Dispatchable energy assets: key components in microgrids

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With the evolution and growth of microgrids, a wide variety of dispatchable distributed energy resources are now in place in numerous applications. Combined heat and power and other on-site energy sources are key microgrid components that deliver 24/7 resiliency and availability, and also maximize energy cost savings and revenue.

IMPROVING ENERGY RESILIENCE

Improving resilience is the principal driver for microgrid development. Utility grid interruptions and natural disasters have caused "energy resilience" to become firmly entrenched in the lexicon. The lessons of Superstorm Sandy and hurricanes Katrina, Irma and others have prompted activity at the federal level to push critical facilities like hospitals to provide more power.

According to Don Allik, former director of facilities for the University of Maryland Upper Chesapeake Medical Center (UCMC) in Bel Air, Md., "The only economical way to do that is through CHP, because to install additional emergency capacity to have that asset sitting there just in case is ultimately very expensive. With CHP powering our daily operations, we can save money and have that additional capacity."

The implementation of CHP provides the opportunity to develop a highly efficient and reliable microgrid. In many states like Massachusetts, New York and New Jersey, government-sponsored energy programs foster the use of microgrids and CHP as the key component of clean, efficient and cost-effective resilience. For example, the New Jersey Energy Resilience Bank opened a program after Superstorm Sandy that has approved funding of nearly $200 million for CHP-centric projects at hospitals and wastewater utilities. Funding prerequisites, such as island blackstart capability and operation of critical facility loads for one or more weeks without utility grid power or liquid fuel transportation, are aligned well with natural gas-fired CHP.

ECONOMIC DISPATCH

Significant savings and/or revenue can be extracted by displacing utility grid power consumption. For example, highly fuel-efficient simple or combined-cycle generation plants provide not only resilience but also attractive ROI opportunities. Peak shaving, or temporarily displacing grid power during a few peak hours, can avoid costly capacity and transmission charges that amount to savings of $100,000-$200,000 per megawatt in some locations. Another opportunity exists to reduce high locational marginal pricing when kilowatt-hour cost elevates due to utility grid supply and demand imbalance. This can occur during summer heat waves, winter freezes, central power plant interruptions, etc. Several other ancillary services revenue streams also exist in various locations, and dispatching of on-site generators can enable monetization of this energy savings and revenue.

> **"THE ENERGY COST SAVINGS ASSOCIATED WITH THE CHP PLANT PROVIDE THE POSITIVE CASH FLOW THAT ENABLES DEVELOPMENT OF THE [MICROGRID] PROJECT."**

According to Gearoid Foley, president of Integrated CHP Systems Corp., whose firm is developing multiple energy resilience and microgrid projects, "CHP not only provides the dispatchable capacity to allow a facility such as a hospital to operate as normal without grid power, but the energy cost savings associated with the CHP plant provide the positive cash flow that enables development of the project."

Existing communications, microgrid controls and information technologies not only make integration and dispatch of multiple generation sources feasible but also allow for layering of energy storage – both electric and thermal. Where electric and thermal loads justify the deployment of CHP, the opportunities for cost savings significantly increase, thereby improving the likelihood of project development.

Utilizing this approach, campuses such as Princeton University have developed highly effective hybrid microgrid resources, integrating CHP, gas and diesel reciprocating engine generators, energy storage, solar photovoltaic technology, demand management and more.

Princeton's microgrid assets include a 15 MW CHP plant powered by a gas turbine with heat recovery to generate steam, along with a chilled-water plant and thermal storage. At the university's High-Performance Computing Research Center, a CHP plant with a 1.9 MW reciprocating engine generator and absorption chiller can be flexibly dispatched. A 27-acre solar PV farm produces an additional 5.4 MW to supplement power from the grid. The center also operates other energy assets including numerous emergency generators that are dispatched during grid outages.

Utilizing its microgrid resources, Princeton University can operate in island mode during emergencies or remain connected to the grid in order to hedge its power purchases based on real-time prices in the wholesale market. The Princeton energy team uses an economic dispatch system, combining analysis and real-time data to determine which assets to use for the best economic benefit.

