WWW.DISTRIBUTEDENERGY.COM JULY/AUGUST 2018

Distributed Energy

THE JOURNAL OF ENERGY EFFICIENCY & RELIABILITY

Distributed Energy Resource Management Systems

PLUS

Microgrids

CHP

Loadbanks

Building Automation

Shared Energy Resources

Innovation is driving the future of microgrids.

BY BRIAN CURTIS

There is a familiar backstory in electric power generation that has influenced the industry over the 40 years since the Public Utilities Regulatory Policies Act of 1978 (PURPA) was signed into law. Industry veterans know this story and the younger generation is coming to learn it. Yet the story is evolving, and today, with new technology and business models, a new chapter is being written with the implementation of more efficient, flexible, and intelligent energy resources.

PURPA was, in large part, a reaction to the energy crises of the 1970s and resulted in a wave of power plant development that swept through the '80s and '90s. This included a large-scale rollout of cogeneration (cogen) plants that enjoyed favorable 20- to 30-year "PURPA contracts." As the industry boomed, generators over-built. This, coupled with other regulatory factors, led to a lull in the investment of new infrastructure.

Subsequently, the landscape changed: Renewable costs dropped, energy efficiency technology improved, business models evolved to allow mass market adoption of solar, and renewable portfolio standards (RPS) were adopted. These technology advancements and new industry practices reopened the market for flexible, dispatchable energy generation projects.

Yet investment in energy infrastructure is struggling to keep pace with growing energy demand. The investment gap in electricity infrastructure is estimated to be $177 billion (Source: ASCE 2017 Energy Infrastructure Report Card). Many of the plants under PURPA contracts are reaching end-of-life and cannot be economically repowered using conven-

All photos: Concentric Power

Taylor Farms' facility in Gonzales, CA, draws power from a behind-the-meter microgrid comprising a 1.85-MW wind turbine, a 1.0-MW solar PV system, and a 2.3-MW cogeneration plant with low-temperature refrigeration that chills to 18°F. The microgrid has provisions for additional cogen capacity and battery storage.

tional approaches. The result is that infrastructure is at a once-in-a-generation inflection point.

The solution to much of what ails the grid appears to be the next wave of distributed energy resources (DERs), which are evolving to be deployed as grid-facing business models to fully utilize complex generation assets and power systems. Think Uber for electric power infrastructure. Welcome to the shared economy.

Cogeneration and chiller at Taylor Farms facility in Gonzales

MICROGRIDS AS A DER

An evolving storyline in energy's shared economy is the intelligent microgrid. Intelligent microgrids have significant potential to provide operational flexibility and value by fully utilizing available assets. Whether behind the meter or in a local area, microgrids can draw from intermittent generation, like wind and solar, as well as dispatchable DERs like cogen and batteries. When managed proactively, the result is an optimized system that is dynamic, flexible, responsive, and efficient.

Designing an intelligent microgrid does not follow conventional power engineering rules. For example, until recently, a microgrid serving a large factory or farm might evolve organically, starting with conventional solar PV and energy efficiency projects, adding fuel cells or cogen (likely with good nameplate efficiency), and focusing on keeping capacity factors high. Thus, conventional wisdom would size firm generation for baseload power and size renewables within net metering limits, then run the system at 100% as much as possible. However, technology and business models have evolved.

Current revenue models incentivize developers and consumers to develop microgrids that get facilities nearly 100% independent of grid power. Excess capacity from these assets can be contracted to the wholesale market either directly or on an aggregated basis. Building microgrids for this model is an important part of realizing the full potential of decentralized electric energy generation. The California Independent System Operator recognized that this approach has merit, "[l]ocal generation, together with smart meters, sensors, advanced IT, and storage, create the infrastructure for local microgrids," leading to "[d]ecentralized distribution networks operat[ing] synergistically with the bulk power system…" (Source: *www.caiso.com/Documents/Electricity2030-TrendsandTasksforthe-ComingYears.pdf*).

The intelligent microgrid model has proved itself in the real world at Taylor Farms' fresh vegetable processing facility in Gonzales, CA. Their behind-the-meter system has evolved to include 1.85 MW of wind, 1.0 MW of solar PV, and 2.3 MW of cogeneration. The cogen plant comprises a 2.0-MW natural gas internal combustion engine and a low-temperature aqueous ammonia absorption chiller providing refrigeration at +18°F. The system currently offsets over 90% of the facility's power consumption with 10% coming from solar, 18% from wind, and 64% from cogen. The system has provisions for additional cogen and battery storage to be implemented in the near future. The system's advanced control is provided by Concentric Power as part of their cogen plant. The controls allow for proactive load following and dispatch of excess capacity from the cogen and the renewables. The result is an optimized DER that benefits Taylor Farms and the grid.

