Hybrid and Advanced Air Cooling

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Specialized Materials and Fluids and Power Plants

Overview

Identify and analyze advanced air cooling strategies that allow air-cooled geothermal power plants to maintain a high electric power output during periods of high air dry bulb temperatures while minimizing water consumption.

Timeline

September 2009 – August 2010

May 2010 = 10% complete

Budget

FY2009 - $875,000

FY 2010 - $458,000

Overview (continued)

Barriers

- Air-cooled heat exchangers are expensive. High ambient dry-bulb temperatures cause large reduction in geothermal plant output.

Partners

- TBD (Barber & Nichols); Rocky Mountain Oilfield Testing Center (RMTOC); and others

Relevance/Impact of Research

Objective

- Develop advanced air-cooled heat rejection for geothermal power plants that decreases loss of capacity that occurs in hot weather

Approach

- Strategic use of minimal amount of water during times of peak demand to boost the economic viability
- Analyze Heller systems (for clean steam plants) and wet/dry combination of ACC in series and/or parallel arrangements
- Prior work indicates deluged ACC are most economical

Scientific/Technical Approach

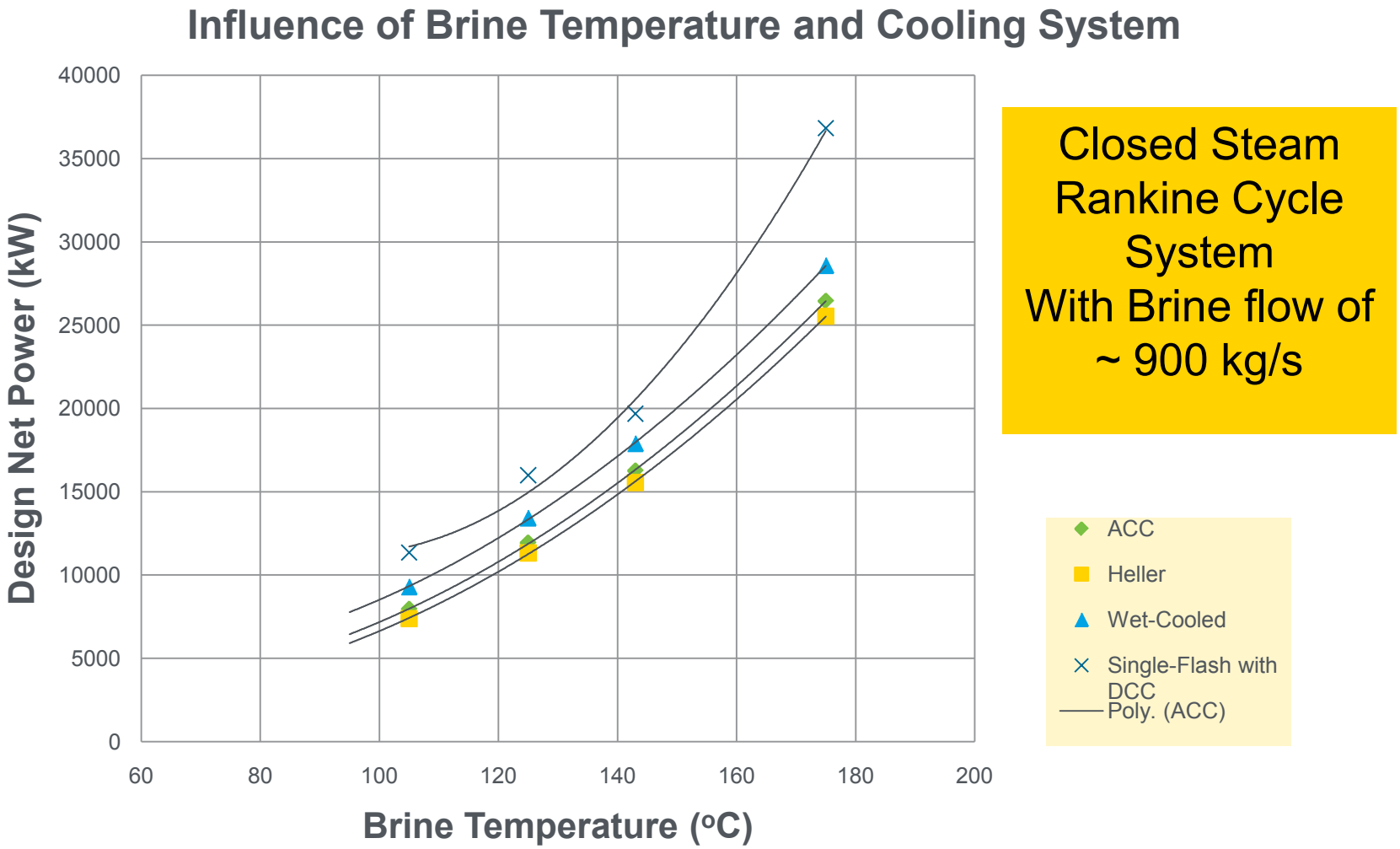
- Assess plants with resources available in the range of 125°C to 175°C
- Brine flash/condense allows disposal of non-condensable gases with minimal parasitic power
- Closed steam cycles allows use of conventional technologies and the use of Heller systems

