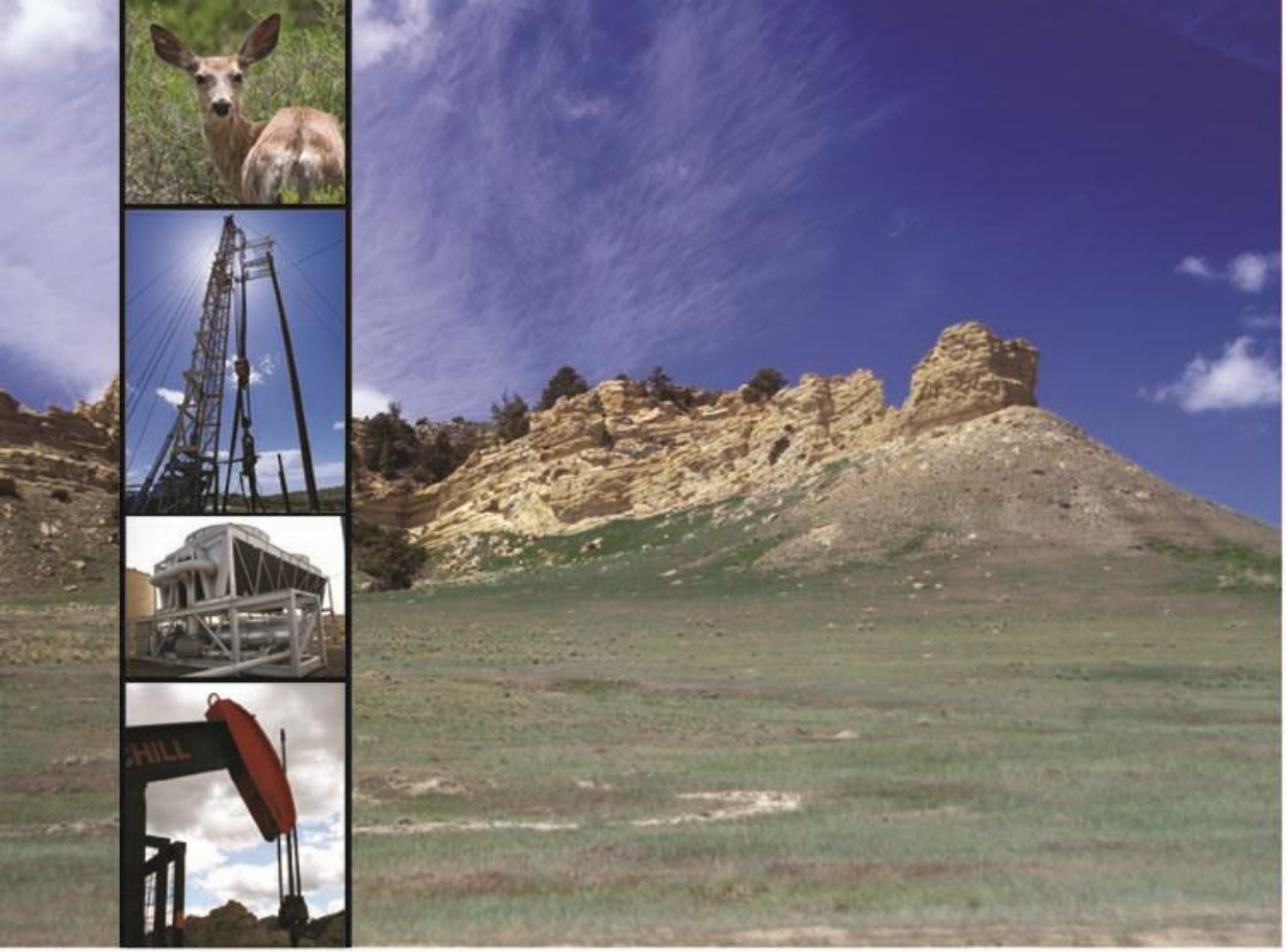
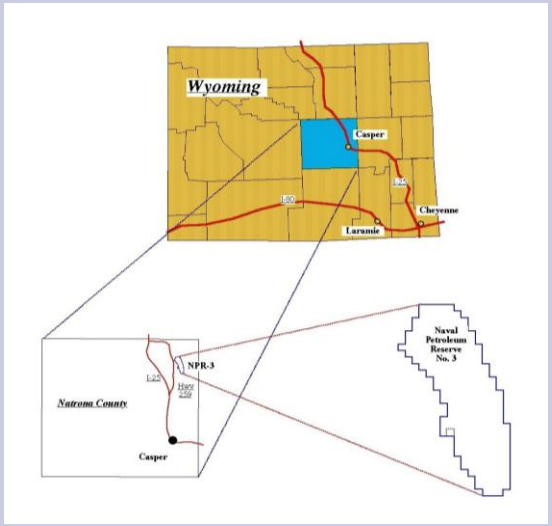