INTELLIGENCE IS THE NEW SMART

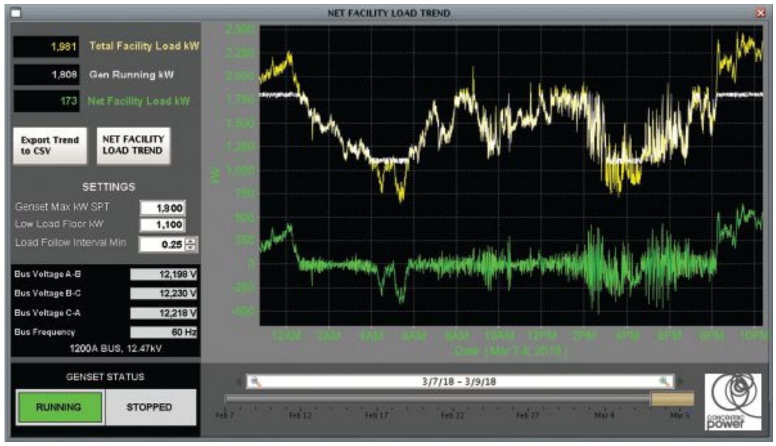
For years, energy developers, consumers, and policymakers have been talking about and implementing "smart" technology. Typically, "smart" means energy assets that include electronics and some level of connectivity for data capture. Smart technology is now only a stepping stone to building a next generation system. Today, smart systems must actually be intelligent systems.

At the plant level, machine learning and artificial intelligence (AI) techniques can help one or more DERs to adapt to its environment by predicting load profiles, renewable energy generation patterns, and ambient conditions. DERs within a microgrid can work together to optimize the system. Through the application of machine learning and AI, intelligent microgrids find opportunities to achieve better results and manage assets in real time.

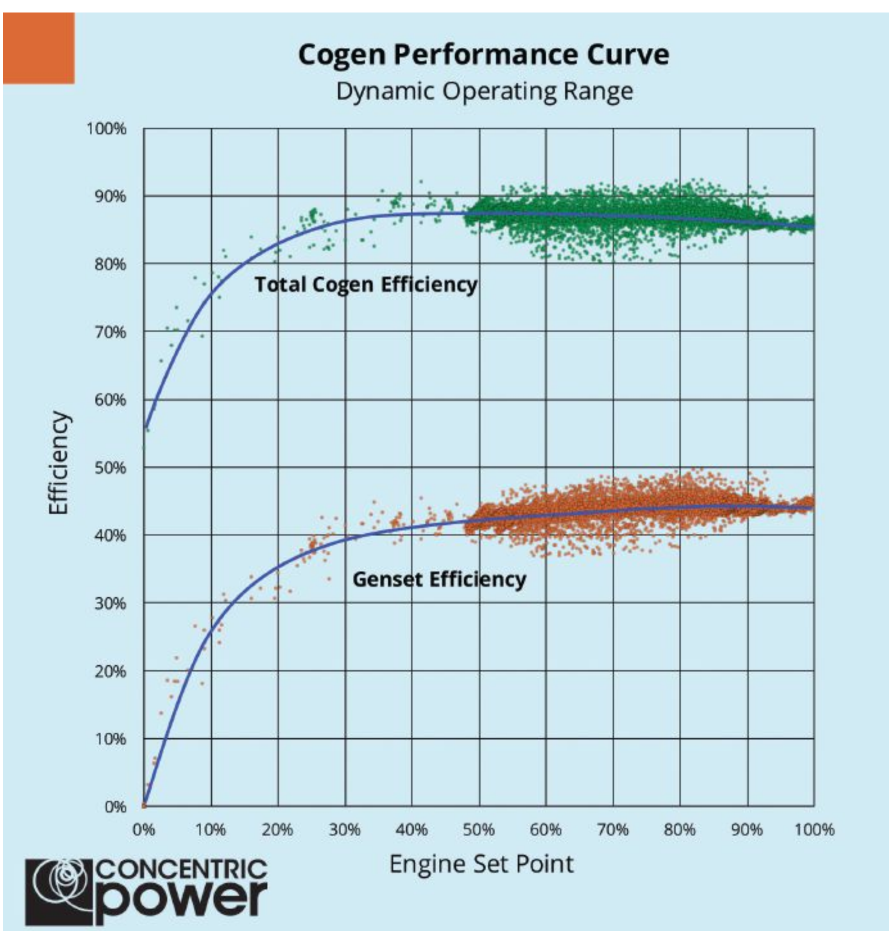
Further, the system can take into account real-time economic signals such as utility tariffs, wholesale power pricing, fuel commodity pricing, etc. The microgrids learn which DERs to mine for storage or dispatch to the grid to take advantage of tariff pricing or metering effects. In doing so, intelligent systems can learn to load follow or generate excess capacity to store or dispatch to the grid.

While this sounds futuristic, these capabilities exist today. Going back to the Taylor Farms case study, that system is continuously verifying its performance curves and load profiles for the site. The cogen plant serves as the main dispatchable power source and load-follows to meet the needs at the site.

