Novel Controls for Economic Dispatch of Combined Cooling, Heating and Power (CCHP) Systems

Enabling More Widespread Use of CCHP in Light Industrial, Commercial, and Institutional Applications

This project will develop and demonstrate novel algorithms and dynamic control technology for optimal economic use of CCHP systems under 5 MW.

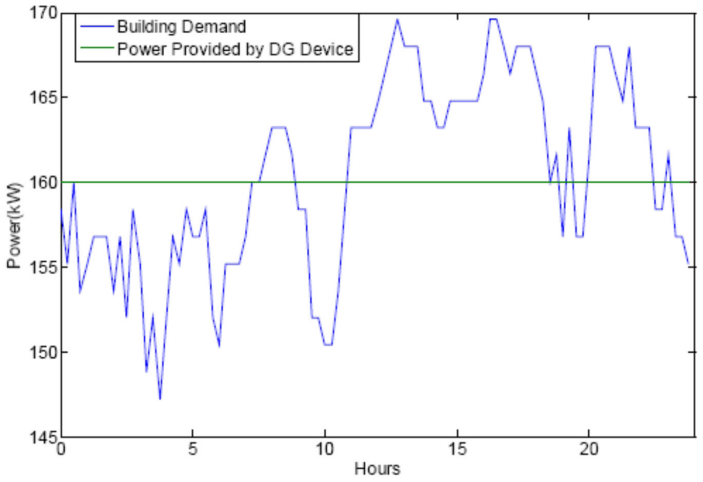
Introduction

The emergence of technologies that efficiently convert heat into cooling, such as absorption chillers, has opened up many new opportunities and markets for combined heat and power systems. These combined cooling, heating and power (CCHP) technologies have successfully entered the market for larger, over 20 MW applications. Smaller systems, between 500 kW and 5 MW, however, have not seen similar market penetration.

Among the barriers to more widespread use of CCHP technologies in the smaller applications are lack of cost-competitive system options and lack of end-user knowledge about the potential benefits of the systems. In addition, a significant barrier is the dynamic nature and relative non-coincidence of the thermal and electrical loads in many of the smaller applications.

The goal of this project is to develop and demonstrate algorithms and control systems that enable optimal economic use of CCHP systems in light industrial, commercial, and institutional applications.

To achieve this, existing CCHP systems and typical electrical, heating, and cooling loads need to be modeled. Based on the modeling, algorithms and architecture for economic dispatch of heating, cooling, and electrical power will be developed and applied to Siemens control technology. The new control technology will be tested and evaluated in an existing CCHP system.



The dynamic nature and non-coincidence of building energy demands with power generated by distributed energy resources creates a challenge for system control and integration.

Illustration courtesy of University of California, Irvine

Benefits for Our Industry and Our Nation

The CCHP control systems and technology under development are expected to increase market penetration of such systems in the light industrial, commercial, and institutional markets. As CCHP systems are much more efficient than separate generation of thermal energy and electricity, more widespread use of these systems will result in significant energy savings as well as reductions in greenhouse gas and criteria pollutant emissions.

The control algorithms will be designed to improve the economics of CCHP systems by maximizing the value of the electricity and thermal energy produced. This will result in financial savings for system owners, while emissions are reduced.

Applications in Our Nation's Industry

The control technology being developed is expected to encourage more widespread use of CCHP systems in light industrial, commercial, and institutional sectors. The likely applications in the 0.5–5 MW size range utilize thermal energy primarily for space heating and cooling, but thermal output can also be used for process heating and cooling.

The light industrial market for CCHP applications is estimated to be 18–54 GW. Market potential for similar applications in the commercial and institutional sectors is estimated at 75 GW.

Project Description

This project will develop and demonstrate algorithms and control systems technology to optimize economic use of CCHP systems in light industrial, commercial, and institutional applications.

Barriers

The project seeks to overcome the following barriers in the development of a CCHP control system:

- Challenges created by the highly dynamic nature and non-coincidence of thermal and electrical loads in targeted applications
- Lack of accurate and realistic dynamic modeling of thermal and electrical loads and CCHP systems
- Difficulty in integrating developed algorithms into control technology software and hardware

Pathways

In the first part of the project, dynamic physical and economic models will be developed for CCHP systems and their components. In addition, dynamic electrical and heating loads will be measured for typical CCHP applications; data from other ongoing building monitoring projects will also be utilized in this task. To verify developed models, simulations of existing CCHP systems will be conducted and the results compared to system measurements.

Based upon the CCHP models and load measurements, algorithms and architecture for economic dispatch of cooling, heating, and power from CCHP systems will be developed. These new algorithms and architecture will then be translated and applied to Siemens control technologies. To successfully achieve this task, Siemens Corporate Research is partnering with UCI in the effort. The performance of the developed algorithms and control hardware will be tested in an existing CCHP system.

In the last phase of the project, integration of the developed control systems and economic dispatch models with high-temperature fuel cells, ultra-capacitors, and other emerging energy conversion and storage technologies will be analyzed.

Milestones

The project started in early 2010. Project milestones and deliverables include:

- Description of the steady-state and dynamic physical models of combined cooling, heating and power technologies
- Review of methods and analytical strategies for conducting economic and environmental assessment of technologies
- Dynamic measurement of relevant electrical and thermal loads
- Dynamic simulation of CCHP systems and comparison of model results to measured data
- Development of novel dynamic control algorithms
- Design, installation, and verification of control algorithms, hardware, and software
- Report on applying modeling and control systems to integrated CCHP systems, including fuel cells and other emerging technologies

Commercialization

The new control algorithms and architecture will be integrated into the Siemens line of industry automation and building monitoring and control products. Once the new control technology performance is tested and verified, it can quickly and successfully enter the market through Siemens' established product lines and marketing channels.

Project Partners

University of California, Irvine (UCI)
Irvine, California
Principal Investigators: Jack Brouwer, jb@apep.uci.edu; Scott Samuelsen, gss@uci.edu

Siemens Corporate Research
Princeton, New Jersey

California Energy Commission
Sacramento, California

For additional information, please contact

Bob Gemmer
Technology Manager
U.S. Department of Energy
Advanced Manufacturing Office
Phone: (202) 586-5885
E-mail: Bob.Gemmer@ee.doe.gov

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INFO (1-877-337-3463)
eere.energy.gov/informationcenter

DOE/EE-0443 • December 2011
Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.