- **FY10 planned milestones**
  - June 2010, report on Heller system analyses
  - August 2010, report on hybrid cooling analyses
  - September 2010, final presentation and go/no-go decision

Accomplishments, Expected Outcomes and Progress

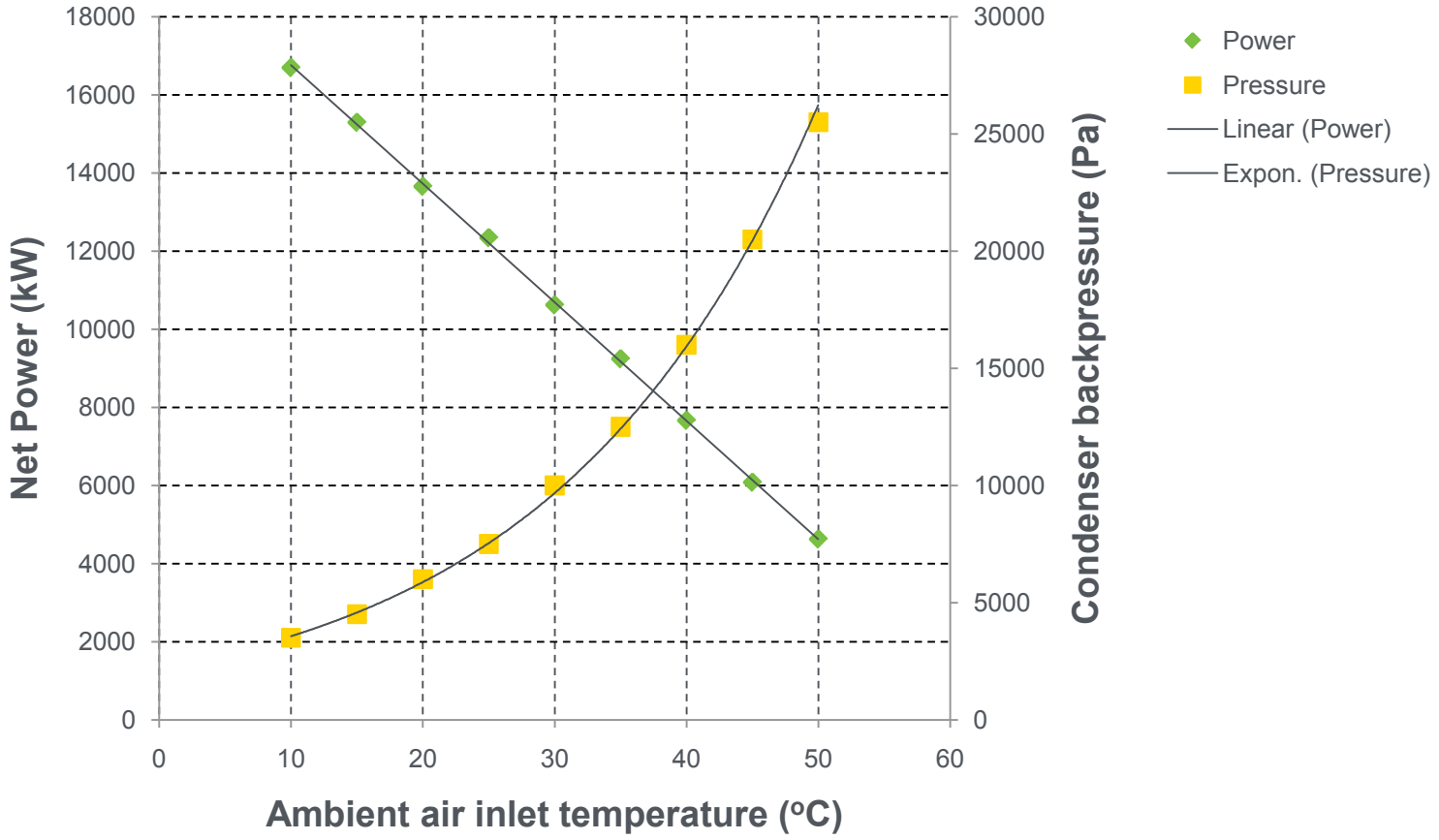
- Project work began in January 2010
- Researchers have reviewed relevant data on prior efforts to enhance output during hot weather
- NREL has acquired relevant software to conduct analyses
  - ASPEN (all modules)
  - EES
  - IPSEpro

