



Optimization of hybrid-water/air-cooled condenser in an enhanced turbine geothermal ORC system

May 19, 2010

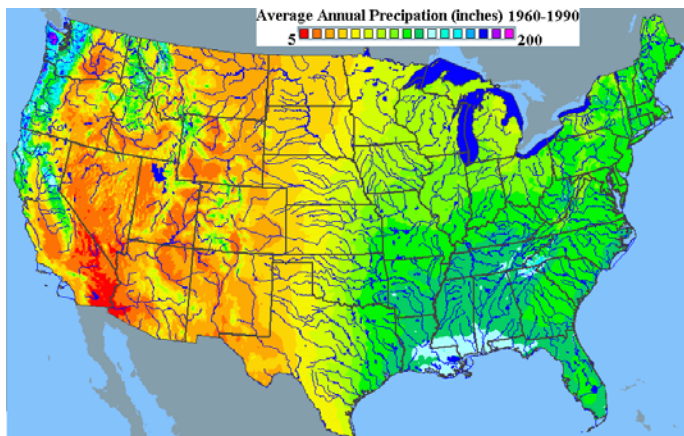
Hailing Wu

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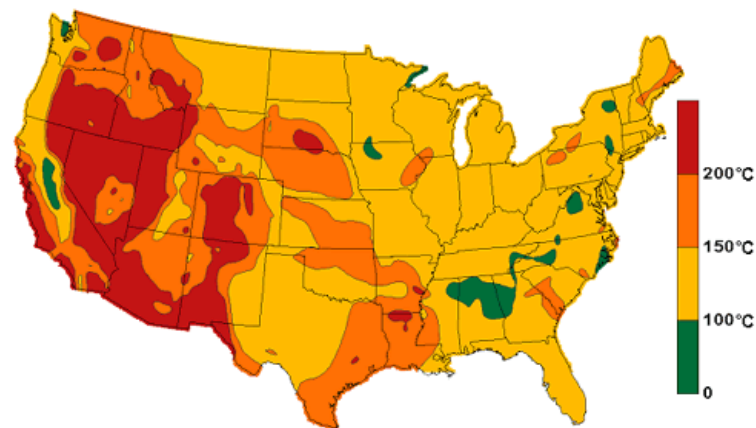
Specialized Materials and Fluids and Power Plants

- **Timeline**
 - Project started in Feb. 2010, ends July 2011.
 - About 10% completed.
- **Budget:**
 - Total project cost \$1,499,910
 - DOE share \$1,199,928
 - Awardee share \$ 299,982
 - Funding for FY10 \$1,064,000
- **Partners**
 - University of Illinois, Chena Power LLC

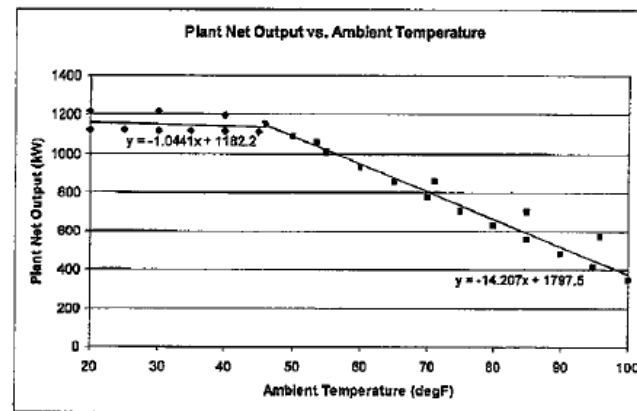
Water saving and output variability improvement



Map of US streams and waterbodies colored by annual precipitation



Map of geothermal resources in US: contours of water temperature at 6 km underground

