Using control systems to optimize microgrids with CHP

Proper system integration is key in today's increasingly complex projects.

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Photo Serge Zinger.

The microgrid/CHP system at the TWA Hotel.

Microgrids are a focal point of discussion in the district energy industry, and this trend does not appear to be going in any other direction but up. As the demand for microgrids has increased, so has their complexity. End users want to gain efficiencies from new technologies and hybrid systems to optimize their microgrids. With the increasing complexity, it is critical to incorporate robust, adaptable controls to ensure the successful commissioning, operation and maintenance of these systems. Whether the project driver is a post-natural-disaster recovery, the aftermath of wildfires or an energy reliability/resiliency goal, microgrid solutions are being discussed and deployed.

Microgrids are sophisticated systems that can generate electrical energy in parallel with or independent of the local electrical utility (main grid). Microgrids typically consist of a prime mover (combustion turbine or reciprocating engine) that can produce power/electrical energy, and they are often utilized with combined heat and power technology to produce steam or hot water. There are also hybrid microgrid systems – consisting of additional original equipment manufacturer (OEM) components – which are gaining popularity.

Whether a district energy system is considering a traditional microgrid, one coupled with CHP, or a hybrid microgrid, a major area of focus should be the supervisory control and data acquisition (SCADA) automation, balance-of-plant (BOP) control system and power management system (PMS). All of these will be used to integrate the OEM equipment and enable the microgrid to function as one coordinated system. This SCADA plant control system should be robust, reliable and responsive to make sure the entire microgrid system works as designed.

Photo Serge Zinger.

A microgrid/CHP system operator monitors hot water production at a SCADA workstation.

To illustrate the successful deployment of microgrid systems, it is useful to explore three different customer types in the New York, N.Y., metro area: Hudson Yards, a real estate megaproject; the TWA Hotel at John F. Kennedy International Airport; and New York University. While the considerations and needs driving each of their decisions to implement a microgrid may have varied, one critical common factor for all was the selection of an industrial-grade SCADA solution with a programmable automation controller-based plant control system.

MAXIMIZING POTENTIAL

Regardless of who the microgrid user is, or what the drivers are, the key to a successful project is the proper integration of OEM components and the intelligent dispatch of energy, both electric and thermal.