Accomplishments, Expected Outcomes and Progress (continued)

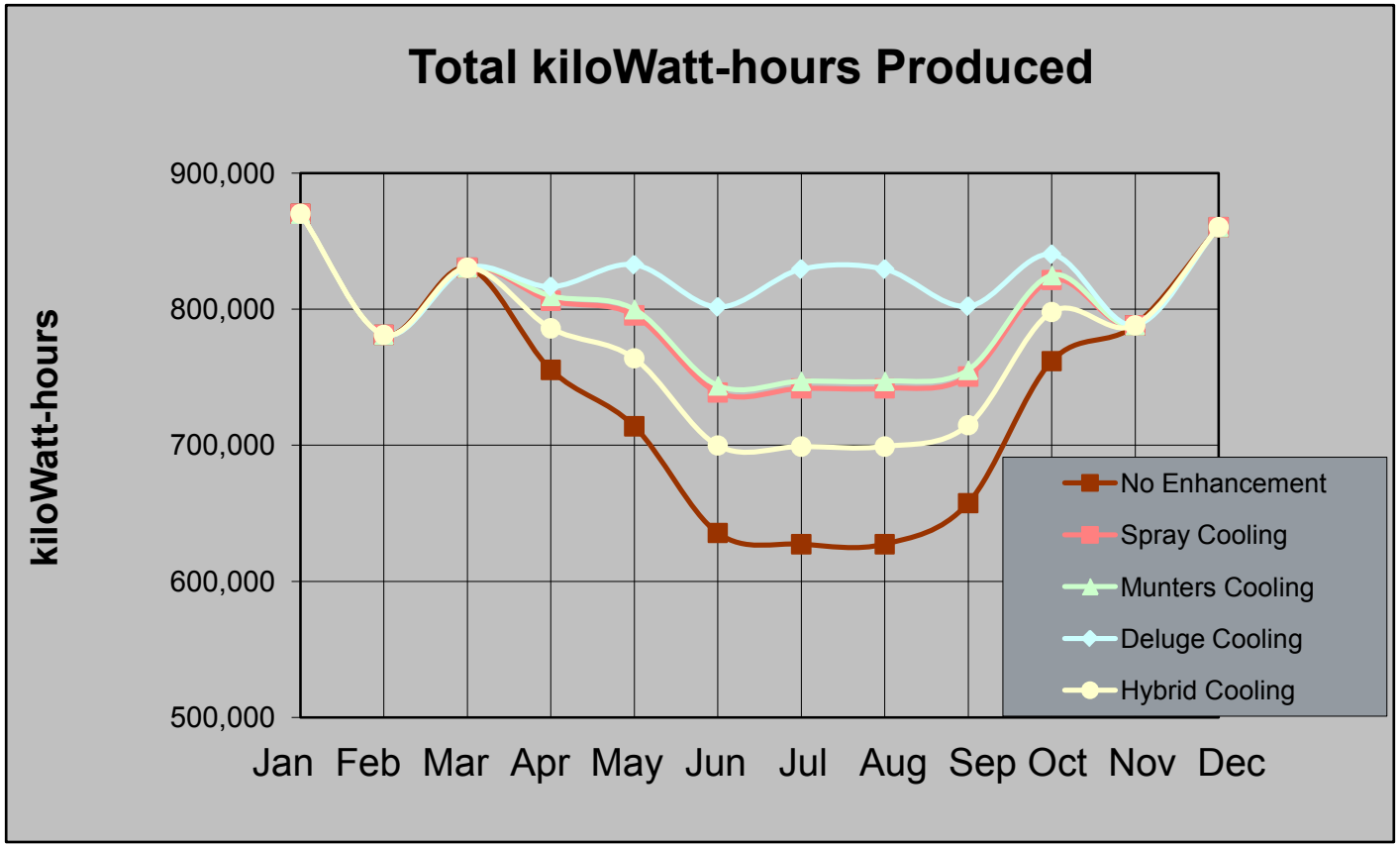


Closed Steam Rankine Cycle System With Brine flow of ~ 900 kg/s

Influence of ambient (db) temperature on back pressure and net power for ACC plant

