TESTING OF AN ADVANCED DRY COOLING TECHNOLOGY FOR POWER PLANTS IN ARID CLIMATES

Final Report

(for the period February 1, 2011, through September 30, 2013)

Prepared for:

Diana Hulme

School of Energy Resources
University of Wyoming
Department 3012, 1000 East University Avenue
Laramie, WY 80271

Prepared by:

Christopher L. Martin
John H. Pavlish

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

2013-EERC-09-13

September 2013

EERC DISCLAIMER

DISCLAIMER

TESTING OF AN ADVANCED DRY COOLING TECHNOLOGY FOR POWER PLANTS IN ARID CLIMATES

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) is developing a novel dry cooling technology to meet the cooling needs of power plants located in arid environments. This technology is intended to address the key shortcomings of conventional dry cooling technologies: high capital cost and degraded cooling performance during daytime temperature peaks. The key feature of desiccant dry cooling (DDC) technology is the use of a hygroscopic working fluid—a liquid desiccant—as a heat-transfer medium between a power plant's steam condenser and the atmosphere. This configuration affords several advantages for overall cooling system performance.

The overall goal of this project was to accurately define the performance and cost characteristics of DDC to determine if further development of the concept is warranted. In order to achieve this goal, necessary supporting project efforts were divided into several activities, including experimental performance measurement of a DDC system, extrapolation of the measured results to full-scale power plants, development of an economic model for DDC, and finally, case study calculations to compare the features of DDC to the conventional cooling options of wet recirculating cooling and an air-cooled condenser (ACC).

The resulting performance and economic models were used to evaluate case studies which were based on cooling a 300-MW_e net coal power plant for three different locations: Gillette, Wyoming; Atlanta, Georgia; and Phoenix, Arizona. The case study calculations indicate that DDC consistently maintained a lower annual cooling system cost compared to an ACC. Annual cooling costs for DDC averaged 60% of those of an ACC for the evaluated cases. Parasitic power requirements for DDC were also estimated to be lower, averaging 65% of those for a comparable ACC. Compared to wet recirculating cooling, the annual costs for DDC were within ±10% of the comparable wet system including the energy penalties associated with lost power production with the desiccant system. The breakeven cost of water for DDC ranged from a low of $1.72/kgal for Atlanta to a high of $3.35/kgal for Phoenix for the specific assumptions used.

Regarding the potential environmental impacts of DDC, experimental testing supports the hypothesis that DDC can be an environmentally benign cooling option. The key environmental concern, carryover of desiccant, appears to be manageable with proper design and operation of the cooling system. Measured drift rates were determined to be less than 0.00006% of the circulating working fluid rate. However, it is desirable to demonstrate an even lower limit for drift to avoid potential particulate emission limits that are currently imposed on conventional wet cooling towers.

This project has also highlighted the key technological steps that must be taken in order to transfer DDC into the marketplace. To address these issues and to offer an extended demonstration of DDC technology, a next-stage project should include the opportunity for outdoor ambient testing of a small DDC cooling cell.

This project was funded through the EERC–U.S. Department of Energy (DOE) Joint Program on Research and Development for Fossil Energy-Related Resources Cooperative Agreement No. DE-FC26-08NT43291. Nonfederal funding was provided by the Wyoming State Legislature under an award made through the Wyoming Clean Coal Technologies Research Program.