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## DEVELOPMENT AND TESTING OF ADVANCED DIRECT-CONTACT CONDENSERS

Desikan Bharathan  
National Renewable Energy Laboratory

### KEY WORDS

direct-contact condensers, hydrogen sulfide abatement, back pressure, non-condensable gas handling,

### PROJECT OBJECTIVES

In pursuit of its goal of reducing the cost of electricity from various geothermal resources, the Department of Energy (DOE) is conducting investigations to improve the performance and economic viability of geothermal power cycles. One of the DOE tasks, carried out by NREL, is the development and implementation of advanced direct-contact condensers, developed at NREL, which offer a potential for reduced condenser back pressure and improved non-condensable gas handling in geothermal power systems.

#### *Technical Objective*

- To develop analytical and design methods for improving the performance of existing direct-contact condensers at the Geysers and to retrofit one of the Geysers units for performance verification.

#### *Expected Outcome*

- Upon retrofit of the existing condenser, the condenser back pressure will be lowered significantly; this retrofit is estimated to have a pay-back period of less than two years.

### BACKGROUND AND STATUS

Pacific Gas and Electric Company (PG&E) owns and operates a set of approximately 14 power plants at the Geysers, utilizing the geothermal steam resource. PG&E produces about 750 MW<sub>e</sub> from the Geysers steam resource, making the power available to California consumers. On some of the power systems (called Units), PG&E has experienced performance problems from existing condensers as evidenced by increased operating back pressures and a high carry-over of steam with the non-condensable gases which must be vented. Over the years, PG&E has pursued different approaches, with limited success, to improve condenser performance. PG&E recognized the potential of the NREL developed condenser concepts for substantially improving the condenser performance and remains interested in developing those concepts into workable hardware.

NREL, DOE and PG&E have agreed to carry out a collaborative research and development effort to develop field test equipment and test data which will quantify the potential heat-transfer performance and non-condensable gas handling characteristics of these advanced condenser concepts. These condenser developments will be applicable to all steam power plants with a potential for improvement of plant heat rate by as much as five percent.

NREL and PG&E are working under a Cooperative Research and Development Agreement (CRADA) to demonstrate the use of advanced design techniques and designs to improve thermal performance and scavenging of non-condensable gases in direct-contact steam condensers, thereby improving the utilization of geothermal steam resource and reducing emission of non-condensable gases.

The work to be carried out was divided in three Phases, with the indicated subtasks:

- I. Conceptual Design Development
  - A. Condenser code upgrade for geothermal applications
  - B. Selection of packing
  - C. Performance projections
  - D. Conceptual design
  - E. Decision analyses for proceeding to the following phases
- II. Engineering Design and Installation (pending Go/No go decision)
  - A. Steam, gas and water chemistry acceptability analyses
  - B. Engineering design
  - C. Procurement and Installation
- III. Operational Tests
  - A. Instrumentation
  - B. Operational tests
  - C. Model validation
  - D. Reporting

Phase I was carried out in FY 1994 by NREL. Phase II was implemented in FY 1995, with the definition of design and costs by March 1995, and the Go/No go decision for this project was made in July by PG&E with a go ahead for the project. The schedule for continuing the project accommodates the installation of the ADCC during the next major overhaul and maintenance of the selected unit, which was scheduled for December 1996.

## **APPROACH**

### Phases II and III. Engineering Design and Installation and Testing

PG&E completed a detailed engineering design of the proposed modifications, initiated procurement, and scheduled installation. NREL provided technical guidance to move the project from the conceptual to the engineering stage.

During Phase III, begun in FY 1996, NREL evaluated the requirements for instrumentation to gather data for use in model validation. NREL, in collaboration with PG&E, conducted a series of pretests on the existing condenser hardware to ascertain the present performance.

Upon completion of installation and commission of the new hardware, NREL, in collaboration with PG&E, will conduct a series of post tests, expected to occur in Spring 1997, on the new condenser hardware to ascertain its performance. NREL will issue a research summary report on the results by 1997 fiscal year end.

## RESEARCH RESULTS

A working version of a computer code for modeling the direct-contact condenser together with the accompanying chemical reactions has been developed by NREL. This code has been exercised by PG&E personnel to evaluate the operation of Unit #11 of the PG&E power plant at the Geysers. These results have been used to develop designs for the retrofit. The project is progressing according to the original plan. However, on account of demands and pricing for electricity and other outages within the PG&E system, the major overhaul planned for Unit 11 had to be rescheduled to December 1996.

## FUTURE PLANS

Upon successful installation and demonstration of the improvements at one particular unit at the Geysers, modifications to other units may be pursued depending upon the established economic viability of the system.

## INDUSTRY INTEREST AND TECHNOLOGY TRANSFER

This project was initiated upon expressed interest of PG&E. Upon completion of the project with validated results, substantial interest from other power producing organizations may be expected.

## REFERENCES

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