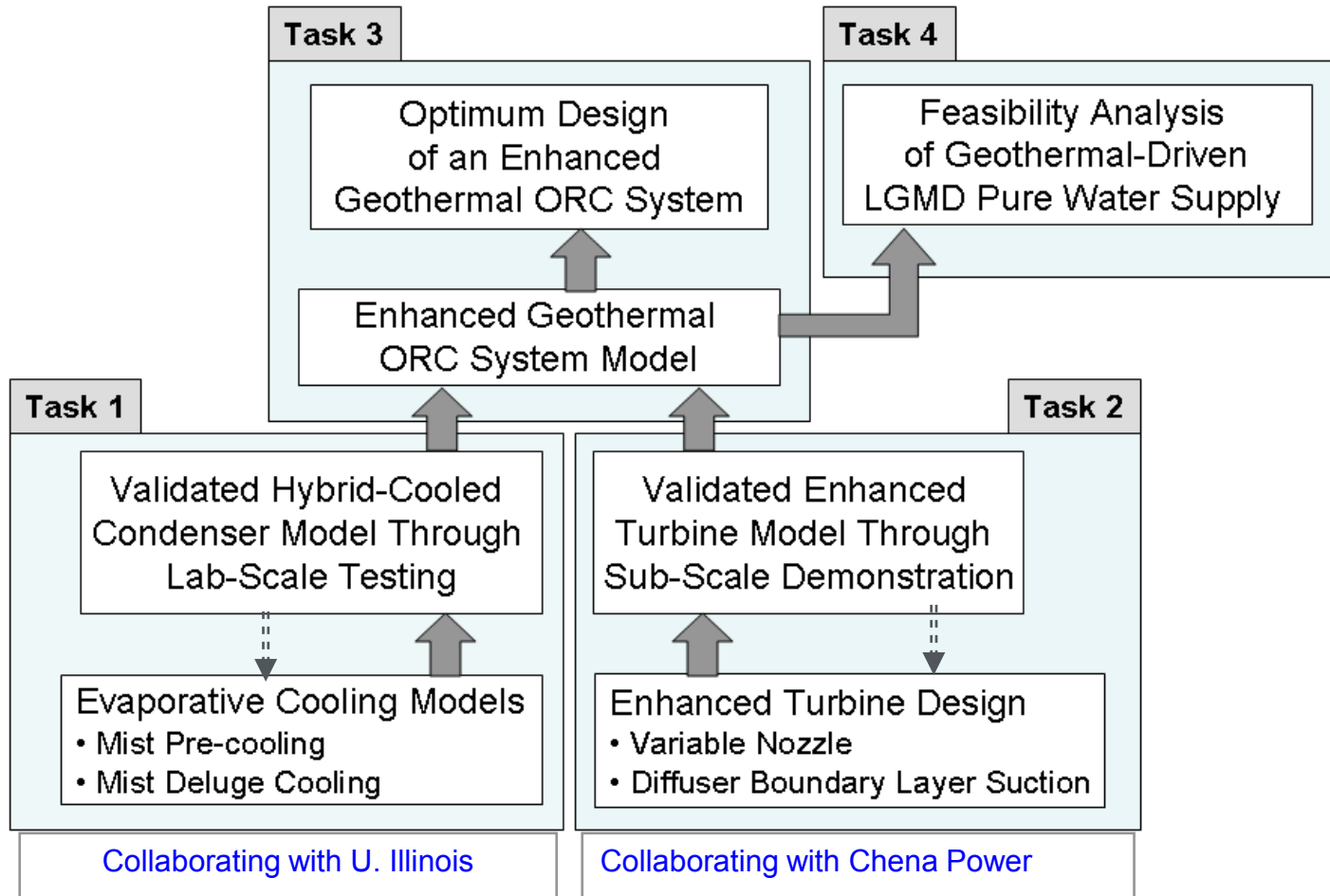


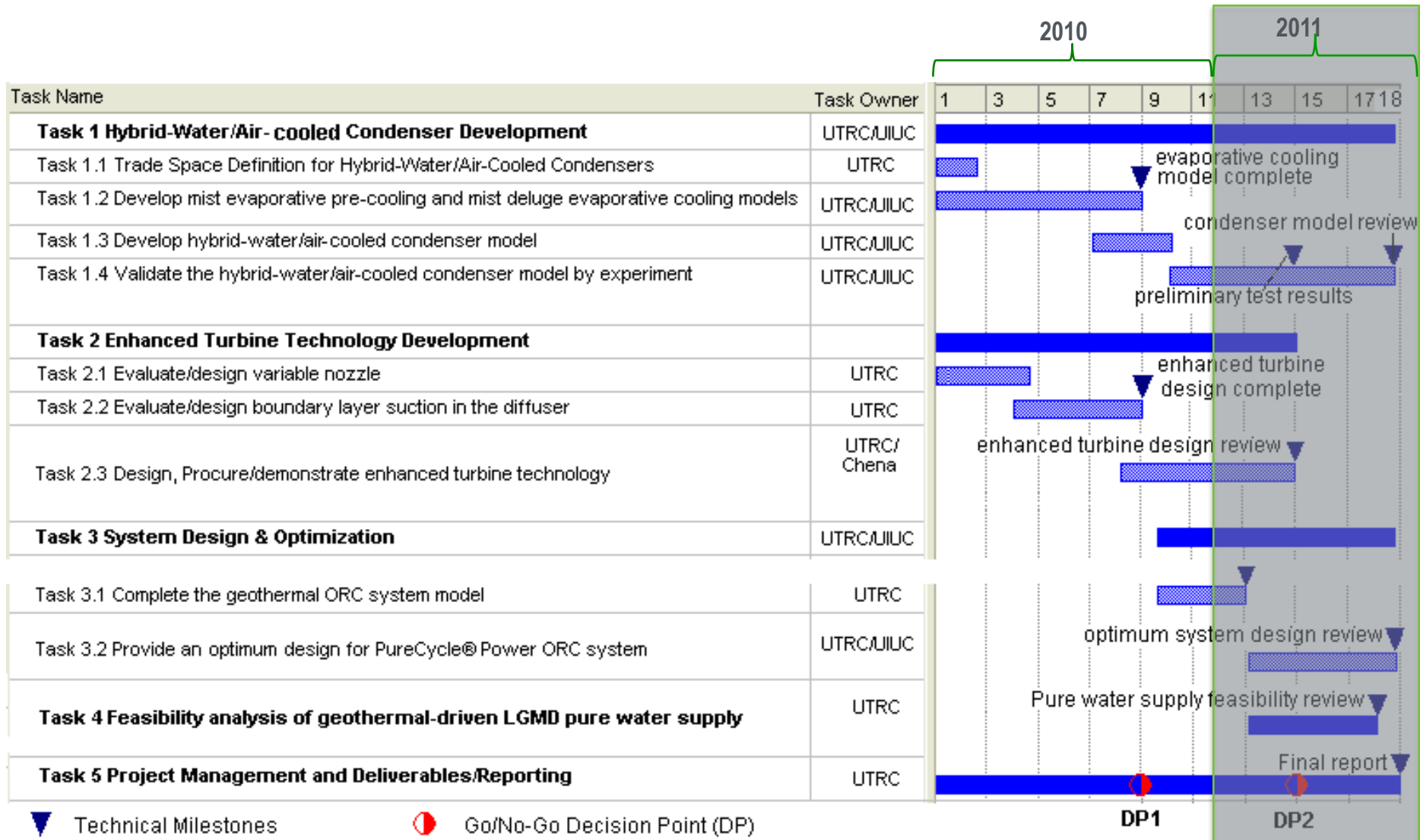
Power Output degradation at high ambient (C. Kutscher, D. Costenaro, 2002, Geothermal Resources Council Annual Meeting, Reno, Nevada.)

Objective: To improve the efficiency and output variability of geothermal-based ORC power production systems with minimal water consumption by deploying: 1) a hybrid-water/air cooled condenser with low water consumption and 2) an enhanced turbine with high efficiency.

Innovation:

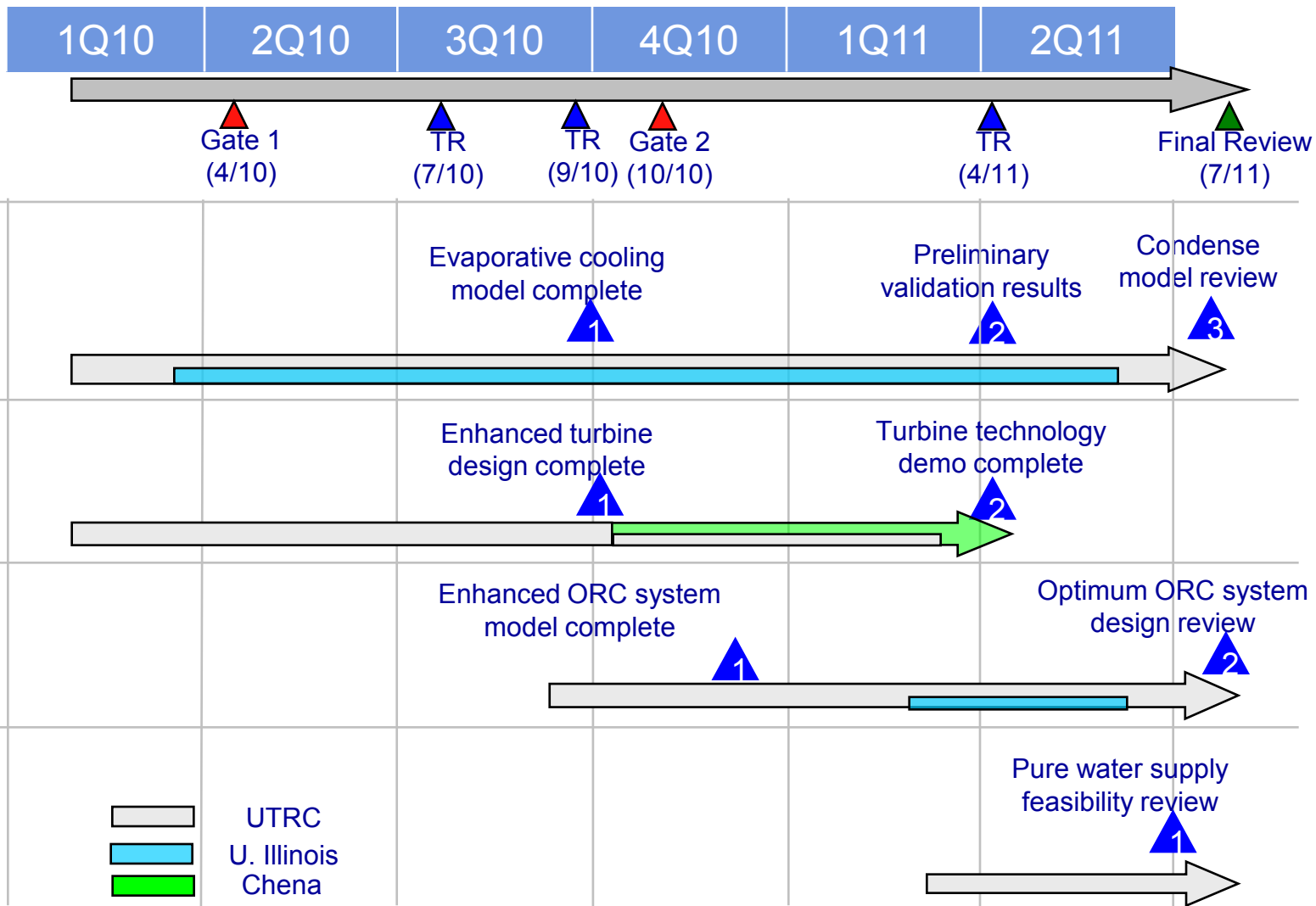
- Hybrid-cooled condenser
 - Combined *mist* evaporative pre-cooling and *mist* deluge evaporative cooling at the condenser surface
 - Microchannel heat exchanger
- Enhanced turbine
 - Diffuser boundary layer control
 - Variable nozzle
- Geothermal-driven pure water supply based on LGMD (liquid gap membrane distillation) technology



