Geothermal Technologies Office 2017 Peer Review

Deep Direct-Use Technical and Economic Working Group Kick-Off Meeting

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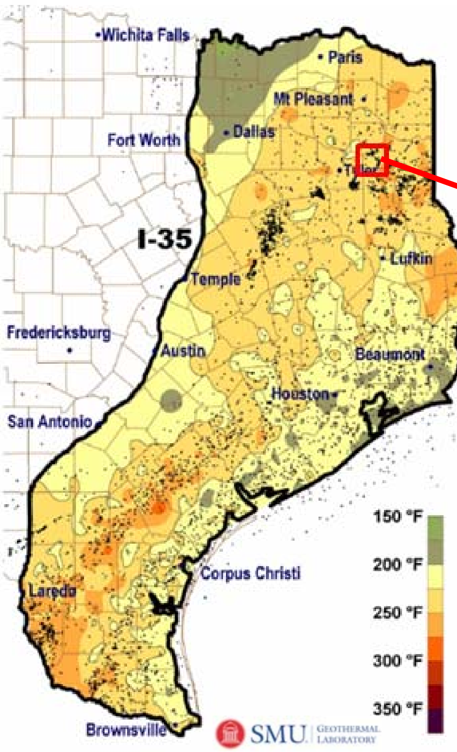



Eastman Chemical Plant, Longview, TX

# Deep Direct Use: Turbine Inlet Cooling in East Texas

Project Officer: Arlene Anderson

Total Project Funding: $560,000

November 13, 2017


Craig Turchi (PI)

National Renewable Energy Laboratory

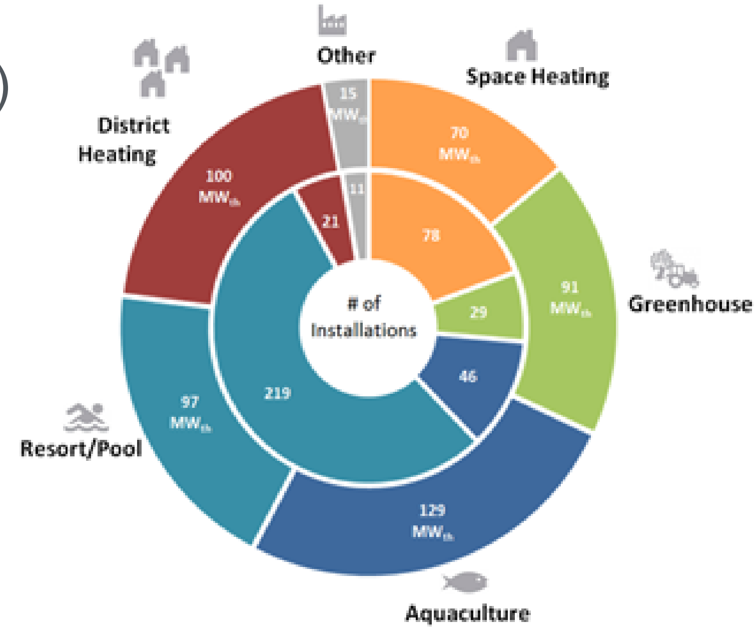

Deep Direct-Use Feasibility Studies Technical and Economic Working Group Kick-Off Meeting

# Project Objectives



**Historically, most U.S. direct-use applications have been small capacity, relatively low-value applications in western states. For example, aquaculture or resort/pool heating. In contrast, this project seeks to:**

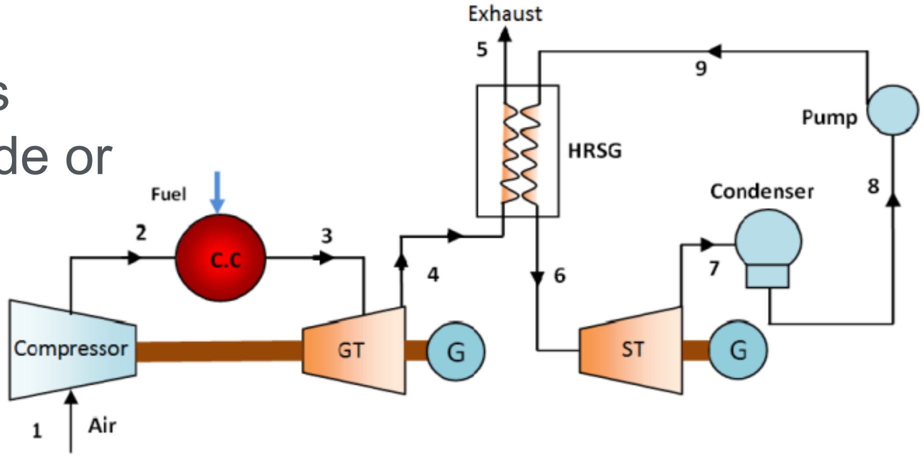
- Target large-scale integration (~50 $MW_{th}$) into industrial application
- Apply storage to decouple 24/7 geothermal availability from varying user demand
- Generate high-value product from low-temperature geothermal resource
- Tap geothermal resource outside of traditional hydrothermal-use regions