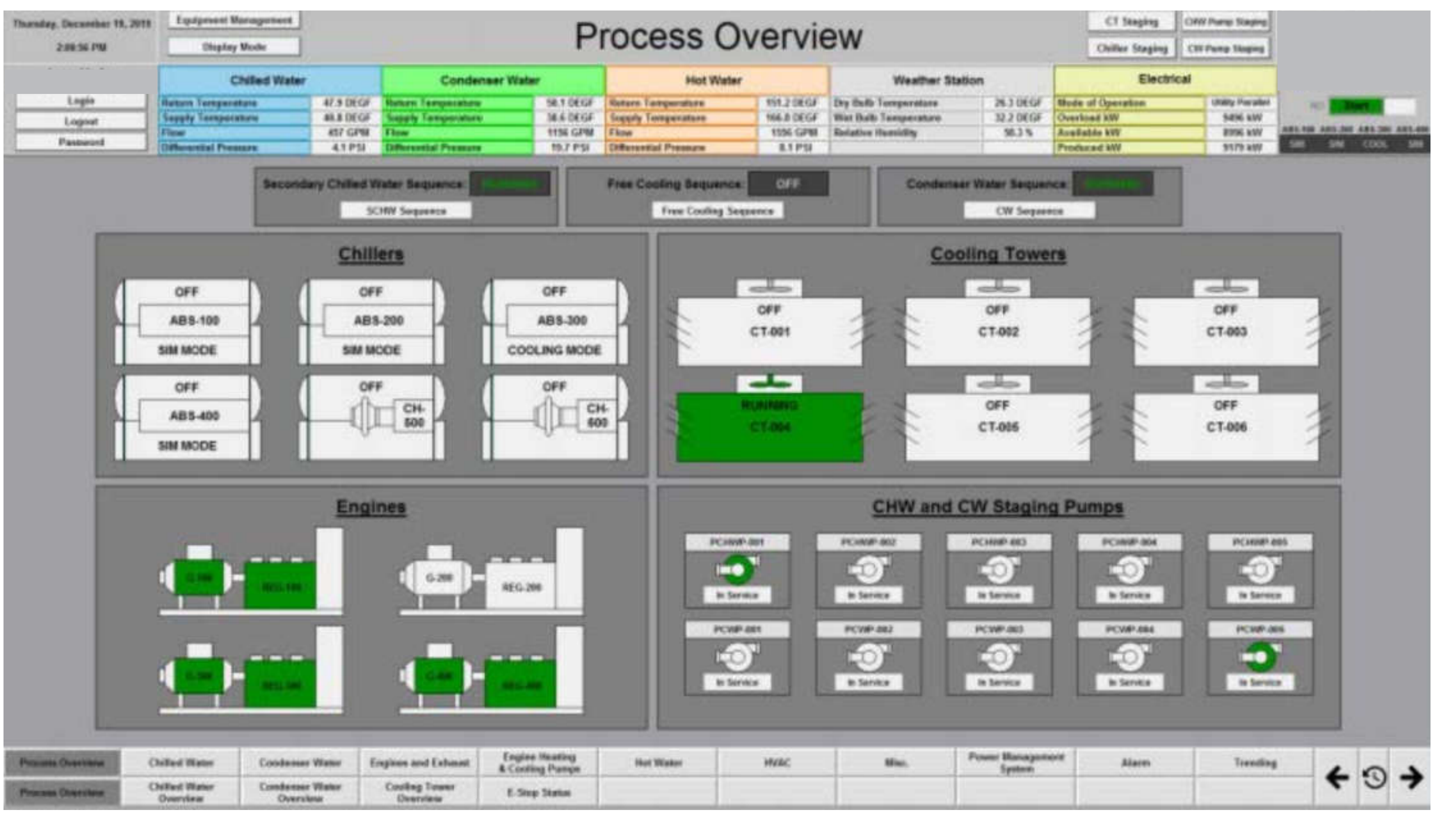
Microgrids with multiple generating resources, energy storage, varying loads and a connection to the utility company require a power management system. The PMS is typically responsible for breaker control/interlocks, load management (automatic load shed and/or restore) and coordination of generating resources. The PMS controllers require fast response times to handle unexpected events and to ensure the cogeneration facility is kept on line through upsets. In addition, the PMS provides remote monitoring/control and long-term historical trending using an overlaying SCADA system. The sequence-of-events reporting for analyzing alarms and determining trip root cause is also commonly included. Utility companies require access into the PMS to monitor critical microgrid information and to be able to trip generating resources offline should the need arise.

Many microgrids include cogeneration or CHP equipment as the source of on-site power generation. These cogeneration units typically utilize natural gas-burning engines or combustion turbines. Cogeneration facilities require use of the engine's or turbine's waste heat to maximize the system's efficiency and return on investment. A BOP control system can be installed within these facilities to coordinate and control the plant's OEM/BOP equipment and ensure the waste heat is utilized effectively. The BOP will also provide control of all the miscellaneous systems within the plant, which is required to keep the electrical generation equipment operational. These systems typically include natural gas, lube oil, gas detection, feedwater, cooling water, plant HVAC, etc. Similar to the PMS, a SCADA is overlaid on top of the BOP to provide remote control/monitoring, long-term historical trending, and alarm management.

See figures 1 and 2 for examples of SCADA human-machine interface screens depicting, respectively, the CHP system process equipment and the PMS used for management and/or coordination of electrical systems.

Effective coordination between the PMS and BOP systems is essential for fully maximizing the cogeneration and

FIGURE 1. Screenshot of combined heat and power system overview.



Source: Thermo Systems LLC.

