



ICF Quick Take

CHP Demonstration Shows Benefits at Data Center

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Data Centers Are a Huge Electricity Consumer, and Demand is Growing

Data centers are a large and fast growing consumer of electricity. Research indicates that data centers consume 1.6 to 2.2% of electricity used in the United States.^{1,2} The Natural Resources Defense Council reports that in 2013 data centers consumed 91 billion kWh of electricity – enough electricity to power 8.3 million homes³ – and are on-track to reach 140 billion kWh by 2020.⁴ This high electricity demand for data centers, and the projected rapid growth, puts strain on the electric grid, which can lead to higher electricity costs and reduced grid reliability.

CHP is an Under-Utilized Solution for Data Centers

Combined heat and power (CHP) is an under-utilized solution that can significantly reduce demand for grid electricity at data centers. In addition to reducing electricity demand and relieving stress on the grid, CHP can reduce energy costs for data center operators and reduce emissions, thereby providing environmental benefits.

While the energy efficiency benefits of CHP are well matched to data center needs, the adoption of CHP has been slow at data centers. One barrier to the adoption of CHP is that data centers have sophisticated redundant backup power systems, and the addition of a CHP system is often viewed as an unnecessary additional layer to conventional data center power schemes.

All data centers have uninterruptible power supply (UPS) hardware to provide power in the event of a grid outage. A conventional data center UPS system typically includes power electronics and batteries integrated with one or more emergency backup generators. The cost of a conventional UPS system varies widely between data centers depending on the required electrical power capacity, specific hardware, and complexity of the control strategy. It is not uncommon, however, for a data center UPS system to cost more than a million dollars. While the UPS function is vital, the cost of a conventional UPS system is high given that most UPS systems are only needed to back up the grid for a few hours each year.⁵

Capstone, a microturbine manufacturer based in California, recognized that CHP systems could offer benefits to data centers if CHP systems could be designed as an alternative to conventional UPS hardware. In response to this need, Capstone launched their Hybrid UPS product to provide data centers with all of the benefits associated with CHP technology plus the added benefit of avoiding the cost of installing or replacing conventional UPS hardware.



¹ E. Masanet et al., 2011, Estimating the Energy Use and Efficiency Potential of U.S. Data Centers, IEEE Proceedings, [web link](#).

² J. Koomey, 2011, Growth in Data Center Electricity Use 2005 to 2010, [web link](#).

³ In 2013, the average U.S. household energy consumption was 10,908 kWh/yr. Energy Information Administration, [web link](#).

⁴ Natural Resources Defense Council, online data, accessed July 2015, [web link](#).

⁵ In 2013, customers in Southern California Edison's service territory were without power for an average of 1.6 hours (94.5 minutes), 2013 Corporate Responsibility Report, p9, [web link](#), accessed January 2015.



ICF and SoCalGas Demonstrate a CHP System at a Data Center

With funding from the California Energy Commission, ICF and SoCalGas® assembled a team to demonstrate the Capstone Hybrid UPS technology at a SoCalGas data center in Monterey Park, California. The demonstration system included three Capstone Hybrid UPS microturbines integrated with one Thermax absorption chiller to meet partial load requirements for the Monterey Park data center. Regatta Solutions served as the general contractor, and completed the hardware installation in 2014.

CHP System Reduces Energy Costs and NOx Emissions

Demonstration results based on data collected between August 2014 and January 2015 are summarized in Table 1. As indicated, there was a significant reduction in energy costs attributed to operation of the CHP system – 20 to 44% depending on the operating schedule for the CHP Hybrid UPS system. In addition to reducing energy costs, the CHP Hybrid UPS system also produced environmental benefits. The South Coast Air Quality Management District (SCAQMD) permitted the system at 10 ppm CO and 9 ppm NOx (values reported at 15% oxygen). The CHP system complied with these stringent requirements, and based on SCAQMD tests, the CHP system reduced NOx emissions by 66% compared to NOx emissions associated with the consumption of grid electricity.

Table 1. Performance Results

Metric		Result
Electric Power Capacity		155 kW
Chilled Water Production		55 tons
CHP Overall Efficiency (1)		57%
NOx Emissions		66% reduction
Energy Costs	24 hr/day operation	20% reduction
	mid-peak and off-peak operation only	44% reduction

Note: 1) Based on electric power and thermal energy extracted from microturbine exhaust stream.

Potential Benefits for California

This CHP demonstration project was conducted at a single data center in California. To examine broader implications, ICF evaluated potential impacts of implementing CHP at data centers throughout California.

There are an estimated 1,200 data centers in California that collectively consume 5.2 billion kWh of electricity each year. A conservative market impact projection was developed based on the adoption of 50 CHP Hybrid UPS systems, each with a capacity of 500 kW (electric power plus cooling). The impact of installing 50 CHP Hybrid UPS systems is estimated to save California data centers nearly 98,000 MWh of electricity each year, and reduce electric demand by 25 MW. At 15.3 ¢/kWh, the CHP Hybrid UPS technology will help these data centers collectively save \$15 million each year.

In addition to helping data center owners and operators reduce energy costs, the CHP Hybrid UPS technology also provides benefits to California ratepayers. Reduced demand avoids the need for more generation, thereby allowing ratepayers to avoid the cost of these generation assets. Reduced consumption of grid electricity avoids NOx emissions and other criteria pollutants, which provides environmental benefits for all residents in California.

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