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behind the buzz

eight smart-grid trends shaping the industry

THE SMART GRID IS A HOT TOPIC at utility executive meetings and broader transmission and distribution (T&D) utility forums across the country. The concept still elicits mixed reaction, but there is increasing agreement on a common definition of "smart grid," as well as an emerging confidence that the smart grid embodies a set of technology investments that can transform the way service is delivered to customers. In addition to cost and service quality improvements, the smart grid is increasingly being linked to environmental goals, including attaining renewable-energy targets and reducing carbon emissions. A wide variety of players—venture capital companies, software and application providers, niche engineering firms—have entered the smart-grid value chain with material investments. Utilities are getting bolder in their program designs and in integrating smart-grid investments with their aspirations for energy efficiency and renewables. State regulators have been approving pilot programs and building precedents with favorable investment decisions. With the development taking real shape, there are still areas to be cautious about, however. Systematic, wide-scale deployment of demand response has yet to be demonstrated. Systems integration is a considerable challenge. Worries regarding technology obsolescence continue, with new twists as new communications capabilities emerge.

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In light of these contrasting developments, opportunities, and challenges, there are eight key trends that will heavily influence the development trajectory of the smart grid in the next two to three years.

1) The definition of "smart grid" has finally expanded, and spending per connection has grown accordingly.

In the industry, the core definition of "smart" has rapidly transformed from "smart metering" to "smart grid" over the past 18 months. In the language of utilities as well as vendors, "smart grid" now refers to a much broader set of needs and applications, hardware and software, than was previously defined. Whereas previously a discussion on the smart grid focused on advanced metering infrastructure (AMI), now the definition has expanded considerably to include home area networks (HANs), grid-side efficiency applications (e.g. volt/var control, automation), and future utility enabling functions [e.g., facilitating distributed photovoltaic (PV), and electric vehicles (EVs)].

This change in definition is material and is reflected in how utilities are beginning to assess smart-grid implementations in a number of ways. For example, the decision to invest in core AMI communications technology is now expanded to consider the potential synergies with investing in communications for grid efficiency applications. Further, utilities are increasingly trying to understand the benefits of combining an outage management system (OMS), field force automation, and a geographical information system (GIS), which span both AMI and grid-side applications. Most importantly, utilities are thinking much more broadly when it comes to the business case. Combining demand response with AMI has been an established trend for the past several years, but now, adding automation, volt/var control, and the enabling aspects of the smart grid helps improve the overall business case. While combining functionalities helps balance the cost-benefit equation of the total case, the package of applications also provides synergies related to grid and customers' service quality, safety, and carbon emissions benefits. Indeed, this trend is highlighted by the fact that only five years ago, utilities were filing rate cases that embedded approximately US$200 per connection based on power line carrier (PLC) or basic radio frequency (RF) implementations. Now, some of the latest filings with added HAN functionality and several basic-level grid-side applications are being filed at US$450 to US$500 per connection. Some of the more advanced projects that draw upon a much broader set of applications (still in the pilot stage) imply investments of about US$700 per connection.

2) HANs are the new frontier for innovation and investment.

While smart-metering technologies continue to evolve, they already have

(continued on page 88)

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reached a level of maturity, exhibited by significant cost compression as well as functionality enhancements. HAN technologies, however, are reaching their prime time for innovation and development. Spurred by the large value of demand response in a typical smart-grid business case, increasing attention is being paid to how this value can be realized.

The promise of achieving demand response at a scale that matters implies significant changes in customer behavior, down to the residential level. The challenge here is that there is yet to be a fully deployed, demonstrable case in the industry. As a result of this absence, many utilities refer to pilot programs that prove out the case of customer behavior change. An additional complicating factor, however, is that comparing results across these pilots often cannot sustain focused scrutiny, since design differences in the pilots (e.g., the voluntary nature of some pilots, the level of technology provided to customers who opt in) can lead to differentiated results.

With so much at stake, from a business case perspective, in the value of demand response and with little evidence on what delivers predictable behavior change, there is significant attention being paid to providing technology that can deliver sophisticated demand and peak reduction with limited customer involvement. As a result, the HAN value chain is buzzing with activity ranging across all components: the gateway; in-home display (IHD); smart thermostats, switches, appliances, and energy interaction software; and demand response program management. A wide variety of investors are actively participating, including venture capital companies, AMI and grid application vendors, appliance manufacturers, and systems integrators. Standards are beginning to emerge, with ZigBee establishing significant momentum, followed by HomePlug.

