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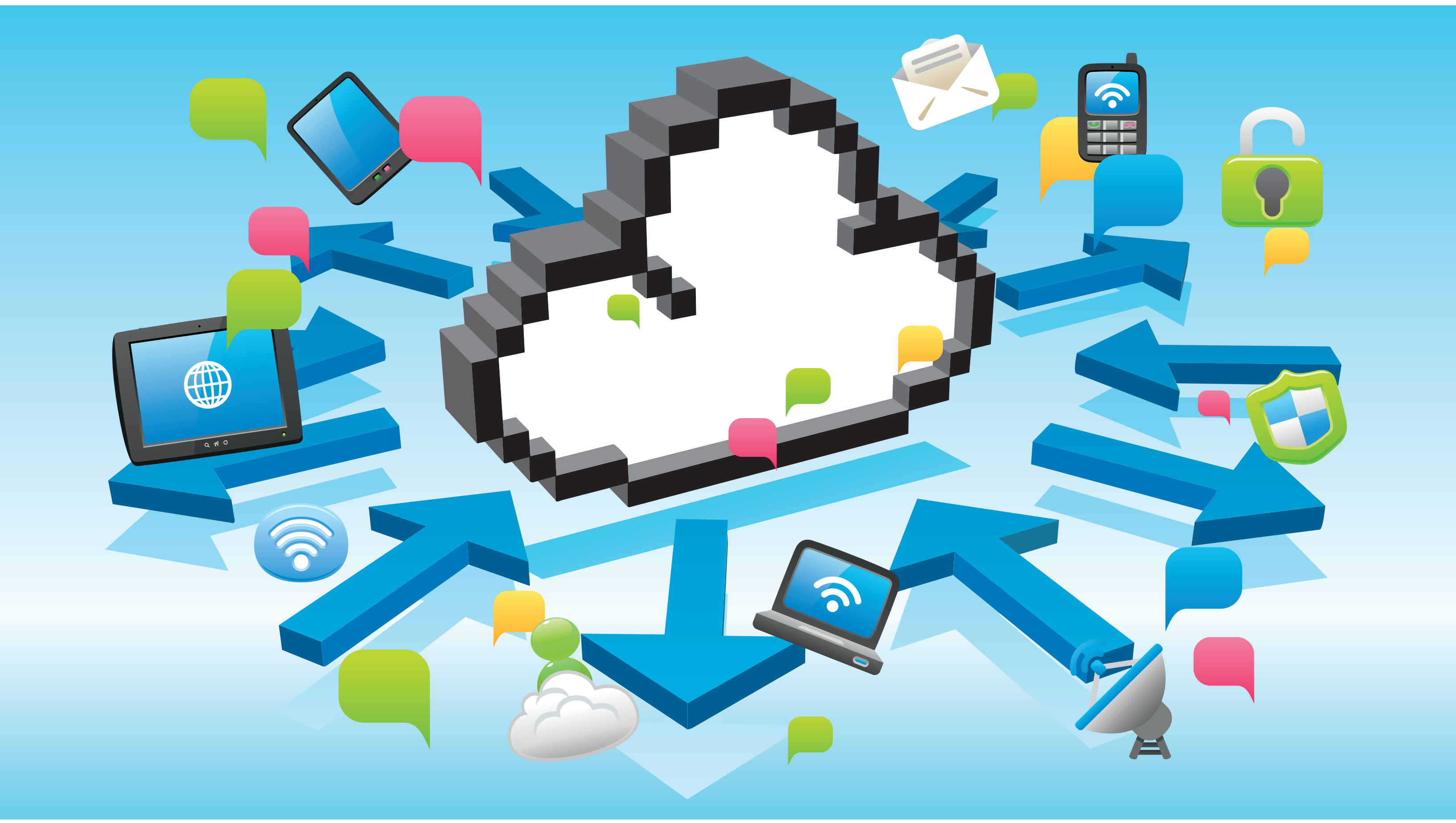

The Impact of Cloud Computing on Intelligent Buildings

Casey Talon notes that the next generation of intelligent building technologies will leverage cloud-based computing.

KEN WACKS' PERSPECTIVES

Transactive Energy for Balancing Smart Grids

By Ken Wacks

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:

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

In 2011 California lawmakers mandated that 33 percent of electricity must come from renewable sources by 2020. The three major investor-owned utilities in California passed the 20 percent threshold in July 2012 according to *Renewable Energy World* magazine.

Renewable energy resources such as wind and solar produce power that varies with the weather and time-of-day. When more power is produced than can be used locally, some utilities buy the excess power and allow it to be fed onto the electric grid. Presently, the levels of renewable production in most countries are so low that this insertion of power has minimal impact on grid operations. However, as renewable production reaches about 30 percent of the total power needed in a region, renewable sources could impact the business of utility power production and the technology of power distribution via the grid.