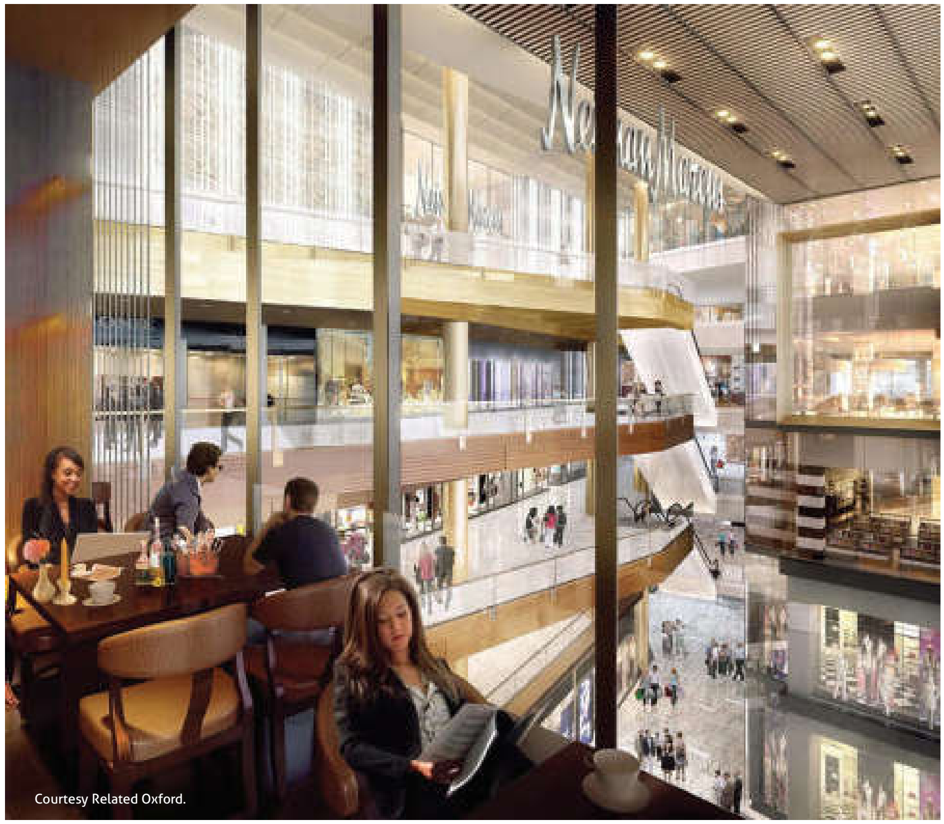
microgrid potential. Every site will have a unique solution based on utility agreements, electrical generating resources, equipment capabilities and thermal load profiles.

THREE SYSTEMS, UNIQUE SOLUTIONS

The microgrid systems with cogeneration operating at the three sites in New York – Hudson Yards, the TWA Hotel and New York University – were each established with different goals and drivers. These included having the ability to reliably keep the lights on and provide heating and cooling to campus buildings, use the microgrid as an infrastructure enhancement to attract tenants, reduce the site's carbon footprint and be the property's sole source of power. These customers are all achieving their goals with microgrids that exemplify the effective use of control systems.

