Increasing the Market Acceptance of Smaller CHP Systems

This project developed a flexible, packaged combined heat and power (CHP) system that produces 330 kilowatts (kW) of electrical power output and 410 kW of thermal output while increasing efficiency and reducing total cost of ownership.

Introduction

Many CHP systems less than 1 megawatt (MW) use reciprocating internal combustion engines. Unfortunately, reductions in the size of these engines are associated with reduced efficiency and increased maintenance costs.

This project leveraged core technologies developed under the U.S. Department of Energy's (DOE) Advanced Reciprocating Engine Systems (ARES) program to lower costs while increasing efficiency.

The project resulted in one of the highest-efficiency systems for a CHP project less than 1 MW in size. The packaged system is expected to increase the adoption rate of smaller CHP systems through simplified installation and reduced total cost of ownership.

Benefits for Our Industry and Our Nation

This project's CHP package will improve the economics of ownership and contribute to a reduction in domestic energy intensity.

Potential benefits of this CHP package include:

- Significant energy savings, equating to an estimated 36% reduction in the end-user's fuel consumption compared to a standard Cummins engine
- Estimated brake thermal efficiency of 38% and overall system efficiency of more than 70% (high heating value)
- Meets U.S. Environmental Protection Agency (EPA) emission standards for nitrogen oxide (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs)
- Yearly reduction of carbon dioxide emissions by 950 tons compared to separate generation of electricity and heat, given 8,000 hours running time
- Lower total cost of ownership including maintenance and installation

The prepackaged and containerized CHP prototype system was installed at Cummins Power Generation plant in Fridley, Minnesota. *Photo credit Cummins Power Generation.*

Applications in Our Nation's Industry

This project will target small applications (100–500 kW power range) in numerous industries, institutions, and other facilities, including:

- Schools and universities
- Hospitals and nursing homes
- Hotels and resorts
- Small facilities in the chemical, food processing, and plastics industries

Project Description

This project developed a flexible, 330 kW packaged CHP system that can be deployed to small industrial and commercial applications at a lower cost than other CHP solutions. The project leveraged prior engine efficiency developments achieved under the DOE-ARES program. A lean-burn combustion configuration provided enhanced reliability and emissions that meet EPA standards. Remote monitoring and control utilizing predictive service and advanced diagnostics additionally minimized maintenance costs and system down time, which will facilitate mass adoption. Overall, lower initial capital investments and improved system capabilities will increase the market acceptance of this small CHP packaged system.

Barriers

- Integrating standard components into a flexible, packaged system, thus reducing initial capital cost
- Developing comprehensive predictive service and advanced diagnostic algorithms and statistical models
- Simultaneously maintaining NO_x, CO, and VOC emissions while increasing efficiency
- Lowering system sound levels to meet commercial customer requirements

Pathways

Cummins Power Generation (CPG) and Cummins Engine Business Unit (EBU), both entities of Cummins Inc., were the primary partners for this project. To ensure that customer needs are met, CPG performed a "voice of the customer" analysis. CPG interviewed potential customers to determine the CHP characteristics most likely to lead to widespread adoption. These "voices" then translated directly into specific product prototype requirements.

As a sub-contractor to CPG, Cummins EBU designed the advanced engine within the Cummins Technical Center (CTC). CPG also managed the controls design and thermo-mechanical integration of the system.

Once the heat recovery system, 330 kW genset, and control system were completed, CPG produced a prototype CHP system. CPG then integrated the prototype system into a field test site to test and measure system performance.

Milestones

- Design and development of heat recovery system
- Design and development of CHP controls and switch gear requirements
- Design and development of advanced engine, controls and sensors, and support hardware
- Design, development, and validation of CHP package
- Validation of installation and operability at a customer site

Accomplishments

- Project team created a flexible system delivering the expected electrical and thermal power outputs and established a path to low-cost commercialization. Observed efficiencies of 70-75% higher heating value (HHV) correspond to significant reductions in operating costs, while the fully prepackaged and containerized solution drastically simplifies installation.
- CHP package incorporates user-friendly predictive service and diagnostic capabilities as well as innovative local and remote monitoring systems.

Commercialization

CPG will integrate custom and off-the-shelf components from the CHP prototype to create a new product for the Cummins line of distributed power solutions. In commercializing the developed CHP system, a key goal will be cost reduction. Based on feedback from customers, CPG will need to achieve a payback of less than 6 years for the small industrial and commercial markets.

The initial product will be marketed to mainstream end-users via the Cummins Energy Solutions Business, with commercialization eventually transitioning to the extensive Cummins distributor network.

Project Partners

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