In previous issues of *iHomes & Buildings*, I introduced the GridWise® Architecture Council (GWAC). GWAC is a panel of 13 experts appointed by the United States Department of Energy to develop smart grid strategies for the government, the electric utility industry, and equipment suppliers. We have focused on developing guidelines for achieving interoperability among smart grid elements. We are now extending interoperability to *Transactive Energy*. Transactive Energy is a new business and technology approach to managing the wide-scale deployment of renewable power generation.

Balancing supply and demand

An electricity system requires a balance between generation supply and customer equipment demand. If the supply is inadequate, the AC frequency of 60-Hz may sag, currents may rise, and blackouts may ensue. 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 1.

Balance in a traditional grid is achieved on a very short time scale of seconds by governors on the generators. A governor senses the speed of a generator, which varies slightly according to the customer equipment load, and adjusts the speed to maintain the 60-Hz AC output. On a time scale of 15 to 30 minutes, engineers at the electric plant can bring additional generators on line or take generators off line through a dispatch process as demand changes. Engineers at generating plants and independent system operators (ISOs) can anticipate loads a day ahead with more than 90 percent accuracy based on historical data, weather predictions, time-of-day, and weekday versus weekend. This continual procedure of adjusting supplies is called load following.

Renewable Energy Resources and microgrids

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 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

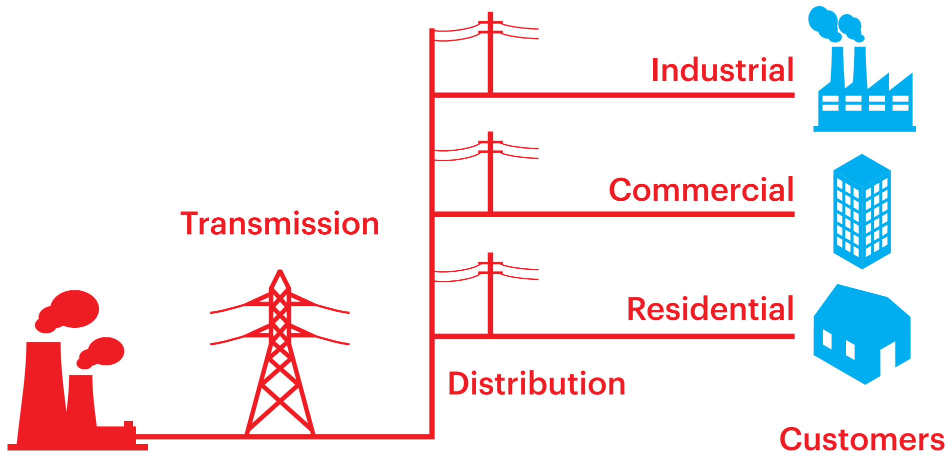

Figure 1 – Conventional Electric Utility

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 2.

Overview of Transactive Energy

As renewable energy installations expand, utilities and ISOs need to:

- Adjust supplies to accommodate renewable energy resources.
- Expand operational tools for achieving grid balance.
- Include customer equipment as active participants in achieving grid balance.

Electric plants have two categories of generators to produce power:

- Base-load plants
- Intermediate or peak-load plants

The base-load plants use fuels such as coal or nuclear that operate most efficiently when running at full capacity all the time. They generate 30-40 percent of all power. As more power is needed during busy times of the day, the intermediate or peak-load plants, typically gas-fired, are brought online.

Utilities will likely scale back or shut the intermediate or peak-load plants, and sometimes the base-load plants, as renewable production surpasses 30 percent. Varying the output level of a base-load plant is usually not cost effective. Therefore, the intermediate and peak load plants need to be more responsive as renewable sources fluctuate.

Fluctuating output from renewable energy resources reduces the accuracy of load-following supply predictions. Therefore, new tools are needed to achieve grid balance between supplies and demand. GWAC has been developing such a tool for this grid management function called Transactive Energy.

Transactive Energy is an automated strategy for balancing the supply and demand for electricity. Traditional load "following" adjusts supplies, while Transactive Energy introduces market and technology methods that adjust both supplies and loads to achieve balance. Thus, utilities and customers will use elements of Transactive Energy.

Transactive Energy markets and controls

Transactive Energy (TE) combines market forces and control techniques to achieve grid balance automatically. In a TE environment, power-producing devices may offer excess power to the grid via a market bid-and-ask mechanism. The device would propose power at a specified level and time, which could be a few minutes or hours later. Loads on the grid bid for this power, a price is agreed, and the power is delivered when promised to settle the trade. The price and power data are exchanged among the devices via a network using machine-to-machine (M2M) communications.