Current geothermal direct-use applications in the United States [Beckers & Snyder 2017].

# DDU Application: Turbine Inlet Cooling

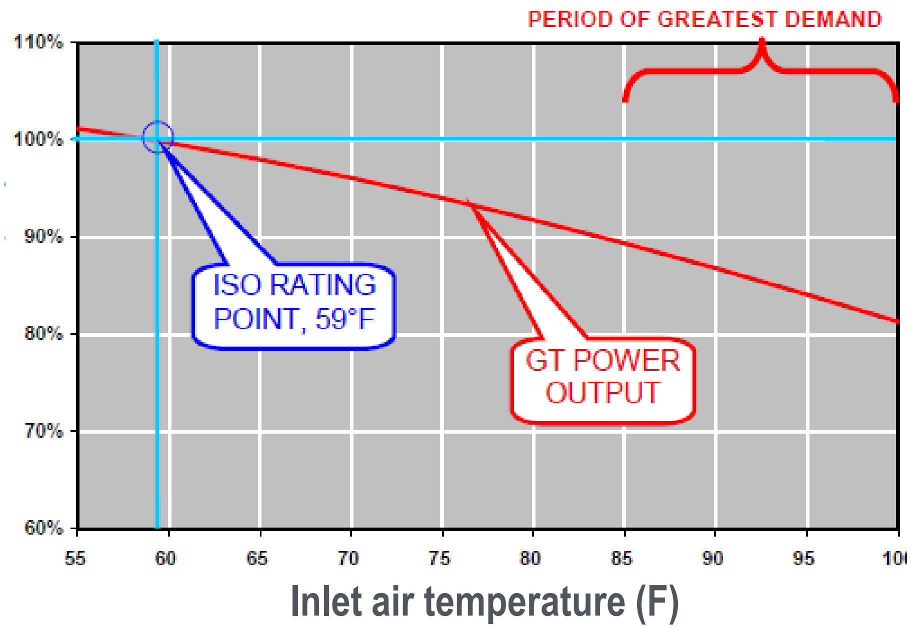
The first step of a gas turbine is compressing ambient air. Altitude or high temperature decreases compressor efficiency.




**Effect of inlet air temperature on turbine performance:**

Gas turbine ratings are made at 15ºC (59ºF).

Turbine performance drops with increasing air temperature.




Tillman, "Weather-Rated Economics of Gas Turbine Installations," Turbine Air Systems, 2005.

