

Systems for Electrical Power from Coproducted and Low Temperature Geothermal Resources

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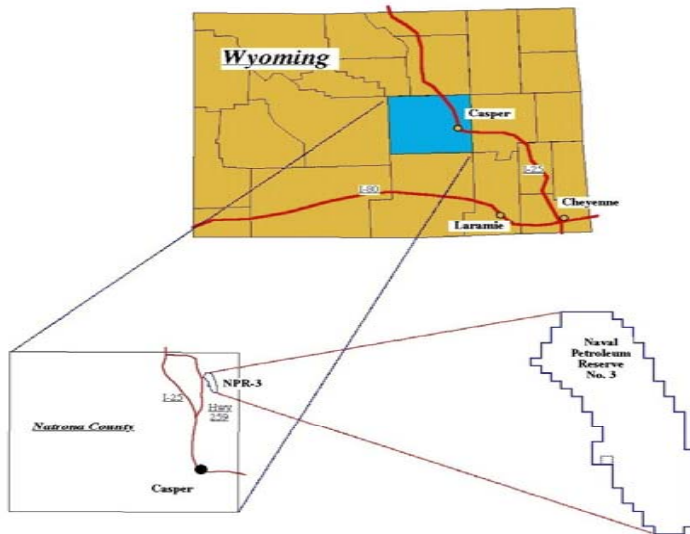
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- Background
- Results and Discussion
- Future Plans
- Conclusion

Background: Field History



- Initial unit installed in September of 2008
 - Phase I from Sept. 2008 – Mar. 2009
 - Phase II from Sept. 2009 - Present

Geothermal Technologies Program (GTP) Goals

- Develop innovative geothermal energy technologies to find, access, and use the Nation's geothermal resources
- Through research, development, and demonstration efforts, GTP is working to provide the United States with an abundant, clean, renewable energy source
- GTP works in partnership with industry, other government agencies, academia, and DOE's national laboratories to establish geothermal energy as an economically competitive contributor to the U.S. energy supply
- In pursuit of these goals, the program has partnered with the Rocky Mountain Oilfield Testing Center (RMOTC) and the National Renewable Energy Laboratory (NREL) to demonstrate technically feasible and economically viable geothermal energy production from oil and gas wells at the RMOTC test site

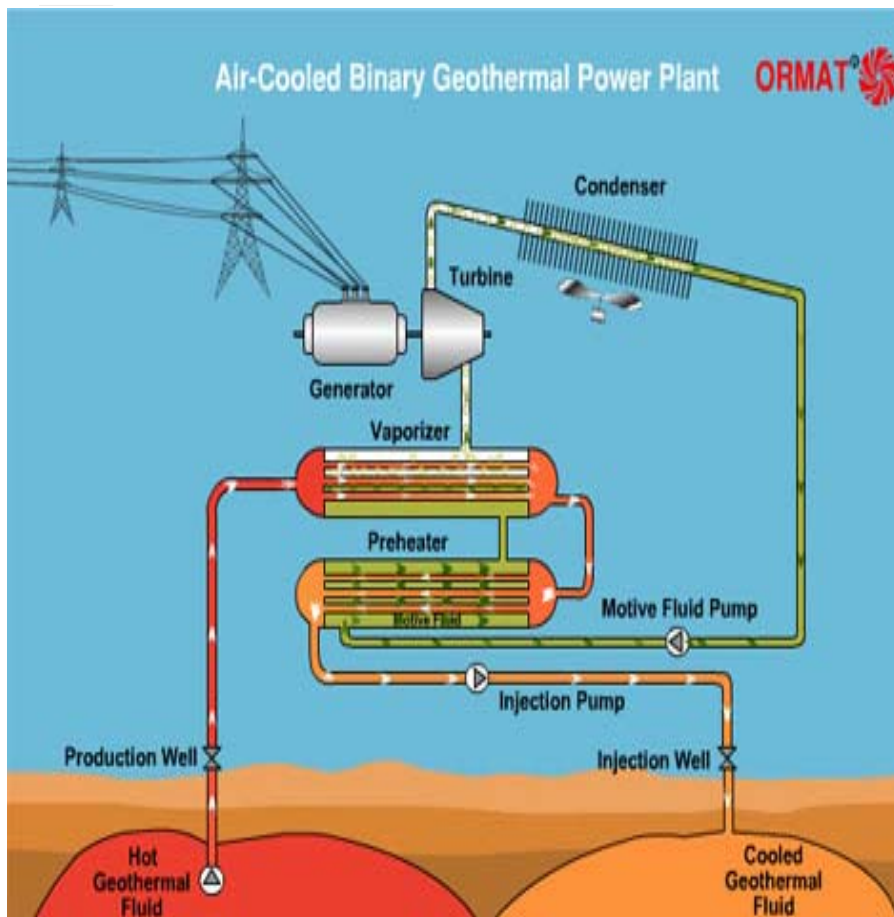
Background: Rocky Mountain Oilfield Testing Center's Role

