Novel Energy Conversion Equipment for Low Temperature Geothermal Resources

April 22, 2013
Overview

Timeline:
This project was awarded on April 30, 2010. Manufacturing of both prototype units is complete. Shipment to OIT is planned for summer 2013 (due to delays outside of DOE scope).

Budget
Total Project Cost: $2,172,423
DOE Share: $1,047,714
>90% Spent as of 3/2013
Overview

Barriers
High cost of electricity generation reduces utilization of low-temperature geothermal resources

Partners
Barber-Nichols, Inc., Oregon Institute of Technology
Objective

• Develop equipment that generates electricity from low temperature geothermal resources at a cost at least 20% below that of the currently available technology.

Geothermal Program Goal:

• “Develop low-cost, high efficiency energy conversion technologies for EGS”

Planned Research Results:

(1) better working fluids and
(2) improved cycle heat management.
Scientific/Technical Approach

• Johnson Controls leverages decades of experience in developing and manufacturing commercial chiller equipment to identify and implement the equipment modifications required to generate electricity.

• Our partners contribute specialized expertise (e.g. Barber Nichols for turbine development)
Progress:
Manufacturing of both prototype units has been completed.

Expected Outcome:
Commercial product that can generate electricity from low-temperature geothermal resources at costs 20% below the current state of the art.

Accomplishments:
• Modeling results show achievement of 20% improvement goal. Lab testing exceeded modeled results.
• Research resulted in novel series-counterflow configuration of managing cooling water and brine flow with substantial gains in efficiency (patent pending).
Series- Counterflow Configuration:

ORC Power Generation System: Series Arrangement

MAKE-UP WELL

CONDENSER

EVAPORATOR

HEAT SOURCE WELL

TGU

GEN

FEED PUMP

PRE-HEATER

REINJECTION WELL

COOLING TOWER

Make-Up Water PUMP

Cooling Tower PUMP

Heat Source PUMP
Series-Counterflow Benefit:

Net Efficiency Gain despite small increase in pump power!
Deployment Strategy:
If successful, the results of this R&D effort can easily be commercialized utilizing Johnson Controls’ existing sales, project development, operations and maintenance organizations.
Research objectives are being met. No major obstacles anticipated for future development of prototype. Interconnection application submitted by OIT February 2012.

<table>
<thead>
<tr>
<th>FY2011</th>
<th>FY2012</th>
<th>FY2013</th>
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<tbody>
<tr>
<td>Target/Milestone</td>
<td>Go/No-Go Decision</td>
<td>Complete Final Design</td>
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<tr>
<td>Results</td>
<td>Go decision in 2011</td>
<td>Completed in 2011</td>
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### Timeline:

<table>
<thead>
<tr>
<th></th>
<th>Planned Start Date</th>
<th>Planned End Date</th>
<th>Actual Start Date</th>
<th>Actual /Est. End Date</th>
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### Budget:

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<th></th>
<th>Federal Share</th>
<th>Cost Share</th>
<th>Planned Expenses to Date</th>
<th>Actual Expenses to Date</th>
<th>Value of Work Completed to Date</th>
<th>Funding needed to Complete Work</th>
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Delay: Installation site at partner organization not yet ready. Two year data collection phase will start once the prototypes are put into service (Fall 2013).