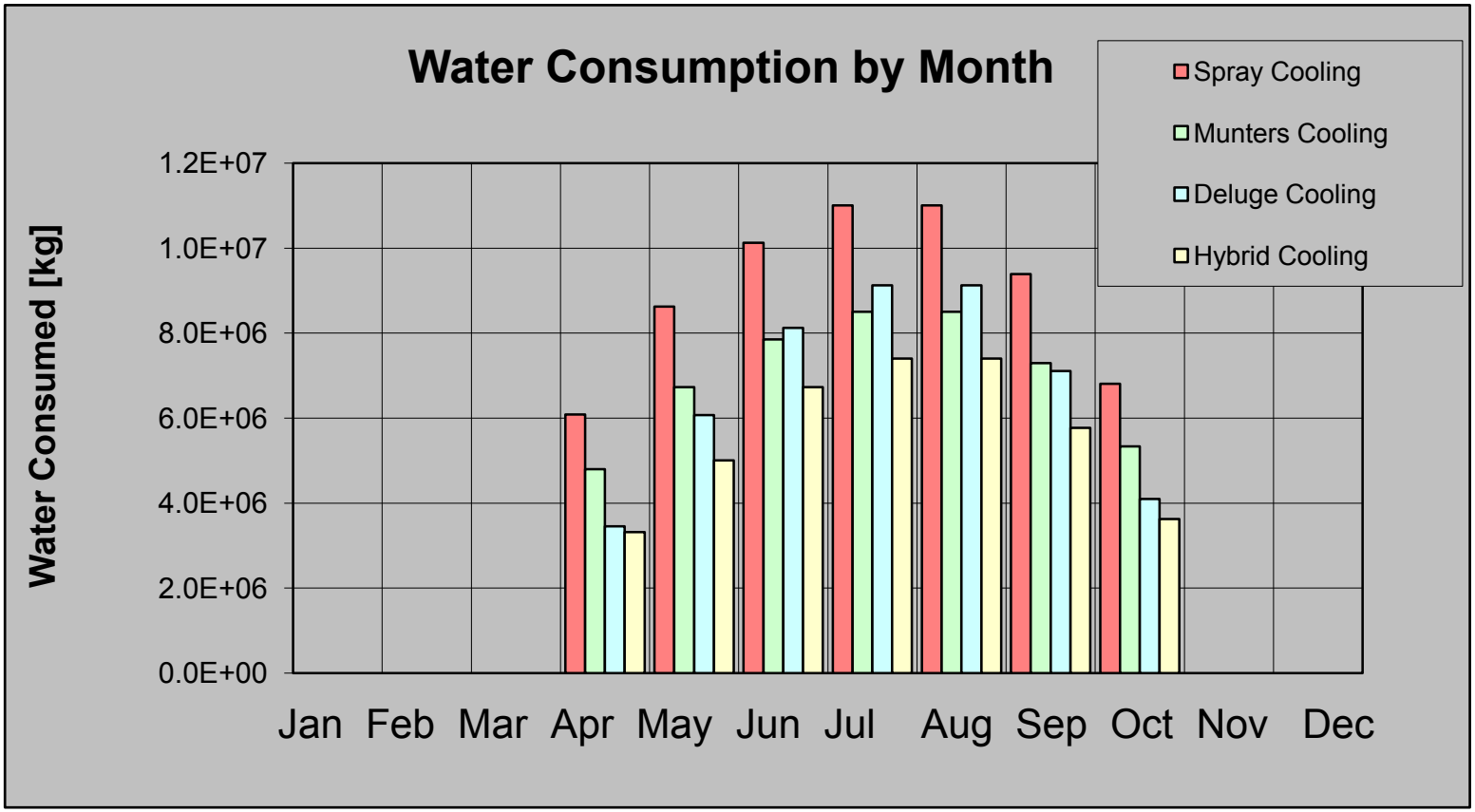


Accomplishments, Expected Outcomes and Progress (continued)



