PROPANE education & research COUNCIL

KAUAI RESORT Marriott

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Propane-fueled combined heat and power

Reducing operating costs and emissions at Kauai Marriott Resort and Beach Club Lihue, Kauai Island, Hawaii

Facility profile	• Full-service resort • More than 1 million square feet, including 350 hotel rooms and 200 time-share apartments • 26,000-square-foot pool • 18-hole golf course • 88 percent occupancy rate
Demonstration period	18 months (November 2008–April 2010)
Installed generators	Two 405-kilowatt units
Annual fuel use	580,969 gallons of propane
Annual generation	5,711 megawatt-hours
Annual operational savings	$1,711,639
Annual bottom-line savings	$572,754
Estimated annual emissions savings	• 22 tons of nitrogen oxides (NO_x) • 9,824 tons of carbon dioxide (CO_2) • 45 tons of sulfur dioxide (SO_2)
Payback period	6.3 years

The Propane Education & Research Council and the Gas Technology Institute field-tested an 810-kilowatt propane-fueled combined heat and power system at the Kauai Marriott Resort and Beach Club. The field test provides the propane and lodging industries with needed data on the in-service performance of propane-fueled engine technology for continuous use in commercial combined heat and power and distributed generation applications.

The Team

Project partners include the Gas Technology Institute (teaming with The Gas Company through the National Accounts Energy Alliance), PERC, and the Kauai Marriott Resort and Beach Club.

The Old System

The resort provided electricity, air conditioning, and hot water for guest use and hotel operations using two new 450-ton electric chillers for air conditioning, two 20-year-old 140-ton heat pumps for hot water and supplemental cooling, and two diesel-fired steam boilers for laundry and kitchen use.

The New System

The new building cooling, heating, and power system replaces the aging 140-ton heat pumps with two 405-kilowatt Caterpillar 3412LE generator sets, a heat recovery system, and a 244-ton absorption chiller. The system is integrated with the resort's existing diesel-fired boilers (which now provide steam for laundry use and supplemental domestic hot water heating) and 450-ton electric chillers. To preserve the resort's electric rate structure, the system is sized to allow the resort to purchase electricity from the grid and use on-site generation only as a supplement to meet at least 50 percent of the resort's daily electric load.

How It Works

The generator sets efficiently combust propane fuel to generate electricity, which is fed into a facility system that can provide power to the entire campus. Heat exchangers capture waste heat produced by the generators and transfer it to the resort's swimming pool, domestic hot water system, and absorption chiller. Any unrecovered waste heat is dumped to a 600-ton cooling tower. The hot water system uses the captured heat to heat water for domestic uses (such as bathing, showering, and washing dishes). The absorption chiller uses the captured heat to provide chilled water for a portion of the resort's air conditioning. Switchgear and a utility transformer connect the system to the electrical grid. A web-accessible data monitoring program measures the system's overall mechanical and economic performance, collecting data at 15-minute intervals from approximately 50 instruments.

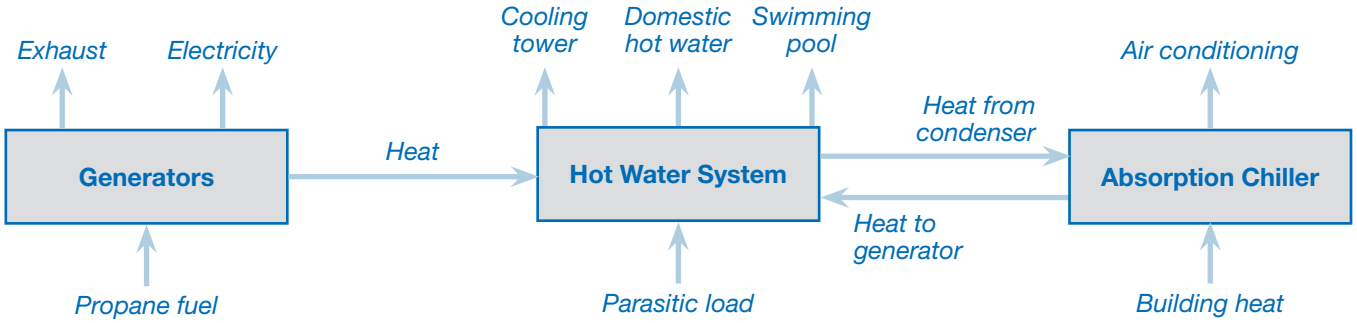
Energy Flow

The system's energy input includes propane fuel (to drive the generators), parasitic load (i.e., electricity consumed by engine radiators, water pumps, and the cooling tower fan), and building heat that is picked up by the chiller cooling water

Technical Performance

Hours of operation	7,213 hours
Fuel consumption	53,532,000 British thermal units 580,969 gallons of propane
Total combined heat and power generation	5,711 megawatt-hours
Percentage of daily electric load	At least 50 percent
Percentage of nightly electric load	At least 70 percent
Percentage of domestic hot water heating load	At least 75 percent
Percentage of pool heating load	100 percent
Average capacity factor	82.3 percent
Average net electrical efficiency	27.8 percent
Average total system efficiency during demonstration	73.0 percent
Expected total system efficiency	Between 80 percent and 90 percent

The three-phase, 405-kilowatt Caterpillar generators are rated at 506 kilovolt-amperes, 480 volts, 1,800 revolutions per minute, and 60 Hertz.



return and transferred to the absorber evaporator. The system's energy output includes electricity produced by the generators, heat exhausted out the stacks, heat delivered to the hot water system and the pool, and heat dumped to the cooling tower.