# DDU Application: Turbine Inlet Cooling

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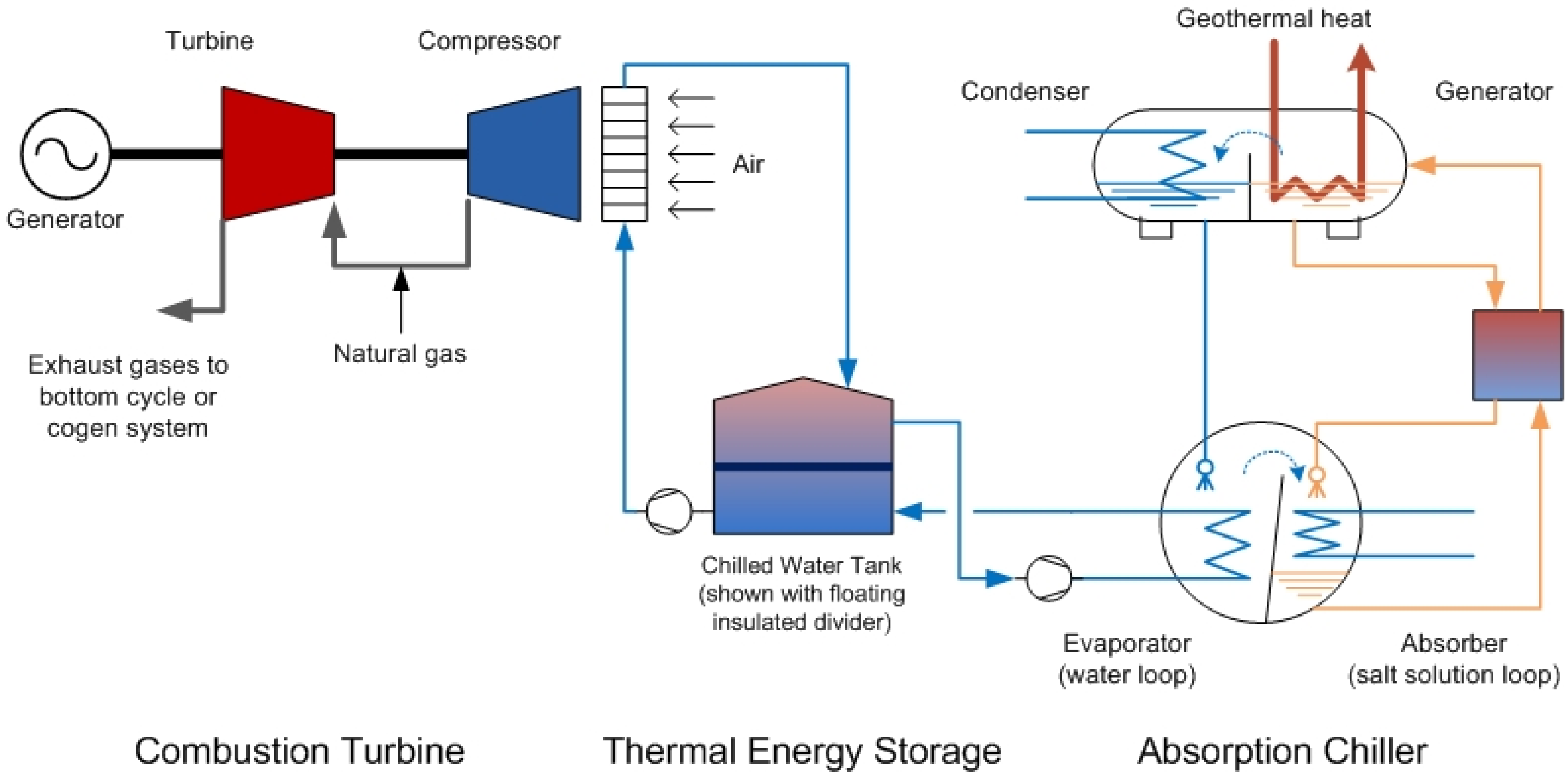
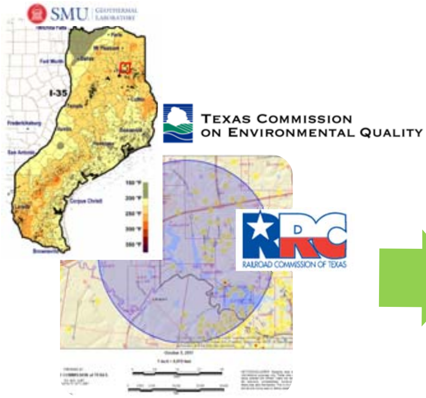
1. **Run small-capacity absorption chiller off geothermal heat**
2. **Stockpile chilled water**
3. **Dispatch chilled water for turbine inlet cooling during hot afternoons**



**Project Tasks:**

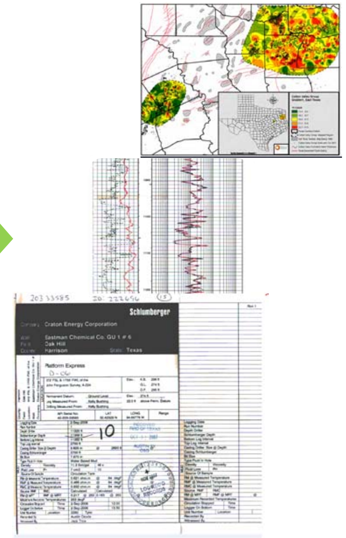
1) Evaluate geothermal resource, local regulations, and other site-specific issues related to regions within the Sabine Uplift of East Texas. Feasibility site is Eastman Chemical Plant in Longview, TX
2) Model absorption chiller and turbine inlet cooling options to quantify performance and efficiency benefits
3) Assess overall economics by cost and sensitivity to geothermal resource temperature, well depth, and well-to-plant distance, thermal storage duration, etc.