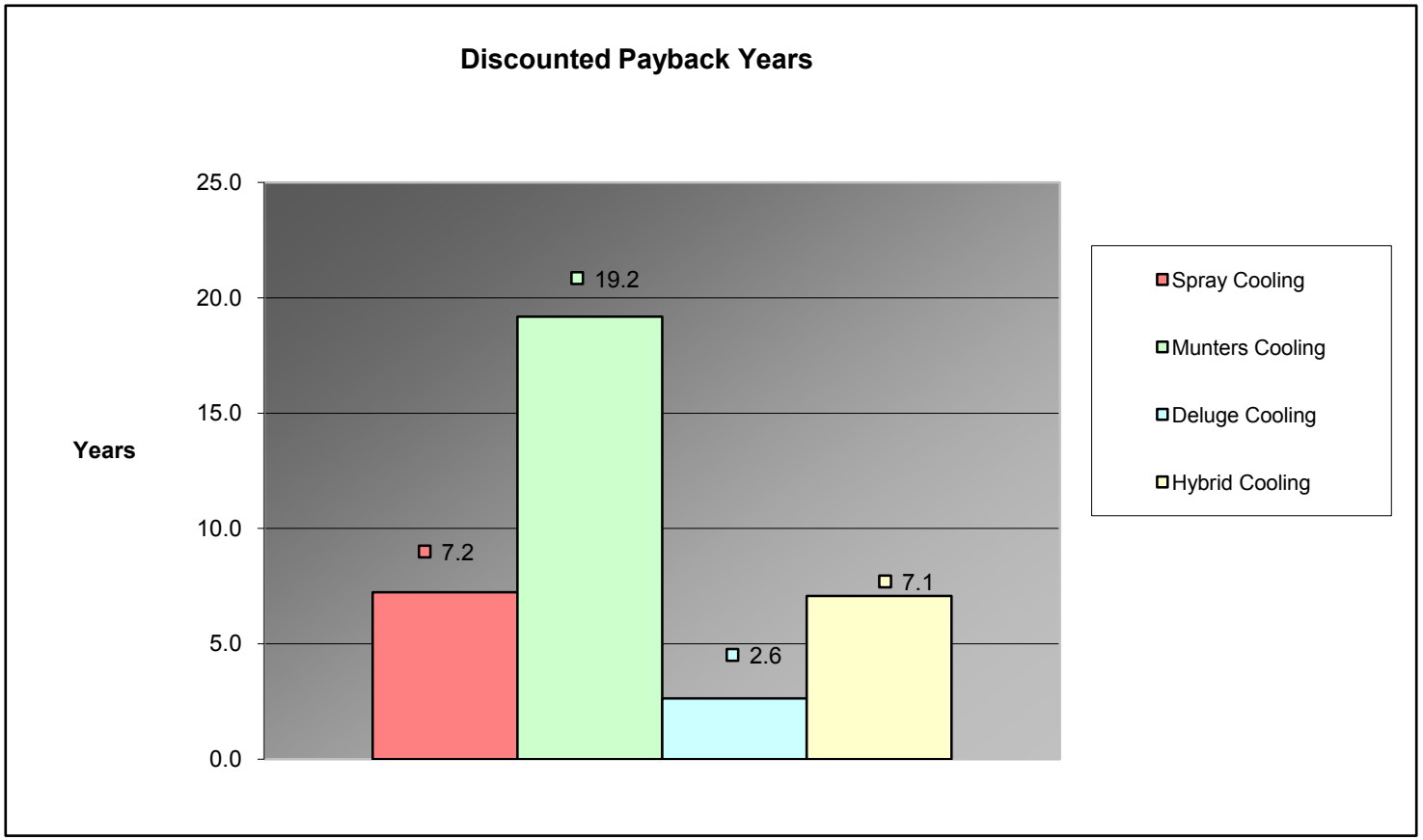
Early results from NREL, Nominal 1 MW Air-cooled Binary Plant