This financial transaction model is similar to a stock market, but with significant physical and business constraints. Power must flow from source to load over wires that

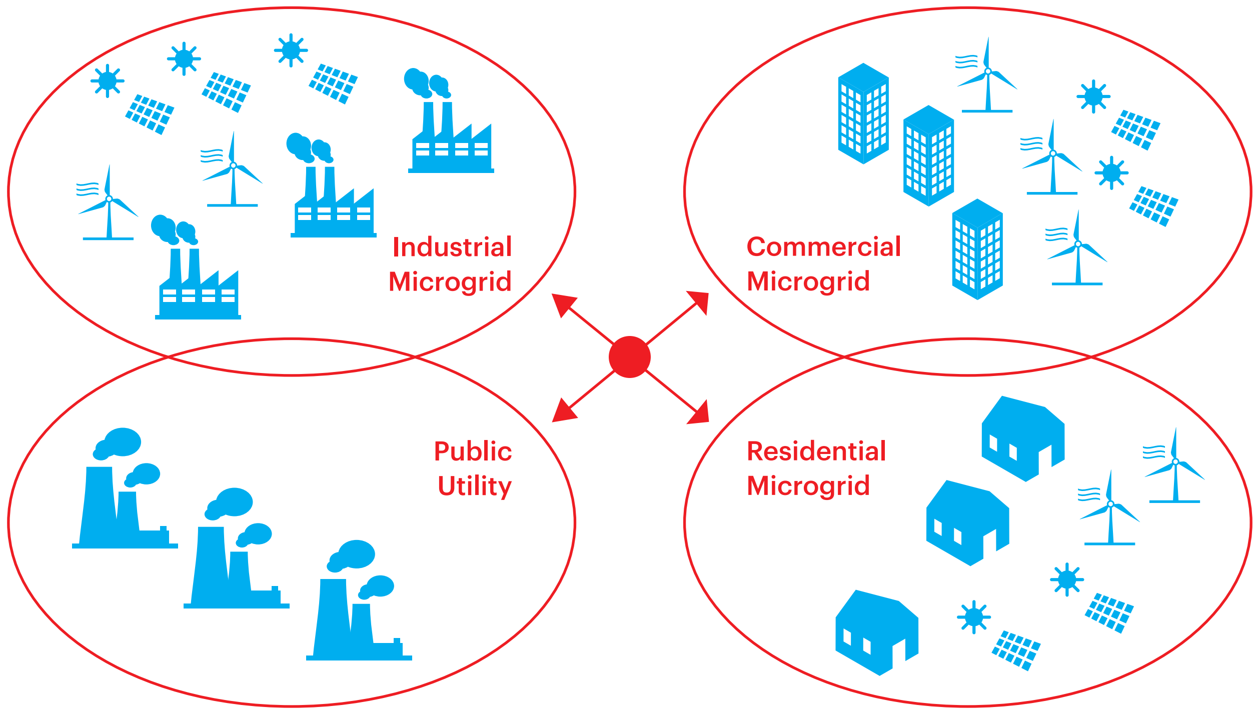

Figure 2 – A Cluster of Microgrids

have capacity limits. Customers expect lights and appliances to operate.

Financial markets occasionally experience anomalies with price spikes and a temporary lack of liquidity where some buyers are shut out. The analogous situation in a retail electric market might result in some customers not able to afford power or not having power available at any price. This would be politically unacceptable. Therefore, TE balances market forces with network limitations and policies, such as a requirement to serve all customers with some minimum level of power.

Elements of Transactive Energy

The GridWise Architecture Council created the GWAC Stack shown in Figure 3 to describe smart grids. As the GWAC Stack illustrates, smart grids combine communication technologies with information and organizational issues such as procedures, economics, and regulations. Drawing upon the GWAC Stack, I arranged the elements of Transactive Energy in a hierarchy as shown in Figure 4. These elements include physical devices, information, control, and policies.

An important concept in TE is the establishment of a TE domain. TE is not like a national stock market, but more like a farmers market, where buyers and sellers strike deals on a local or regional level. Eventually, TE could expand into a market comparable to an ISO.

Transactive Energy challenges

Transactive Energy 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.