- DOE's Rocky Mountain Oilfield Testing Center (RMOTC) and GTP developed a program to test power generation from oil field waste streams
- Collaborative agreement between RMOTC and GTP to extend and expand testing of geothermal systems



- RMOTC will maintain operability of unit(s) and collect relevant performance data from the demonstration(s)

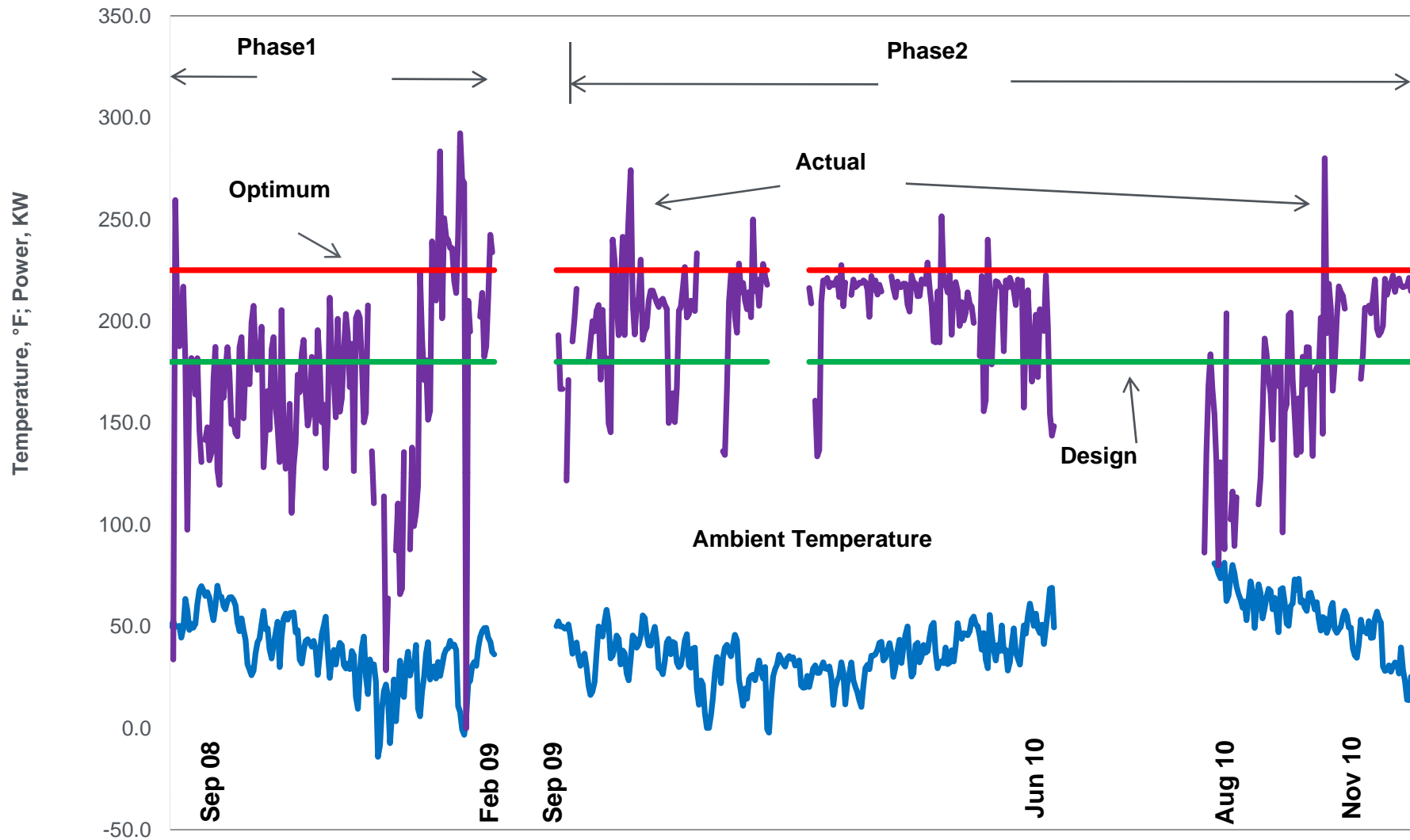




NREL's Role in the GTP

- Advance the geothermal industry through technical analysis, technical guidance, innovation and information dissemination
- Help DOE evaluate new geothermal technologies and address challenges facing these technologies
- Coproduction challenges being addressed:
 - Increase net power
 - Cooling innovations to reduce water use and increase net power during summer

Results and Discussion



Results and Discussion

	<u>Design</u>	<u>Operational Results</u>	
		Phase 1	Phase 2
Flow rate, bpd	40,000	12,000 to 40,000	11,000 to 50,000
Total hot water used, bbl		3,047,192	7,860,737
Inlet water temperature, °F	170	195 to 198	196 to 198
Outlet water temperature, °F	152	80 to 170	47 to 150
Average ambient temp., °F	50	-7 to 85	-2 to 81
Generator gross power, kW	180	105 to 305	105 to 300
Daily avg. net power output, kW	132	80 to 280	80 to 275
Overall avg. net power, kW		171	185
Total power produced, MWhr		586	1,332

- Phase 2 has produced over 1,332 megawatt hours of power from 7.8 million barrels of coproduced hot water
- Total produced power from the unit is 1,918 megawatt hours of power from 10.9 million barrels of coproduced hot water
- Online percentage for the unit, eliminating downtime caused by field activities, has been a 97%

Results and Discussion

Project Rationale:

- Numerous resources too cool for flash steam generation
- An estimated 10 barrels of water are produced per barrel of oil in North America
- Facilities have lower cost, shorter lead time, broader geographic distribution than conventional geothermal

Subprogram Objective:

- Demonstrate production from oil and gas fields, geopressedured fields, and low temperature resources across the U.S.