Accomplishments, Expected Outcomes and Progress (continued)



Early results from NREL, Nominal 1 MW Air-cooled Binary Plant

Accomplishments, Expected Outcomes and Progress (continued)



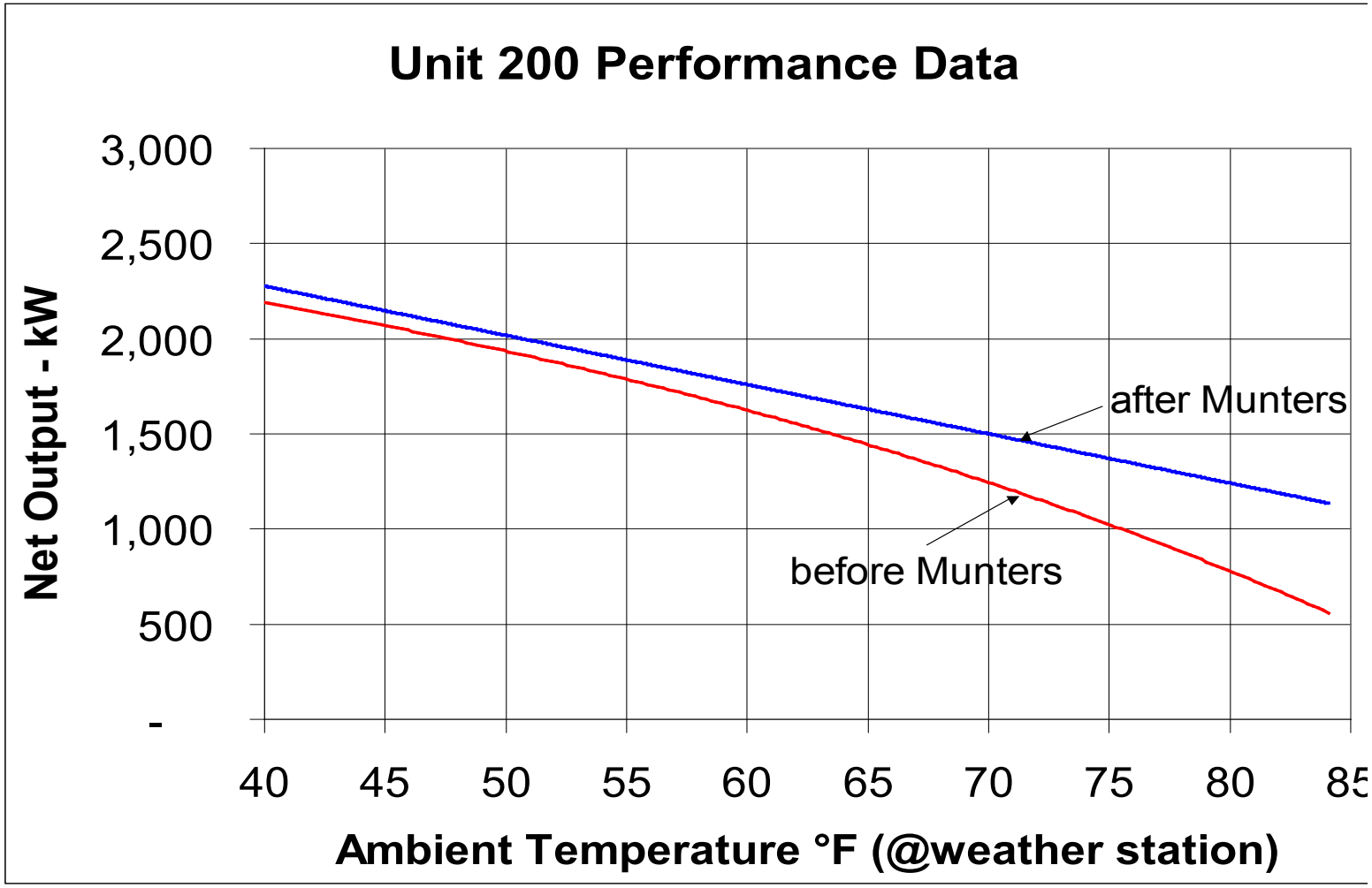
Early results for 1 MW Air-cooled Binary Plant are promising