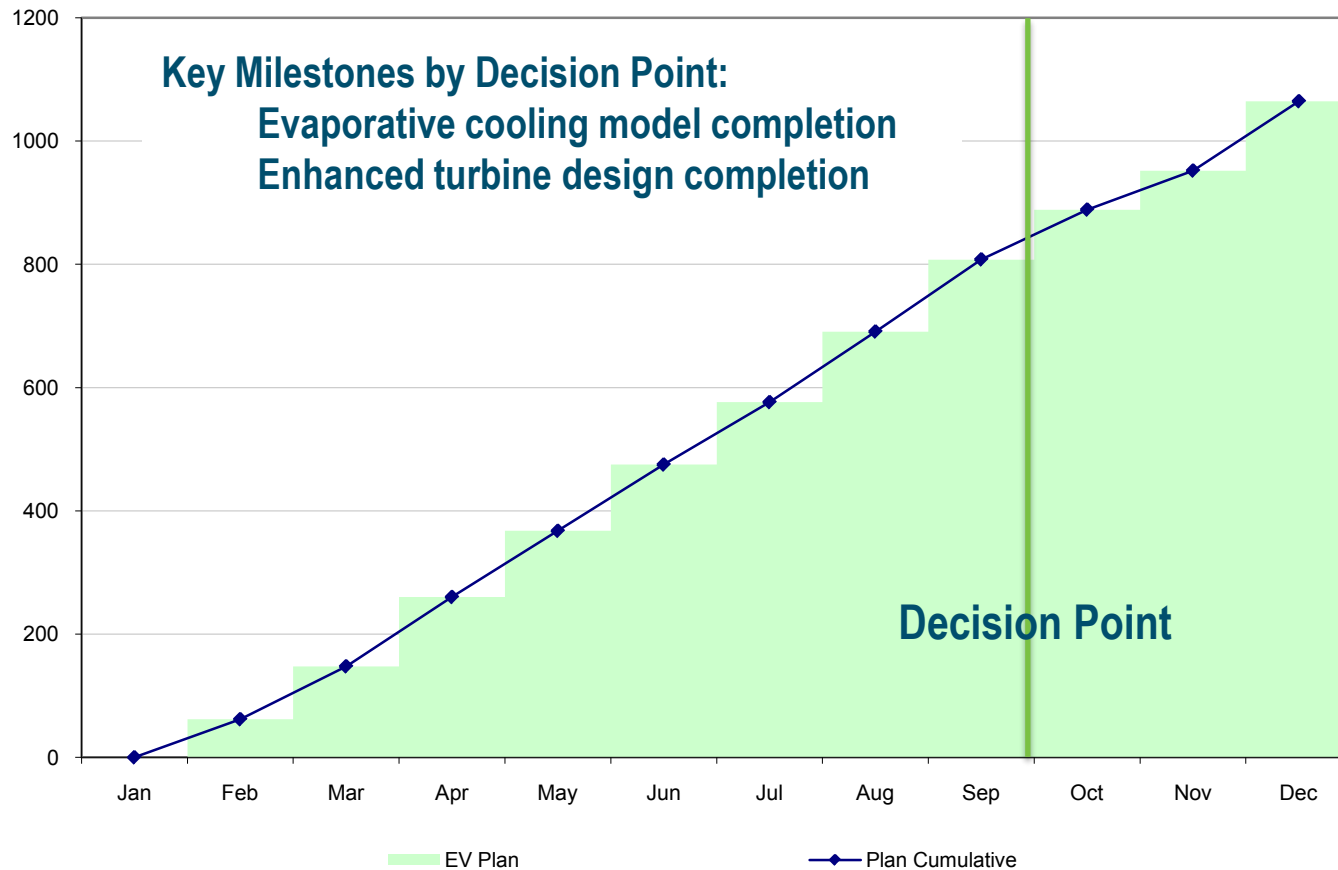


Expected Outcomes:

- A validated hybrid-water/air-cooled condenser model
 - A verified enhanced turbine design
 - An optimized design for UTC's PureCycle® geothermal ORC system that integrates both technologies
 - A feasibility analysis of geothermal-driven LGMD pure water supply
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- Potential impact: improving power output by over 30% during the hottest parts of summer with an annual-basis improvement of at least 8% is possible from this technology.



2010 Spending Plan



- Complete upcoming key milestones (2010):
 - Develop mist evaporative cooling model and hybrid-cooled condenser model, and validate the model
 - Develop enhanced turbine design and procure hardware
 - Develop hybrid-cooled enhanced turbine geothermal ORC system model
- Explore technology insertion potential for both hybrid-cooled condenser and enhanced turbine not only in the geothermal ORC applications, but also in a broad range of DOE applications, such as air conditioning/ refrigeration, as well as steam power plants.
- Engage UTC business units associated with the project to ensure successful technology transfer and commercialization.

- Project objective is to improve geothermal ORC plant output variability and efficiency with minimal water consumption by deploying a hybrid-cooled condenser and an enhanced turbine.
- Project has been initiated and executed according to the management plan.
- Technology insertion potential is large for geothermal ORC as well as air conditioning/refrigeration and steam power plants.