Coproduced and Low Temperature Geothermal Resources as Electrical Power Producers

Timothy Reinhardt[1], Lyle A. Johnson[2] and Neil Popovich[3]
U.S.DOE's GTP[1], RMOTC[2] and NREL[3]

RMOTC

Location of RMOTC



NPR-3 is 35 miles north of Casper, WY

- 9481 acres
- 650+ wells
- 9 Oil producing formations
- 2 formations > 200 °F
- Geothermal Gradient is ~ twice normal gradient
- Produced brine of high quality (2500 – 3000 TDS)
- Extensive recharge region
- Government owned and operated

RMOTC

Project Goals

- Show the relative seamless integration of the technology into the oil field infrastructure.
- Demonstration of the long term operations of binary power generation units in an oil field environment
- Provide data for determining reliability, efficiency and system economics
- Provide testing of innovations to improve the system efficiency
- Provide a testing facility for testing of units with both low-temperature and co-produced fluids
- All data will be available to the entire geothermal industry.

Collaborating partners

Geothermal Technologies Program, U.S.DOE

National Renewable Energy Laboratory

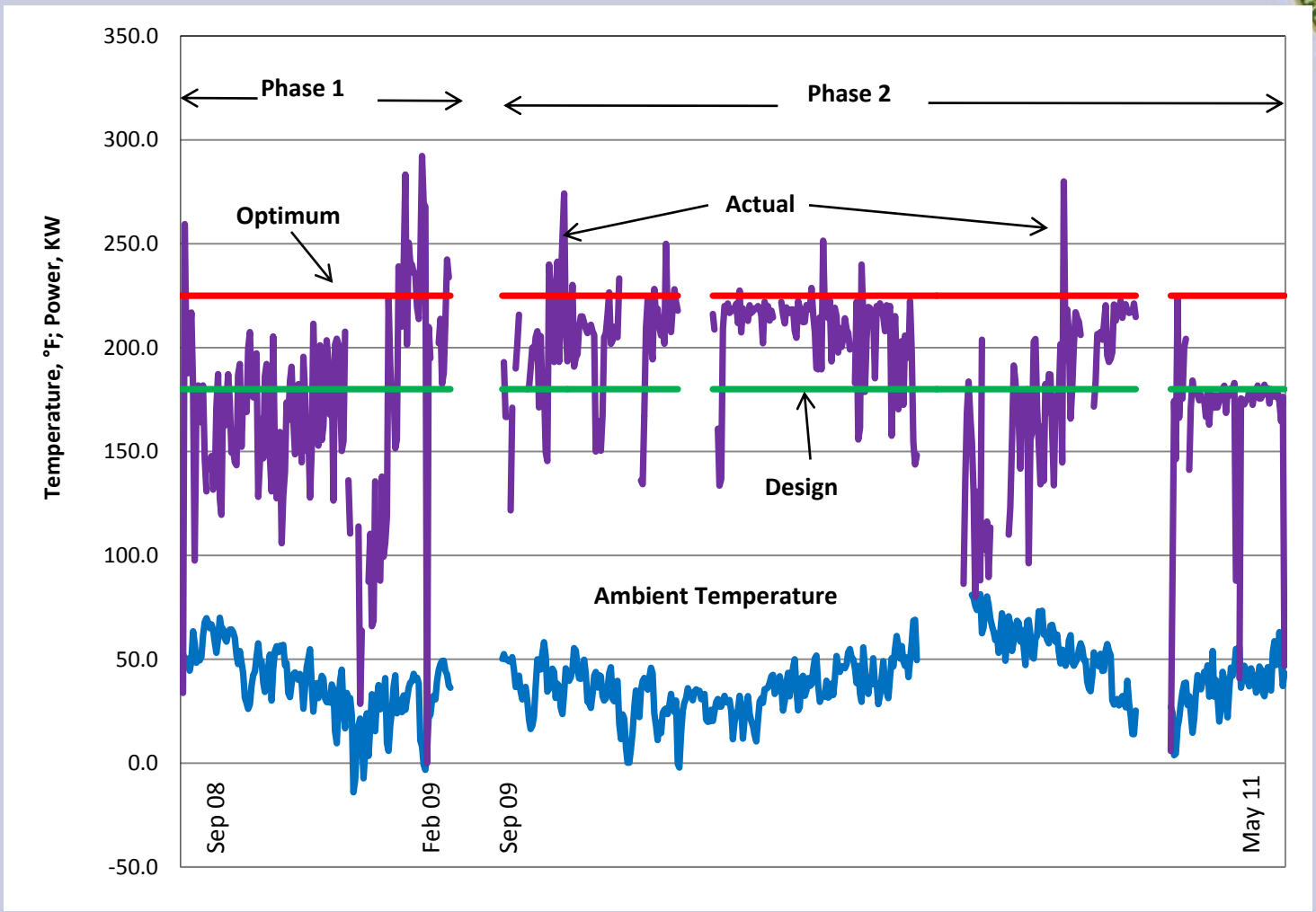
RMOTC

Initial Binary Unit

- Ormat nominal 250 kW ORC unit
- Isopentane working fluid
- Air cooled condenser
- Unit installed under testing program with Ormat Technologies

RMOTC

Operational Trends



RMOTC

SMU Geothermal Energy Utilization Associated with Oil and Gas
Dallas, Texas, June14, 2011

Operational Summary

	Design	Operational Results	
		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	9,077,323
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 to300
Daily avg. net power output, kW	132	80 to 280	80 to 275
Overall avg. net power, kW		171	190
Total power produced, MWhr		586	1,595

- Phase 2 has produced over 1,595 megawatt hours of power from 9.1 million barrels of coproduced hot water

