Combined Heat and Power: Kauai Marriott

Benefits of propane-fueled CHP demonstrated at Hawaiian beach resort

Commercial buildings in the United States currently draw over one trillion kWh annually—approximately 20 percent of the nation's primary energy consumption—with demand projected to increase 60 percent by the year 2020. As on-grid electricity becomes increasingly costly for large commercial facilities, Combined Heat and Power (CHP), a form of distributed generation (DG), offers an alternative to purchasing electricity from local suppliers. Propane-fueled CHP systems can produce thermal and power output, addressing both heating and electrical needs for institutional, agricultural, commercial, and industrial facilities.

CHP eliminates transmission and distribution losses associated with purchasing electricity via the central grid, and recovered waste heat is used to meet a facility's space heating, water heating, and cooling needs. As a result, CHP systems operate at 70 to 80 percent (electric and thermal) efficiency, compared to the typical gas engine electric efficiency of 35 to 45 percent. In Hawaii, the state with the highest utility rates nationwide, the current cost advantage of a typical on-site commercial CHP installation is approximately 10 cents/kWh compared to purchase from the local utility.

To reduce energy-related costs at the Kauai Marriott Resort and Beach Club, Marriott formed a partnership with the Propane Education & Research Council (PERC), the Gas Technology Institute (GTI), The Gas Company of Hawaii (TGC), and the U.S. Department of Energy (DOE), to initiate *Design, Testing, and Verification of an Advanced Integrated Energy System at Marriott Hotel, HI* (**Docket 10974**). This project is expected to save the resort about $706,000 per year.

Project Description

The project has the following objectives:

- Design, install, and test an optimized propane-fueled CHP system, consisting of a continuous-duty reciprocating genset engine with heat recovery steam generator and absorption chiller
- Create a template to guide future CHP system installation
- Develop a testing procedure for industrial propane-fueled reciprocating engines that can be further developed and implemented as an industry-wide testing/performance standard
- Provide recommendations on future advancements of reciprocating engines

A Caterpillar 3516B engine similar to the two 3412 units to be used at the Kauai Marriott.

CHP Benefits in Brief

CHP systems are increasing in popularity due to the following benefits:

Customer Drivers

- Reduce energy costs
- Improve power quality
- Increase reliability
- Reduce emissions
- Reduce energy waste and water usage

Industry Drivers

- Expand product options with demonstrable benefits
- Increase propane sales
- Increase off-season load

GTI estimates CHP penetration for lodging and health care markets could increase propane sales by 150 million gallons over the next five years.

The Kauai Marriott CHP system will cogenerate electricity and hot water. The containerized engines will be installed at the loading dock pictured below.

Performance Testing

To broaden applicability and address implications of variations in fuel composition, the Marriott team proposed testing the effects of varying propane specifications on performance and life of reciprocating engines in continuous duty operation. The program includes periodic analysis of the gas stream supplying the engine to determine the rate of increased concentration of heavier constituents forecast to degrade engine life and performance.

The proposed testing program, developed by PERC, GTI, TGC, and Caterpillar, includes:

- Develop the lab testing program (range of propane grades/constituents based on propane industry feedback, patterns of variation, etc., including effects on emissions).
- Test engine at GTI for the entire range of propane grades to thoroughly understand the effects of varying fuel constituents on engine output, efficiency, heat rejection rates, and emissions; and analyze the gas periodically to determine if constituent concentrations vary.
- Verify test results in-field through limited tests of Marriott system.
- Monitor system performance for one year of operation including periodic gas analyses.
- Identify/confirm areas for further equipment development, testing, etc.

Project Status: In Progress

Marriott will install the propane-fueled CHP system in spring of 2007. The onsite power and heat recovery equipment is expected to use about 860,000 gallons of propane per year, and meet all of the domestic water and pool heating needs for the one-million square foot facility at 70 to 80 percent energy efficiency.

Conclusions

The successful completion of this project will provide valuable testing and in-service performance information on commercial propane-fired engine technology. This data is expected to lead toward propane CHP applications beyond current "back-up" or emergency generation applications to new markets and continuous use in DG/CHP.

This project will enhance market development for propane in CHP in larger-scale commercial facilities, providing the industry with substantial load potential in high load factor (year-round) applications.

The Kauai Resort and Beach Club CHP System

The CHP system is comprised of two 405 kW propane-fired reciprocating engines, a 244-ton absorption chiller, a 480-ton cooling tower, an 800-gallon water pre-heating tank, and additional balance of plant to supply recovered heat.

The CHP system will provide 50 percent of the hotel's base power load on a 24-hour basis while maintaining system efficiency in the range of 70 to 80 percent. The heat recovery system is designed to meet 100 percent of the hotel's domestic water heating load and 15 percent of its cooling load, effectively eliminating two existing low-performing heat pumps.

Analysis of the proposed CHP system showed payback of capital costs within four years based on anticipated energy savings.

A Trane 600-Ton Absorption Chiller (left) and Cain Industries Engine Exhaust Heat Recovery Unit (right) used during preliminary lab testing at GTI.

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