THE IMPACT OF TRANSACTIVE ENERGY ON APPLIANCES

Transactive Energy combines market forces and control techniques to achieve grid balance.

by kenneth wacks, Ph.D

***Dr. Wacks** has been a pioneer in establishing the home systems industry and a management advisor to clients worldwide, with a focus on home and building systems, energy management, and digital entertainment networks. The United States Department of Energy appointed him to the 13-member GridWise® Architecture Council. For further information, call (781) 662-6211, email kenn@alum.mit.edu or visit www.kenwacks.com.*

Power generation from renewable energy sources such as wind and solar is advancing from demonstration projects to a few pioneers to mainstream. The proliferation of renewable energy resources will profoundly reshape the electric utility industry, while offering business opportunities for appliance manufacturers.

The growth of renewables

Presently, the levels of renewable production in most countries are so low that these sources of power have minimal impact on electric utility systems. However, as renewable production reaches about 30% of the total power needed in a region, renewable sources could impact the business of utility power production and the technology of power distribution.

Many governments have established national goals for the proliferation of renewable energy resources. For example, in 2008 the European Union adopted the 20-20-20 Renewable Energy Directive to reach the following goals by 2020:

- 20% reduction in greenhouse gas emissions compared with 1990 levels.
- 20% reduction in energy consumption through improved energy efficiency.
- 20% increase in the use of renewable energy.

The three major investor-owned utilities in California passed the 20% renewables threshold in July 2012. In October 2013, the California legislature adopted a renewables target of 25% by the end of 2016 and 33% by the end of 2020.

Reliable power with renewable resources

A fundamental tenet in operating an electricity system (called a power grid) is that supply must match demand to deliver power needed by industrial, commercial and residential customer equipment. Grid operators are continuously monitoring the grid to maintain this supply and demand balance while ensuring that the wires are not overloaded and that the electrical parameters of voltage and frequency are maintained. If the supply is inadequate, the AC frequency of 60 Hz may sag, currents may rise, and blackouts may ensue.

Utility engineers can anticipate loads a day ahead with more than 90% accuracy based on historical data, weather predictions, time-of-day, and weekday versus weekend and adjust supplies. This continual procedure of adjusting supplies is called load following. On a time scale of approximately 15 to 30 minutes, utility engineers can bring additional generators on line, take generators off line, or alter generator outputs through a dispatch

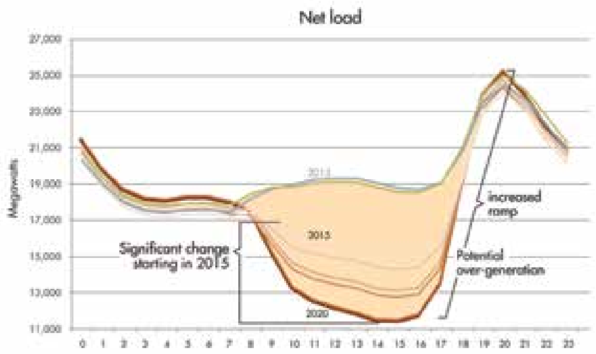

Figure 1.

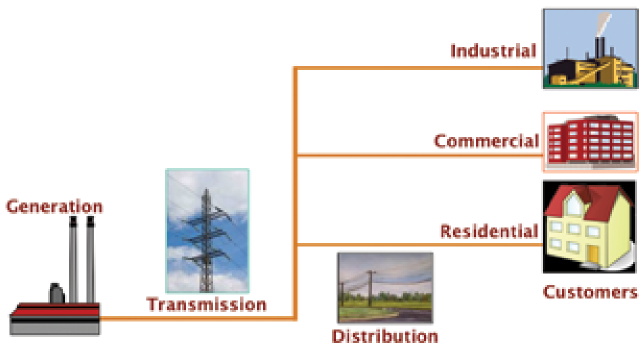

Figure 2.

process as demand changes (these supplies are characterized as dispatchable).

Renewable sources may be wind and solar farms operated by utilities or by consumers acting as producers (called prosumers). Prosumers usually use their renewable power locally. However, many utilities buy any excess power generated by prosumers and allow it to be fed into the electric grid. The power from renewable resources fluctuates rapidly as weather and daylight change. ***Figure 1*** is a prediction of the hourly fluctuation of power needed from conventional utility power sources in California. Of particular concern is the huge increase in power needed between 5 and 6 PM as solar sources that peaked during the day cease at sunset. Dispatching renewable sources in an orderly and predictable fashion is not possible, so new tools are needed. These tools may encourage the development of customer equipment including appliances that automatically adjust demand for electricity as supply fluctuates.

The evolution of microgrids

A traditional utility is comprised of a limited number of generating stations and lots of industrial, commercial, and residential customers connected via a tree-like structure of transmission and distribution wires. A simplified view is shown in ***Figure 2.***

The future of electricity generation and consumption looks quite different from the traditional utility. The installation of renewable energy resources such as solar, wind, and eventually energy storage, perhaps as stationary batteries, will proliferate. Excess power not consumed locally will be transferred onto the grid. This creates two-way power flows that will vary significantly by time-of-day and weather. A passing cloud might reduce the output quickly in a neighborhood that has lots of solar power.

Power production will be shared among traditional utility plants, renewable resources from large wind and solar farms, and distributed energy resources operated by customers. Eventually, the electricity grid may evolve from a tree structure to a mesh of local power grids called microgrids, as shown in ***Figure 3***.

Transactive Energy and smart grids

In 2004 the United States Department of Energy (DoE) assembled a panel of 13 experts from the utility and supporting industries to form the GridWise® Architecture Council (GWAC). GWAC develops smart grid strategies that enhance reliability by ensuring that smart grid elements function seamlessly as an interoperable system.