"We look at what it costs to make the next kilowatt-hour, and then we look at the price of power from the grid. Anytime the grid price is higher than our marginal cost to make kilowatt-hours, we dispatch the equipment," says Ted Borer, energy plant manager for Princeton University.

"Based on the status of the regional PJM electric grid, and the real-time price, our program analyzes all the variables – including weather conditions – and tells the facilities staff what equipment they should be running and when," adds Eric Wachtman, chief engineer for Princeton's cogeneration plant.

THE "H" IN CHP

When it comes to general building design, ambient-driven HVAC loads force a designer to size equipment to meet the peak operating load even though this load only occurs a minimal amount of the time. For microgrids this problem is even greater, as the investment in equipment can be significantly higher. Utilization of thermal energy storage allows designers to flatten the demand curve and use lower-capacity systems to meet the same load needs. This can help optimize costs by spending less on equipment that works longer hours.

Microgrid designs that incorporate CHP and thermal storage provide an even greater level of efficiency, cost optimization and resilience. Combined heat and power in conjunction with chilled-water or ice storage offers multiple benefits both for utility peak-shaving operation while the grid is available, as well as for increasing the effectiveness of the microgrid when the central grid is unavailable.

Hospitals benefit from CHP with the generation of steam and/or hot water year-round, and in summer they can utilize absorption chillers to lower power demands by displacing electric chillers. At the University of Maryland Upper Chesapeake Medical Center, waste heat from a Caterpillar 2 MW generator set is utilized to produce hot water as well as steam in a heat recovery steam generator. The system can direct steam into absorption chillers to create chilled water for air conditioning.

"The byproducts of a CHP system make it more efficient than traditional electricity," says UCMC's Allik. "Combined heat and power at the hospital runs at 65 percent to 75 percent efficiency (lower heating value [LHV]), much higher than the combined efficiency of the utility grid and boilers. Also, carbon emissions coming from a CHP plant firing natural gas are much lower than with other utility options."

Data centers that have large thermal needs to maintain space temperatures within server room limits benefit from cooling-only CHP, which, through the use of thermally activated chillers to offset electric demand for conventional chillers, can boost the effective energy output substantially. In regions like the Mid-Atlantic, a CHP plant with modern high-efficiency reciprocating engines (41 percent to 45 percent or more LHV) and absorption chillers can be economically dispatched for approximately 20 percent to 25 percent more hours against wholesale market prices than a simple-cycle plant, and a significant resilience advantage is gained by incorporating the chiller.

Princeton University has deployed a CHP plant for cooling the Ivy League school's High-Performance Computing Research Center. The CHP plant consists of a 41 percent electric efficient (LHV) gas-fueled generator set and absorption chiller that can be dispatched based on economic signals. With combined cooling and power, the overall CHP system energy efficiency is high enough that it can be dispatched often to produce energy less expensively than the power grid.

"Because the gas engine can run to offset operating expenses, it can 'pay for itself' rather than sit idle while waiting for a rare emergency," Borer says.

He adds, "By combining the gas engine with an absorption chiller, I can get 1.9 MW of power and 600 tons of cooling. It's an ideal combination for the data center."

Multifamily residential buildings often utilize CHP as a component of their microgrid. These plants provide winter heating, domestic hot water and summer cooling as components of the output, enabling the buildings to be fully functional without the electric grid. Commercial, industrial, institutional, municipal and other segments have also benefited from this for decades.

FUTURE GROWTH OF MICROGRIDS AND DISPATCH

The deployment of microgrids is growing. Pro-microgrid policies and incentives in many states are fostering future project design and development – through, for example, Massachusetts' Community Microgrid Program, New Jersey's Town Center DER microgrid program and New York state's NY Prize. Whatever the objectives of the microgrid design, the deployment of dispatchable generation including CHP can significantly enhance operating economics and thereby enable the development of more microgrids with resultant increased energy resilience, energy efficiency and security.

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