Hudson Yards

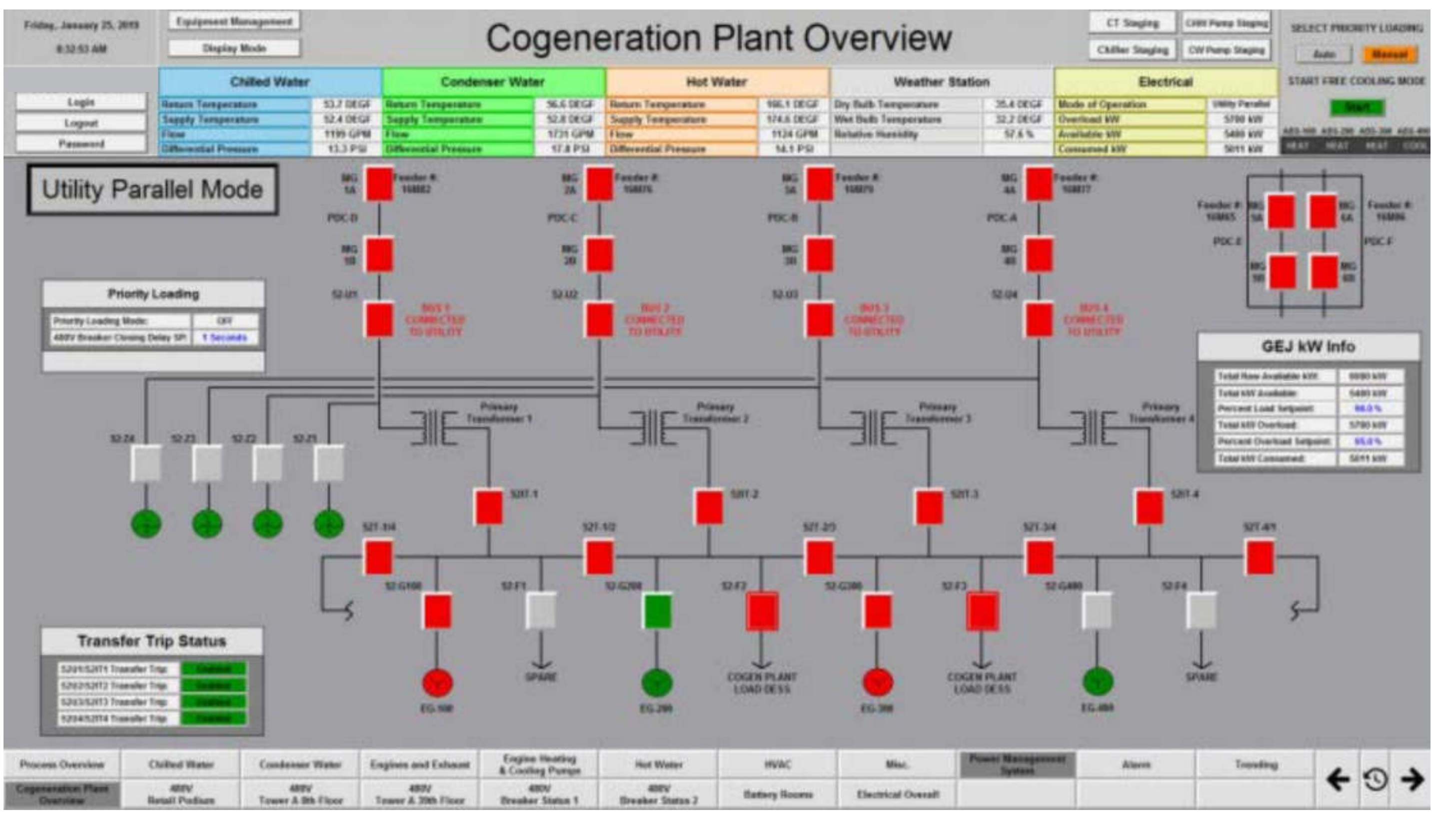
On Manhattan's West Side, Hudson Yards is New York's newest neighborhood,



Courtesy Related Oxford.

Restaurant view, the shops at Hudson Yards.

FIGURE 2. Screenshot of power management system overview.



Source: Thermo Systems LLC.

considered the largest private real estate development in the city since Rockefeller Center. Comprising 28 acres, it will ultimately include more than 18 million sq ft of commercial and residential space, along with more than 100 shops, a collection of restaurants, a public school, 14 acres of public plazas and gardens, and more. The microgrid/CHP system serving Hudson Yards comprises four reciprocating engines, four directly coupled absorption chillers and a free-cooling system.

Operation of the Hudson Yards microgrid system is financially driven. Depending on conditions at the site, the system may be either thermally or electrically led. Regardless of which approach is selected, the objective is to ensure that the tenant/retail spaces receive the best payback.

Once electrical demands are satisfied, the electrical output of the engines may need to be increased in order to produce more waste energy to satisfy the thermal demand (chilled or hot water) of the site. The decision of where to set the engine's output is determined with input from both the BOP and PMS systems. Using a programmable automation controller, the BOP collects information from the chilled- and hot water-consuming residents and tenants on the property. The BOP utilizes this information to determine where to invest the waste heat energy from the engine generator. The waste heat can be used to generate hot water, chilled water or both via the use of an absorption-type chiller.

Once the waste heat energy is properly allocated, the BOP can determine whether it has too much or too little waste heat available. If there is excessive waste heat, the plant will be required to reject the heat using cooling towers, which is a waste of the electrical energy created from the generators. On the other hand, if there is insufficient waste heat, then other boiler and chiller assets from the facility will need to be utilized. Based on the current state, the BOP will request that the generators increase or decrease output in an attempt to balance the waste heat with the thermal demand.

In a similar fashion, the PMS programmable automation controller is monitoring the demand of the electric energy customers to determine the appropriate electric output of the Hudson Yards CHP plant. The thermal and electric loads will likely never be equal. As a result, an advanced control scheme had to be developed to determine where the output of the engines will be set. This control scheme takes into account the electric rate structure with the utility company, availability of other plant assets and criticality of the load consumers. Additionally, the control scheme provides the ability to limit some customers' consumption in extreme cases. Without this control scheme and coordination, the engines cannot run at an optimal output, and the Hudson Yards plant would not meet the needs of its customers or could overproduce and negatively affect their efficiency and payback period.