Impact of Transactive Energy

For Transactive Energy to be effective and to proliferate, manufacturers need to adapt products such as appliances, thermostats, HVAC equipment (heating and cooling),

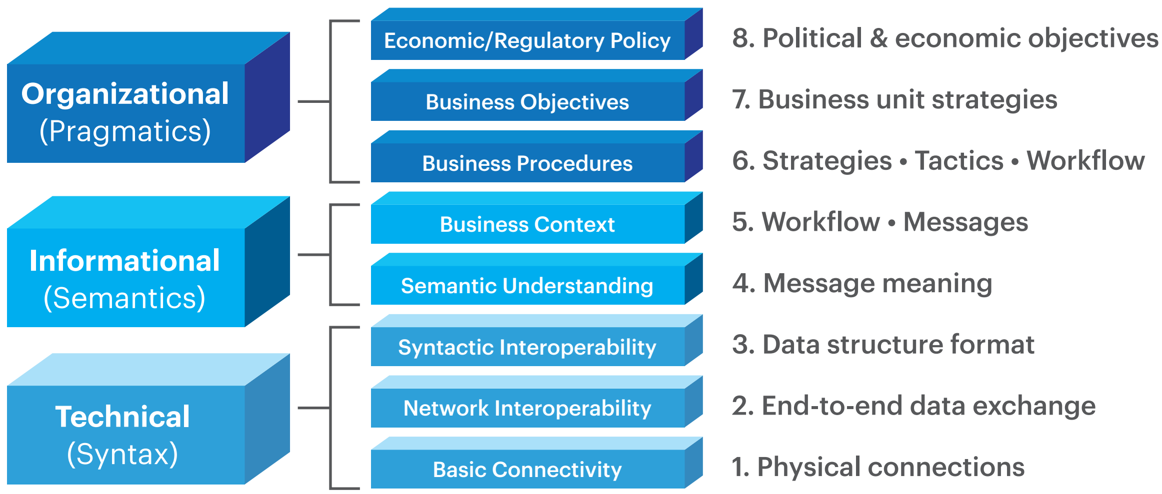

Figure 3 – The GWAC Stack

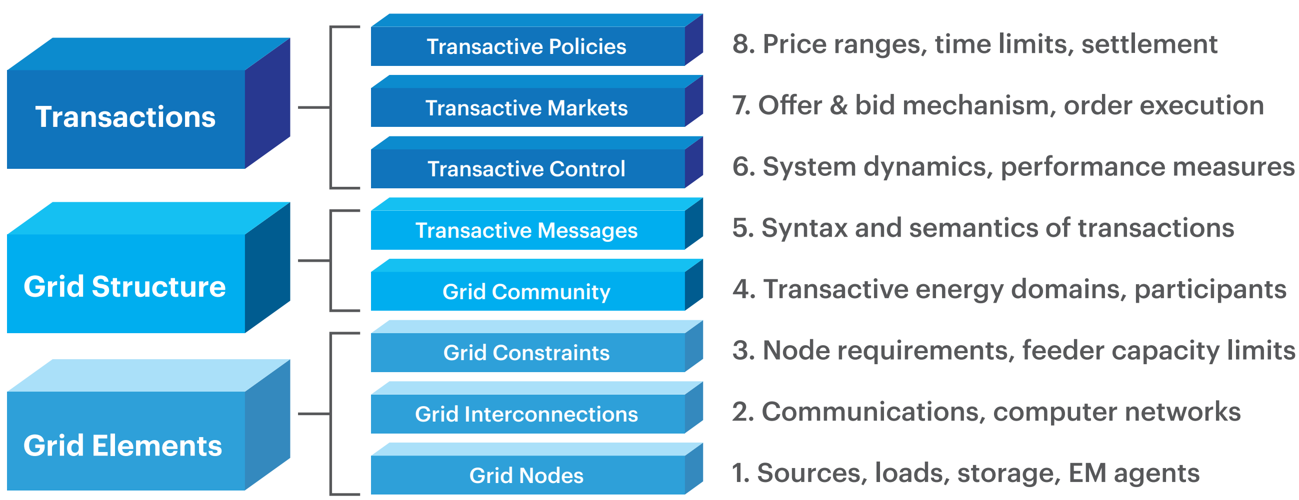

Figure 4 – Elements of Transactive Energy

lighting, and distributed energy resources. Some low-cost devices may not be able to afford TE interfaces. TE functionality may be offered by systems acting as proxies for a group of these low-cost devices. These systems might include building automation systems and energy management agents (controllers for an energy management (EM) system).

The GridWise Architecture Council organized the first Transactive Energy Conference on May 23 and 24, 2013. We hoped for about 50 attendees and ended up with 150 registered. The smart grid industry is starting to take note of TE. The GridWise Architecture Council will continue to work with the Department of Energy to support TE integration into smart grids. Our goal is to maintain grid reliability as installations of renewable energy resources expand. ●

Dr. Kenneth Wacks has been a pioneer in establishing the home systems industry. He advises manufacturers and utilities worldwide on business opportunities, network alternatives, and product development in home and building systems. In 2008, the United States Department of Energy appointed him to the GridWise Architecture Council. For further information, please contact Dr. Wacks at 781.662.6211; kenn@alum.mit.edu; www.kenwacks.com.