Measurements at Mammoth Binary Power Plant

Munters system

Hybrid spray/Munters system

Munters Performance at Mammoth



Mammoth Measurement Results: 2001

- Field instrumentation
  - Type T thermocouples
  - Optical dew point (chilled mirror) hygrometer
  - Handheld anemometer

- Munters had 79% saturation efficiency; hybrid was 50%

- Air flow rate with Munters dropped 22%-28%

- Munters increased net power 62% (800 kW to 1,300 kW) at 78ºF ambient

Project Management/Coordination

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	Project	Hybrid and Advanced Air Cooling											
		FY 2010				FY2011				FY2012			
	Tasks	1 Qtr	2 Qtr	3 Qtr	4 Qtr	1 Qtr	2 Qtr	3 Qtr	4 Qtr	1 Qtr	2 Qtr	3 Qtr	4 Qtr
Phase I Analyses													
	Heller cycle												
	Hybrid cooling												
	Final Report												
	Go/No Go Decision												
Phase II Field Test Design													
	Plant selection												
	Design and costing												
	Final design												
	Go/No Go Decision												
Phase III Field Installation/Testing													
	Order equipment												
	Installation												
	Data collection												
	Final report												

Project Management/Coordination (continued)

Application of resources and leveraged funds/budget/spend plan (NREL hopes to get some cost share for field tests)

- Phase I 417K
- Phase II 458K
- Phase III 650K

Project is highly integrated with overall low-temperature development efforts within GTP

Coordination with industry and stakeholders

- NREL intends to continue to present progress and results at various geothermal meetings and conferences

Future Directions

Expected outcome

- FY10: Continue to provide an assessment of the benefits of hybrid cooling
- FY11: Address steps toward field tests
- Upcoming key milestone will address viability of using direct and indirect cooling options for hybrid cooling

Future research, development, or deployment needs

- FY12: Provide industry an opportunity to view and evaluate field tests

Summary

- Addresses a critical need for air-cooled geothermal plants that suffer major loss in capacity during hot days
- Early results are promising
- Success will support
  - Reduced environmental impact with respect to water use
  - DOE goals for Low Temperature Demonstration Projects