Additional Funding Actions:

- Up to \$18.7M in American Recovery and Reinvestment (ARRA) funds for 10 near-term energy projects including new hybrid plants, and speedy modular plant designs and up to \$20 M in available funding for seven energy projects with FY10&11 funds



- GTP's, RMOTC's and NREL's activities will provide information and understanding necessary to create new and more efficient and reliable technologies and to enable the U.S. geothermal industry to compete for base-load electricity generation
 - In light of this more promising climate for low temperature geothermal development, the present collaboration takes on an even greater importance
- Results demonstrate that significant results can be achieved over a short time-span and with relatively modest funding
- Further data collection and analysis, particularly after commissioning of the second unit, will provide invaluable knowledge to the geothermal community



Future site of second unit

- RMOTC will continue to operate the unit for an addition two years under the collaborative agreement
- A second power generation unit of the same nominal generation capacity but water cooled will be installed and tested for three years
- This period of performance will provide operational data and experience to transfer to potential users for both air and water cooled systems in both an oil field and low temperature geothermal settings
- During this time, RMOTC will be operating a test facility for smaller geothermal systems and developing plans for EGS applications and testing

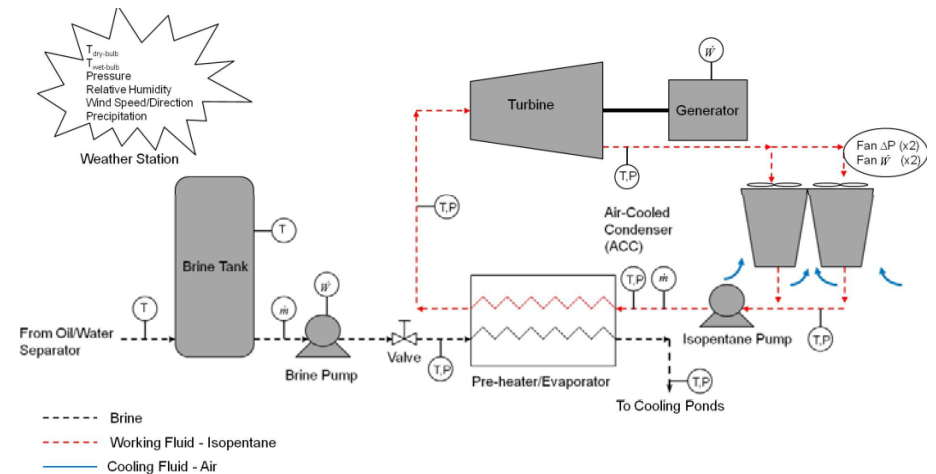
GTP's Low Temperature and Coproduced subprogram will work to achieve its low temperature power production goals thru a coordinated effort with RMOTC and NREL staff

- Program will provide funding for continued testing of program related geothermal activities at the site
- Future Financial Opportunity Announcements (FOAs) may become available to help companies implement unit testing at the facility
- Subprogram will provide guidance and oversight on all projects, and seek to discover and employ innovative concepts and ideas at the RMOTC test site, specifically those related to system improvements

Future Plans

Data Collection and Information Dissemination

- Continuously monitor/record data on the Ormat and UTC unit
- Collect/analyze data:
- Power output
- Parasitic losses
- Ambient weather effects
- System temperatures, pressures and flow rates
- Modeling system parameters to evaluate system improvements: system efficiency, LCOE, base load power offset.
- Integration of non proprietary data into the National Geothermal Data System (NGDS)
- Data display screens of non proprietary data will be made available to the public



System Improvements

- Evaluation of hybrid cooling technologies and other power output improvement technologies

- GTP's Low Temperature and Coproduced subprogram intends to provide the geothermal community with the means to achieve development and widespread deployment of economically viable, innovative, and scalable technologies that will capture a significant portion of the low temperature geothermal resource base over the next two decades
- The subprogram has identified three avenues, or activity areas, that must be pursued in order to turn this goal into a reality
 - Advancing technologies
 - Fostering deployment
 - Informing policy
- **RMOTC will continue to play an integral role**

GEOPRESSURED

PERMEABLE STRATA

Co-Production with Oil & Gas

Modifying Marginal/Stripper Wells for Co-Production

Geothermal in Strata Lacking Hydrocarbon

Carbon Sequestration Plus Geothermal