Capital Costs and Financing

The final installed project cost was $3,611,622. Co-funding from GTI, the Department of Energy, and PERC covered 17 percent of the project costs ($616,000), with Marriott paying for the remainder. No tax credits were available at that time.

Estimated Payback

Several factors limited savings from operation during the demonstration, including record-low electricity rates, unusually high propane prices, and technical issues that prevented the system from realizing the maximum savings from pool heating and absorption cooling.

Low electricity rates were especially problematic because a majority of the savings from operation are derived from the cost of utility-provided electricity that is displaced by on-site generation. As a result, the payback period, calculated based on performance during the demonstration, totals approximately 20 years. Under more realistic circumstances (a price of 30 cents per kilowatt-hour of electricity and a price of $2.30 per gallon of propane), the system can realize a much shorter payback period—6.3 years.

Business Benefits

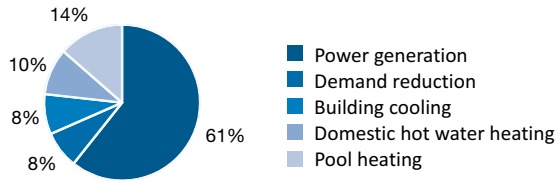
- ***Reduced dependence on expensive grid-supplied electricity.*** The system generates power and captures waste heat to meet a portion of the resort's electric, heating, and cooling loads.
- ***Reduced energy costs.*** With average electricity and propane pricing, the system could save an estimated $572,754 per year.
- ***Domestic hot water heating.*** The system provides at least 75 percent of the resort's domestic hot water heating.
- ***New pool heating.*** Before the project began, the resort did not heat the outdoor pool. Now, the system maintains the outdoor pool at 80 to 85 degrees Fahrenheit, improving the guest experience year-round.
- ***Reduced greenhouse gas emissions.*** The system reduces the resort's emissions by an estimated 22 tons of nitrogen oxides, 45 tons of sulfur oxides, and 9,824 tons of carbon dioxide. The reduction in carbon dioxide is equivalent to removing 1,623 passenger vehicles from the road.
- ***Improved efficiency.*** The system, which is optimized to minimize wasted heat, has an estimated operating efficiency of 80 to 90 percent.
- ***Improved performance monitoring.*** The data monitoring program helps the resort monitor system performance to maximize energy and environmental savings.
- ***Discreet, quiet operation.*** The generators are installed with noise-dampening, weather-resistant enclosures in an open area that is out of guest sight.

Financial Performance

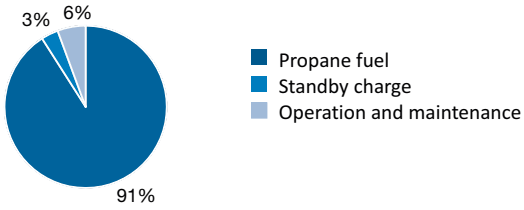
	Demonstration Period	Average Fuel Pricing
Annual savings from operation	$1,711,639	$2,043,252
Annual cost to operate	$1,531,713	$1,470,498
Annual bottom-line savings	$179,926	$572,754
Estimated payback	20 years	6.3 years

Note: Savings from operation represent money that the resort saves by generating some electricity on-site (rather than purchasing it) and transferring captured waste heat to the swimming pool, domestic hot water system, and absorption chiller.

Savings from Operation



Cost to Operate



Would Propane-Fueled Combined Heat and Power Be a Good Fit for Your Hotel?

A propane-fueled combined heat and power system could be a good choice if your hotel has the following:

- Year-round, consistently high demand for hot water and cooling.
- A use for the captured waste heat, such as pool heating, domestic hot water heating, space heating, or absorption cooling for air conditioning.
- High grid-supplied electricity costs.
- A short-term need to replace aging or inefficient boilers or other equipment.
- A need to provide reliable power during grid outages.
- Operations that have already incorporated basic energy efficiency measures.
- Unreliable grid supplied electricity.

Assumptions

The following numbers were estimated based on performance data from months featuring a capacity factor greater than 60 percent: annual fuel use, annual generation, annual operational savings, annual cost to operate, annual bottom-line savings, annual hours of operation, average capacity factor, average net electrical efficiency, and average total system efficiency.

The estimated annual operational savings, cost to operate, bottom-line savings, and payback period with average fuel pricing assume a price of 30 cents per kilowatt-hour of electricity and $2.30 per gallon of propane. Figures include the potential cost savings realized by using captured waste heat instead of propane-fueled heaters for pool heating.

The expected total system efficiency value of 80 percent to 90 percent is the system's capability when the absorption chiller is functioning properly and the pool requires heat.

Project:

Design, Testing, and Verification of an Advanced Integrated Energy System at a National Hotel Resort (Test and Verification Program Expansion) — **Docket 10974**

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