TWA Hotel

In another case, the TWA Hotel – formerly the iconic Eero Saarinen-designed TWA Flight Center – at Kennedy Airport in Queens was constructed without connection to the electrical grid. This was done to avoid the high utility prices and costs for upgrading the old interconnection infrastructure that once provided

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The new TWA Hotel opened to guests in May 2019.

power to this 1960s-era TWA terminal building. With the aid of the microgrid, all the electrical and thermal energy at the TWA Hotel is generated on-site.

The property's microgrid includes three reciprocating engines and an electric storage system consisting of two batteries. The electricity and waste heat generated by the engines is utilized to produce the hot and chilled water for the hotel and convention center. The electric storage system provides the means to allow the engines to baseload while the battery maintains frequency and voltage. The electric storage system also provides a safety net to keep the lights on through any unexpected interruptions of power to the plant.

The coordination between this system's BOP and PMS is intertwined on many levels. In this case, both systems were combined into a single programmable automation controller, allowing for one central processor to monitor conditions and instantaneously make operating decisions. Without the grid for reliability and inertia, the plant's control system must make decisions regarding turning on and off engines, charging or discharging the battery, and using either gas-fired or electric chillers. Load shedding of noncritical loads in the case of an emergency is also utilized to maintain plant operations. Tight coordination between the PMS and BOP enables reliable, effective and efficient operation of this plant.

New York University in Manhattan's Greenwich Village.

New York University

In Manhattan's Greenwich Village neighborhood, New York University (NYU) operates a microgrid with CHP equipment to provide heating, cooling and electricity to its classroom, office and dorm buildings. The CHP system includes two gas turbines coupled with heat recovery steam generators. The gas turbines create electricity, and the heat recovery steam generators produce steam that feeds a steam turbine generator, a steam-driven chiller and steam-to-high-temperature-hot-water heat exchangers.

Under normal circumstances, the plant runs per design in a relatively simple control scheme; the gas turbines operate at maximum capacity, and the duct burners of the heat recovery steam generators modulate to match the steam demand of the steam turbine generators, chiller and heat exchangers as needed. NYU utilizes energy from the utility company to make up the excess demands of the campus buildings. The plant operates in this fashion 99 percent of the time.

However, in 2012 when Superstorm Sandy hit, and the electrical grid of lower Manhattan went dark, the plant had to change operations to an electrical island mode. With the safety net of the grid gone, the control systems of the plant were relied on to manage campus electrical demand, ensuring it did not exceed the CHP system's capacity and endanger its operations. In the end, the plant was able to remain on line during the extended grid outage, and NYU received praise for its vision and planning for an event such as this.

COMBINING BOP, PMS

Effectively integrating the BOP and PMS systems requires planning and consideration upfront. The most streamlined and cost-effective means is to combine these systems into a single programmable automation controller, as seen in the TWA Hotel example. This is an industrially hardened solution with varying levels of redundancy applied to ensure minimal disruptions to operations. This approach of a single programmable automation controller is not always practical, especially for larger, more distributed systems. In that case, ensuring that the controllers of the BOP and PMS systems natively communicate with each other at high speeds is imperative.

To ensure smooth integration, it is advisable to have a single provider of the two systems with expertise in both microgrid and CHP applications. Developing an upfront design specification for the control scheme makes sure that the systems can be put through extensive factory testing before they are deployed on-site. Due to the critical nature of the loads that microgrids and CHP systems support, on-site testing would be disruptive or impossible.

Today's microgrid/cogeneration systems are evolving into complex hybrid systems. In addition to combustion turbines, reciprocating engines and battery storage, these hybrid systems now include photovoltaic arrays, fuel cells, flywheels, etc. – increasingly driven by the desire for more sustainable systems. These control systems, which make complex electric and thermal microgrids possible, also make it possible to integrate renewables and waste heat, thus lowering carbon emissions.

As these systems grow in size and complexity, so does their dependency on being integrated into a robust, reliable and appropriately matched SCADA and BOP plant control system. Early engagement with an experienced controls integration provider – one that can recommend the proper technology to apply and has the expertise to deploy it – can aid in achieving a successful outcome for the project.

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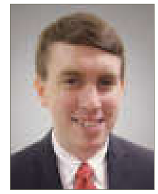

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