermal Power Plants, Hydrogen Production & Minerals Recovery
- **400°F (204°C)**: Geothermal Power Plants
- **350°F (177°C)**: Geothermal Power Plants
- **300°F (149°C)**: Geothermal Power Plants
- **250°F (121°C)**: Geothermal Power Plants
- **200°F (93°C)**: Geothermal Power Plants
- **150°F (66°C)**: Geothermal Power Plants
- **100°F (38°C)**: Geothermal Power Plants
- **70°F (21°C)**: Geothermal Power Plants
- **60°F (16°C)**: Geothermal Power Plants
- **50°F (10°C)**: Geothermal Power Plants

- **40°F (4°C)**: Geothermal Power Plants

*Geothermal activity can produce renewable hydrogen.

**Cold water is added to make the temperature just right for the fish.

Courtesy of the Geothermal Education Office
SPAS AND POOLS

• Use of low temperature resource $<$140°F
• Temperature and mineral content important
• Drinking the water and using muds important
• $<$85°F for pools and $<$110°F for spa water
• Water used directly desirable – flow through
• May need to be treated (chlorine)
• Secondary water heated through HE
• Mixing required with higher temperature resource
• Covered and uncovered
SPACE AND DISTRICT HEATING

• Heating (and cooling) of individual buildings or a group of buildings
• District heating requires a high thermal load density >0.7 MMBtu/hr/acre or a favorability ratio of 1.5 MMBtu/acre/yr most favorable.
• Peaking with fossil fuel often economically viable as geothermal can provide 50% of the load 80 to 90% of the time.
• However, district heating is capital intensive – especially the distribution network – 35 to 75%
• Typical savings of 30 to 50% compared to NG
Meeting peak demand with fossil fuel
Klamath Falls district heating system
GREENHOUSES

- A variety of crops can be raised: vegetables, flowers, house plants, trees
- Various heating systems can be used
- Geothermal reduces costs and allows operation in colder climates
- Temperate climate zone: 100 Btu/ft$^2$/hr
- 5 acre facility: 22 MMBtu/hr (6.5 MWt) peak
- Annual requirement with LF of 0.50 =100 billion Btu/yr (28 million kWh/yr)
Greenhouse heating systems
• Raising catfish, bass, tilapia, shrimp and tropical fish and even alligators
• Temperature of water from 55 to 90°F
• Increase growth rate by 50 to 100%
• Water quality and disease control important when using the geothermal water directly
• Outdoor pond in temperate climate zone:
  – 250 Btu/hr/ft²
  – 5 acre facility: 50 MMBtu/hr (15 MWt) peak
  – With LF of 0.60 = 260 billion Btu/yr (77 million kWh/yr)
Typical aquaculture facilities
INDUSTRIAL

• Generally require higher temperatures as compared to space heating - >200ºF.
• Drying of timber, extracting minerals, and dehydration of vegetables and fruit are important.
• They also tend to have high load factors in the range of 0.4 to 0.7 – which reduce the unit cost of energy.
Industrial applications
Cost of Energy

After Rafferty, 2003
SELECTING THE EQUIPMENT

• Geothermal fluids often must be isolated to prevent corrosion and scaling
• Normally need a plate HE to isolate the fluid
• Care to prevent oxygen from entering the system
• Dissolved gases and species such as boron and arsenic can be harmful to plants and fish.
• Hydrogensulfied attacks copper and solder.
• Carbon dioxide can be used in greenhouses.
• Peaking or backup fossil fuel plants often used
Typical direct-use system equipment
Downhole pumps – line shaft and submersible
Geothermal piping systems
Nesjavellir to Reykjavik pipeline
29 km long – 80 – 90 cm diameter
560 L/s – seven hours - <2°C loss
HEAT EXCHANGERS

Plate type HE
CONVECTORS

Room heat convectors
TEMPERATURE REQUIREMENTS

- Two primary temperature differences govern feasibility, flow requirements and design of direct-use equipment
  - (1) Difference ($\Delta T$) between entering geothermal temperature and the process
    - Temperature of the entering geothermal must be sufficiently above the process temperature to be reasonable to size heat transfer equipment
    - The greater the $\Delta T$ the lower the cost of the heat exchange equipment.
  - (2) Difference ($\Delta T$) between the entering and leaving geothermal
    - which determines the flow rate
    - The greater the $\Delta T$ the lower the required flow rate
- “Rules of Thumb” developed (Rafferty, 2004)
Fundamental direct-use temperature differences
(from Rafferty, 2004)
Flow requirement proportional to $T_{ge} - T_{go}$

- At 105°F, flow = 2x
- At 95°F, flow = 4x
- At 90°F, flow = 8x

Direct pools and aquaculture pond heating
(from Rafferty, 2004)
CONCLUSIONS

• Many possible direct-uses of geothermal fluids
• Number of parameters will limit choices:
  – Temperature, flow rate, chemistry and land availability
  – Market available, and do you have the expertise to provide the product (i.e. heat and/or flowers/fish, etc.)
  – Can you get the product to the user economically – (i.e. pipelines or truck/rail/airline transportation)
  – Availability of capital, income and ROI/payback
  – Can you attract investors (i.e. minimize the risk)
• Alternative to consider – combined heat and power project – to better utilize the resource and help the bottom line
Combined heat and power project example
Thank you