At the grid level, intelligent systems demonstrate true processing smarts when they are positioned to control aggregated generation capacity across various DERs. When networked together, intelligent DERs can respond to grid demand by adjusting generation and dispatching stored or generated capacity on short order, becoming a network of distributed assets. An intelligent system could easily control 200 5-MW microgrids, thereby having 1 gigawatt of power to dispatch at will. The decentralization of the dispatchable generation provides increased security and resilience for the grid, while making microgrid systems more efficient. In essence, the inputs to one of the networked DERs influences the other networked DERs. The result is a network of highly intelligent, disparate systems interacting to optimize the economics and the network.



Load following capabilities of a high efficiency natural gas engine demonstrate the ability to generate or dispatch excess capacity through intelligent, advanced controls.



Concentric Power modular cogen system with 2.0 MW Caterpillar G3516H gas engine genset plus low temperature aqueous ammonia absorption chiller at +18degF. Efficiency shown in LHV in accordance with ISO 3046/1 and exhaust to +248degF. Charts based on run data from 1/1/18 to 4/30/18 at Central Coast California site.

Genset and cogen efficiency curves that demonstrate flat efficiency performance when the genset is running between 40% and 100%

DYNAMIC EFFICIENCY

Energy efficiency has often been measured by nameplate efficiency; however, in the context of intelligent controls, it is not enough to have a high efficiency rating. It's the net system efficiency over time that matters—i.e., dynamic efficiency. Efficiency also needs to hold up over a wide range of conditions and set points. For example, natural gas internal combustion engine performance curves have improved dramatically in recent years. Efficiency begins high and remains high even as the engine is turned down as low as 40%, resulting in a flat performance curve. This technical improvement enables the intelligent controls.

This combination of intelligence and dynamic efficiency allows conventional wisdom to be flipped. In the not too distant past, it was considered best practice to size combined heat and power for baseload power and run it at 100%, or else the economics would not pencil out. However, where you have a high penetration of renewables, intelligent systems, and dynamic efficiency, you can effectively size firm, dispatchable power from cogeneration, for example, at a site host's full load or higher. The advanced controls allow for real-time site-host load-following, as well as dispatching into local adjacent microgrids. Much lower capacity factors on assets can actually work well. Further, when utility tariffs are well understood, it may be that certain assets can be utilized for prime power even when the site load is seasonal.

SUSTAINABLE INFRASTRUCTURE

Although the new generation of microgrids incorporate separate and distinct generation sources, they also provide much of the physical, software, and economic foundation on which those resources are built. As RPS standards increasingly focus on reducing carbon emissions, microgrids will by necessity have to rely on renewable generation sources. Distribution and transmission infrastructure, both on micro and macro levels, are not prepared for this. In some cases, the basic infrastructure already exists at a site in the form of transformers, switchgear, and protective equipment, not to mention conduit and cables, but often needs to be built or upgraded. These upgrades can fall in front of or behind the meter, but in any case, are required to unlock the full potential of the system. The developing software and advanced microgrid systems will be able to take advantage of intermittent renewables such as solar and wind power on an "as-is" basis.

Additionally, the required infrastructure can get complex quickly, both in terms of technical design as well as codes and standards. All told, the complexities and costs add a layer of challenges to any project. To succeed, system and infrastructure complexity needs to be simplified. Customers need these changes before they will adopt it. They do not want to have to think about managing the complexity whether it's in project planning or in operation. Complex systems will have to be able to manage all this, probably in an ad hoc, distributed way.

The name of the game is how to build the infrastructure sustainably with optionality for future upgrades since whatever is built now will be around for the next 30–40 years. Unfortunately, plugging in disparate technology projects is not sufficient to achieve the complete zero carbon vision. The good news is that these realities are being recognized by new business models and investment asset classes that embrace sustainable long-term infrastructure. Investment firms have recognized that a class of projects have been underfunded and see an opportunity for long-term returns.

> Through the application of machine learning and AI, **intelligent microgrids find opportunities to achieve better results and manage assets in real time.**

Emerging microgrid business models are borrowing from some familiar playbooks. Power purchase agreements similar to those in the solar industry are geared towards assets that generate firm, dispatchable power. Aggregated generation and storage is taking inspiration from demand response.

THE NEXT CHAPTER

As DER adoption reaches critical mass and we enter a post-PURPA world, the familiar story is heading in a new direction that encourages microgrid systems and DERs to combine sustainability, intelligence, and flexibility. The resources are available to make microgrid systems more valuable.

The next generation embraces complexity. Microgrid systems being built today that realize their role in a group of distributed network assets will succeed in bringing sustainable infrastructure together with firm power to create a well-balanced grid of the future. Pushing the envelope with technology and innovative business models makes us all better and can shove aside stodgy conventional wisdom. The exciting news is that it is happening today. **DE**

__Brian Curtis__ is a mechanical engineer by training and the CEO and founder of Concentric Power Inc.