At the request of the DoE GWAC is now extending interoperability to Transactive Energy. Transactive Energy is a new business and technology approach to managing the wide-scale deployment of renewable energy resources while maintaining grid reliability. In October 2013, GWAC issued a draft of the Transactive Energy Framework document (available at http://www.gridwiseac.org/about/transactive_energy.aspx).

What is Transactive Energy?

Transactive Energy (TE) combines market forces and control techniques to achieve grid balance. Since renewable power from sources fluctuate, TE seeks to adapt customer equipment demands for power. In a retail TE environment, customers (typically using automation tools) purchase power for delivery at a specific time according to anticipated loads and pay for the power when delivered. This business process is called a forward transaction in a forward market, similar to a market for future delivery of commodities.

The participants in a TE market include prosumers, central generation owners, and grid operators. If a customer has excess generation capacity or stored energy, these may be sold to a buyer via a TE market. Power is bought and sold at a specified level and time, which could be a few minutes or hours later. Forward transactions enhance grid stability because supplies (generation and storage) can be prepared for delivering power to a load at an assured price.

This TE financial transaction model is similar to a stock market, but with significant physical and business constraints. Power

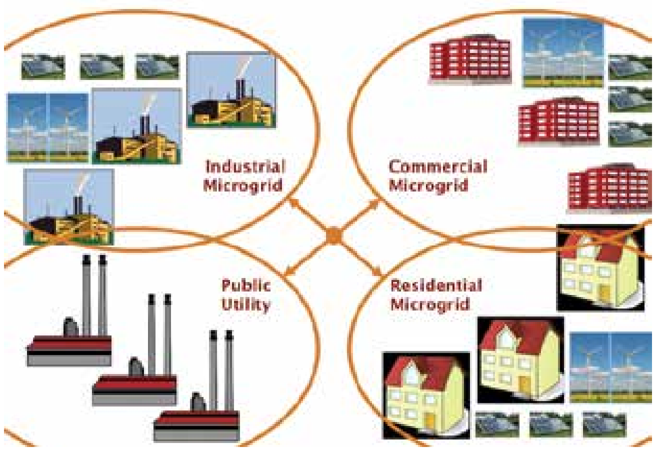

Figure 3.

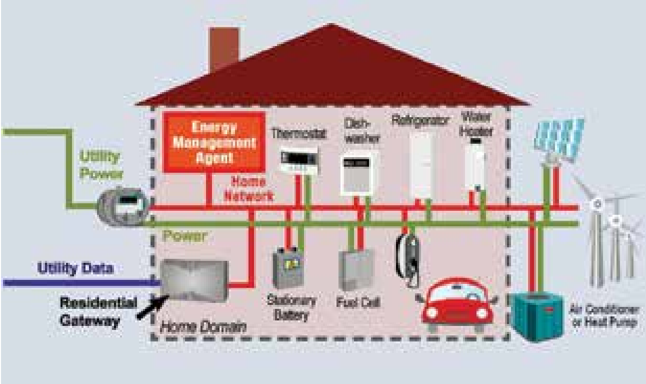

Figure 4.

must flow from source to load over wires that have capacity limits. Furthermore, customers expect lights and appliances to operate. Therefore, a TE market needs constraints to protect small-volume consumers from excessive price volatility and from being squeezed out of the market for power.

Appliance role in Transactive Energy

Transactive Energy (TE) at the retail level will depend on automation to act as an agent for the customer. Customer-premises equipment participates in TE by communicating with other smart grid devices. For TE to be effective and to proliferate, manufacturers need to adapt products such as appliances, thermostats, HVAC equipment (heating and cooling), lighting, and distributed energy resources. TE coordination for appliances in a household may be provided by an energy management system.

An international standard for energy management was published in 2012 featuring an Energy Management Agent (EMA) that manages energy consumption and generation for household appliances . These appliances will need communication interfaces and control programs that enable interaction with the EMA, as illustrated in ***Figure 4***. The customer will enter parameters into the EMA including a monthly budget for electricity and preferences for appliance usage.

For example, "I have budgeted $100 for paying my electric bill this month. I would like hot water for showers at 8 AM, cooking at 6 PM, and can do the laundry anytime between 7 and 11 PM." The EMA allocates power using TE tools based on these customer preferences, the price of electricity, the availability of locally generated power and any stored energy, and the power needs of appliances. In this scenario, appliances might be sold with flexible control capabilities that allow operation in various modes by modulating the amount of energy consumed.

The introduction of the TE and the EMA may offer new business opportunities for adding energy management features to appliances that can differentiate these products in the marketplace. Such appliances might be valued by consumers, who would pay a premium or might receive subsidies from utilities and government conservation programs.

Transactive Energy challenges

TE enables smart grids to adapt to new challenges introduced by more variable renewables, more distributed generation and storage, two-way flows on a distribution grid, and more automated management of usage.

TE is a new concept that is now in field trials with some success stories. A consortium of utilities, equipment suppliers, and the Department of Energy has run successful demonstrations of TE features in the Pacific Northwest. Wide-scale deployment of TE faces challenges including:

- The ability of TE to achieve grid balance consistently must be proved.
- Methods must be developed for accommodating physical constraints such as feeder capacity limits.
- TE must be scaled to the community or region.
- Consumers need to be educated about TE, convinced of the benefits, and assured that the lights will stay on.
- Appliance manufacturers need a business case to justify adding TE features. ■

References:

1 http://www.caiso.com/Documents/Presentation-Mark_Rothleder_CaliforniaISO.pdf

2 ISO/IEC 15067-3, Model of a demand-response energy management system, available at http://webstore.ansi.org/RecordDetail.aspx?sku=ISO%2FIEC+15067-3%3A2012