# Task 1: Resource Characterization




## Temperature Data & Lithology Data

- SMU Heat Flow Databases, NGDS and SECO work
- Texas RRC Database of well data
- Literature Review of Geological Structures
- Local well operator provided data
- Subscription databases, if necessary (IHS)




## Determine Porosity & Permeability

- Flow rates and/or pressure data
- Lithology Correlation from Log Review and Literature Review
- BEG Reservoir Analysis from NGDS Project

$$F = kH$$

$$PI = \frac{Q}{\Delta P} = \frac{2\pi kH}{\mu ln\frac{D}{r_w}}$$

$$T(z) = z_r\frac{dT}{dz} + T_s$$

$$k_w = 0.578k_g^{1.097}$$

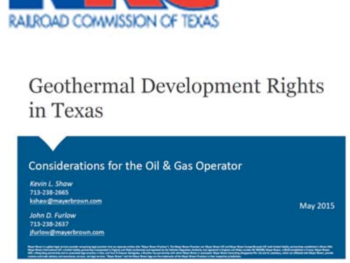
$$k_w = \frac{k_g}{1+\frac{b}{p}};$$

$$b = 15.61\left(\frac{k_g}{\phi}\right)^{-0.447}$$

## Calculate Reservoir Productivity Index (RPI)

- Method: Use Geothermal Play Fairway Analysis Appalachian Basin (GPFA-AB) Natural Reservoir Memo
- Data output in Geological Reservoir Content Model

Railroad Commission of Texas




Texas Commission on Environmental Quality

## Permitting Review

- Texas Railroad Commission (RRC)
- Texas Commission on Environmental Quality (TCEQ)
- Public Utility Commission (PUC), etc.
- Harrison County
- City of Longview
- Possibly ERCOT

# Task 2: System Modeling

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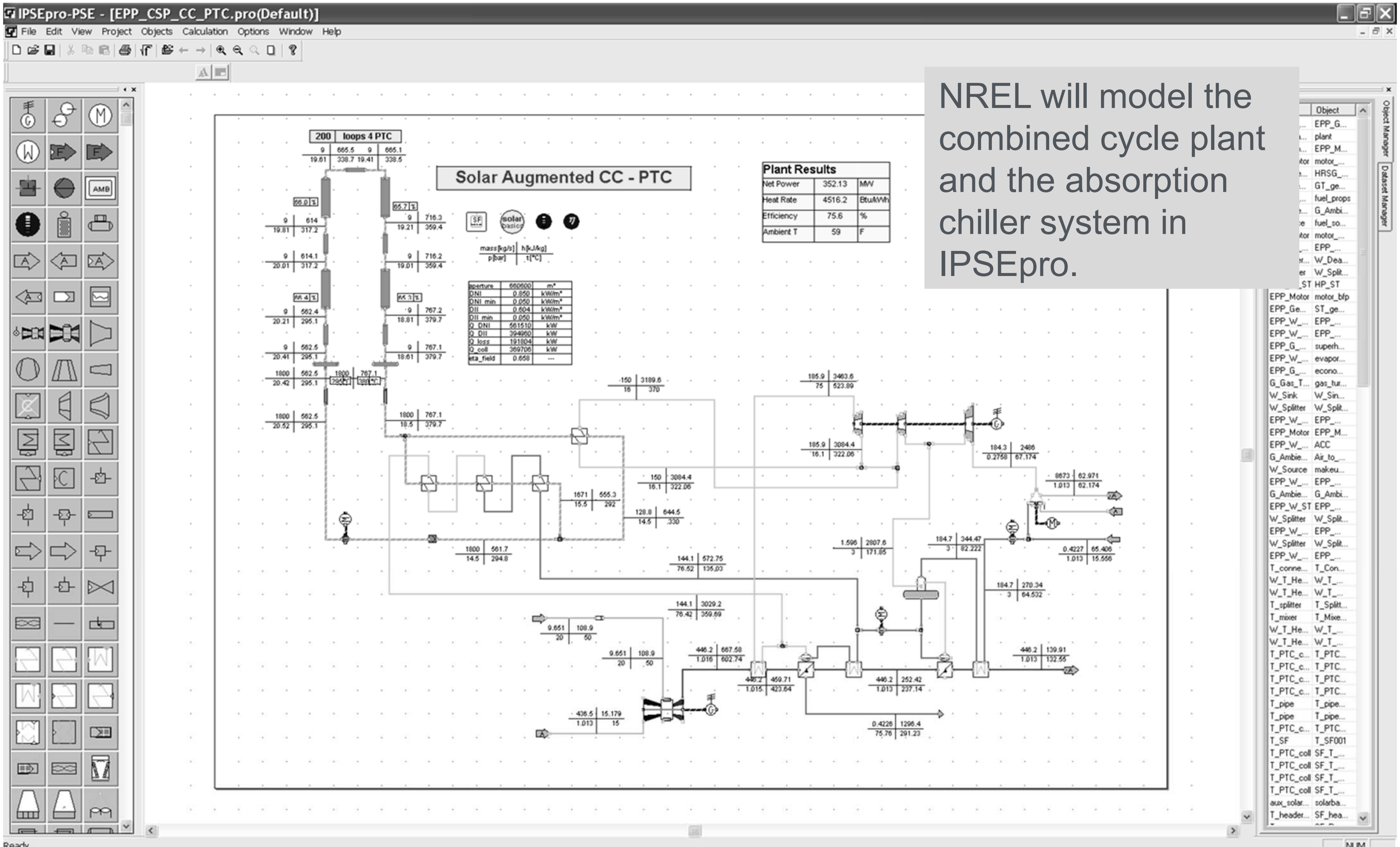