- Total produced power from the unit is 2,181 megawatt hours of power from 12.1million barrels of coproduced hot water

- Online percentage for the unit, eliminating downtime caused by field activities, has been a 97%

RMOTC

Second Binary Test Unit

Pratt & Whitney Pure Cycle 280
Genetron 245fa operating fluid
Water cooled Condenser

Project Plans

- Continue operation of the air-cooled unit for a minimum of 2 more years
- Finalize installation and commence operation of a water-cooled power generation unit of a nominal 250 kW capacity for three years
- Perform data collection, data analysis and information dissemination for both units. Integrate non proprietary data into the National Geothermal Data System (NGDS)
- Evaluate system improvements that increase system efficiency and provide better system economics. Seek improvements suggestions from other sources.
- During this time, RMOTC will also be operating a test facility for smaller geothermal systems and is developing plans for EGS applications and testing

RMOTC

Project Plans - NREL

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

RMOTC

Project Plans

Data Collection and Information Dissemination

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RMOTC

Program Participants

- Collaborators on this project are:
  - U.S.DOE/RMOTC – Operation, maintenance and analysis of the power systems; install and evaluate innovations to the power systems; funding
  - U.S.EERE/GTP - Provide guidance and oversight; seek innovative concepts and ideas related to system improvements; and funding
  - National Renewable Energy Laboratory – Data acquisition; efficiency and economic analysis; develop innovations to increase net power output

RMOTC

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Thank You

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