NREL will model the combined cycle plant and the absorption chiller system in IPSEpro.

# Technical Objectives & Milestones

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| Milestone | Milestone Description | Milestone Verification Process | Project Quarter |
|---|---|---|---|
| **Task 1. Resource Characterization** | | | |
| M1.1 | Initial assessment of geothermal resource | Listing of existing subsurface data cross-referenced to the case study location | Q2 |
| M1.3 | Tabulated RPI results | Database of Reservoir Productivity Index (RPI) results for identified wells within approx. 10-km radius zone of interest around selected plant site. | Q5 |
| M1.4 | Permitting assessment | Report documenting relevant federal, state, and local permitting required for geothermal development at the selected case-study locations. | Q6 |
| **Task 2. Geothermal Integration Modeling: Turbine Inlet Cooling** | | | |
| M2.1 | Natural-gas combined cycle plant simulation model | Demonstration that model matches heat rate prediction within 5% for the same plant design from a third-party source | Q1 |
| M2.2 | Process schematic and analysis of the TIC process | Table of chilled water production rate (temperature and mass per time) as a function of geothermal resource and ambient conditions. | Q4 |
| M2.3 | Integrated performance results | Relative comparison of case study site with and without TIC indicating >10% increase in power output during hot, humid afternoons (90°F and 60%RH). | Q6 |
| **Task 3. Techno-economic Assessment** | | | |
| M3.1 | Geothermal resource cost model | Table of delivered geothermal energy as a function of well depth, RPI, drilling and completion costs, and brine transport costs | Q5 |
| M3.2 | NPV estimates for case study site | Case study documenting the net present value of a TIC system using geothermal heat. Includes process schematics and major component specifications, climate and financial assumptions, including revenue from generated electricity and heat (if applicable). Sensitivity analysis that identifies variables of greatest influence,. | Q6 |
| M3.3 | Stakeholder workshop | Disseminate project findings and facilitate potential follow-on technology demonstration. | Q6 |

# Proposed Metrics

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**Key Metrics:**

1) Thermal resource quality and proximity to site
2) Capital cost and performance of absorption chiller system
3) Optimal storage capacity
4) Performance boost from turbine inlet cooling and impact to plant revenue

# Project Team & Roles

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| | |
|---|---|
| NREL | • Project management & reporting<br>• Absorption chiller and combined-cycle modeling<br>• Techno-economic assessment |
| SMU | • Geothermal resource assessment<br>• Local regulatory requirements evaluation |
| EPRI | • Consultant on techno-economics<br>• Stakeholder workshop participant and liaison to utilities |
| Eastman Chemical | • Site infrastructure and operational data<br>• Well data and/or potential data-source contacts |
| TAS Energy | • Guidance on design, cost, and performance of turbine inlet cooling and chiller systems |

TAS™ economic. clean. energy.™

SMU. Geothermal Laboratory

EPRI Electric Power Research Institute

EASTMAN Eastman Chemical Company

**Value of the Working Group Collaboration:**

- Share resource evaluation methodology
- Compare methodology and estimates for drilling and brine transport costs
- Harmonize financial assumptions for project value analysis

**Data Management:**

- Data Management Plan assumes the majority of the data is nonproprietary and will be released via the GDR. Proprietary data shall be identified and public-release reports and data shall be scrubbed of proprietary information.