Utility models of engagement are also beginning to take shape. The first issue that needs clarity is where the utility draws the line between basic HAN rate-based investment and allowing individual customers to finance added functionality at their own expense. Another key question utilities need to think through is to what degree they want and need to be involved in driving HAN-based demand response hardware and programs. Maintaining services in the home once the IHDs or program controllable thermostats (PCTs) are installed is a new challenge that many utilities will opt to outsource to third parties. Customers will also add to the need for third-party services by requiring help to maintain the added functionality that they choose to finance on their own account. As a result, innovation in the HAN space will begin to explicitly address more sophisticated vendor service provision models for utilities in the near future.

While utilities develop their thinking on the HAN front—from concept to implementation—they should keep in mind that technology choice is critical, but it's only one of several factors that ultimately determine whether customer behavior can predictably and sustainably be changed. Utilities also need to drive an appropriate pricing program, which can often be supported by new rate structures (e.g., inclining block), as well as a business model that encourages customers' participation both in initial technology adoption and in the degree to which they alter their usage.

3) Grid-side applications are beginning to win their place in smart-grid business cases.

While the HAN space is the spot for step-change innovation, the innovations in grid-side applications have been more gradual, but significant developments are under way. Over the past two years, enhanced grid applications—the core of which are automation, volt/var applications, and asset monitoring—have begun to take a significant role in utility and vendor thinking about smart-grid applications.

This thinking is still evolving and faces some notable challenges. For one, some utility executives view these applications as existing concepts that have already been adopted as part of the utility's traditional T&D investments; therefore, in their view, including these

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Peter Steimer
for leadership in high power converters and drive systems

David Sun
for leadership in power system management and control

Takeshi Taneichi
for leadership in developing and applying advanced power generation and transmission technology

Nikolai Voropai
for contributions to power system planning and emergency analysis and control

Xi-Fan Wang
for contributions to power system planning and power engineering education

Oleg Wasynczuk
for contributions to modeling and analysis in power electronics

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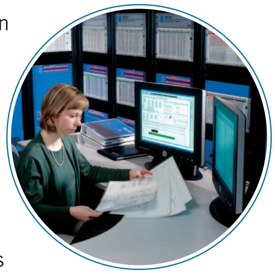
Ryuichi Yokoyama
for leadership in electrical power system management

Zi-Qiang Zhu
for contributions to analytical modeling of permanent magnet brushless machines

applications as part of the smart grid is simply a relabeling exercise. In addition, there are fundamental challenges in making the cost-benefit case for automation, which is by far the most common grid application considered to date. Finally, there is a silo effect that takes place within utilities: Smart-grid opportunities are typically pursued by a team that is at arm's length from the core T&D investment planning decisions.

These perspectives tend to overlook several critical factors that make the case for grid applications to be included as part of the smart-grid business case. Technology on the grid side has rapidly changed, and, across each of the three core applications, significant improvements in decentralized intelligence have occurred and are continuing to take place. Moreover, the inclusion of grid applications also strengthens the broader smart-grid case from a utility perspective. While the automation case is difficult to justify on a stand-alone cost-benefit basis, it can have a step-change impact on system reliability. With volt/var control bundled in with automation, the cost-benefit position improves considerably. As a package of investments, AMI, HAN, and grid applications form the core value proposition of a smart grid that promises to deliver step change in cost *and* service delivery. Finally, by introducing projects that may have been treated as conventional T&D activities through a smart-grid lens, these projects may be able to access a higher level of priority and may be appropriated capital accordingly, either through the utility's decision-making process or through the interest of the public utility commission (PUC) (e.g., recent activity in Illinois to consider a smartgrid rider). Increasingly, grid-side applications are becoming a fundamental component of utility business cases, as seen, for example, by filings and statements from the larger investor-owned utilities (IOUs) in Ohio.

This part of the value chain traditionally has been dominated by a combination of the large T&D hardware service providers and the niche engineering products and services firms. These companies are responding to the opportunity by increasingly integrating both software and applications into their hardware as complete packages. In addition to the known names, the traditional broadband power line providers have positioned themselves as players in grid services applications by leveraging their grid-intensive infrastructure. Technical engineering consulting firms have also strengthened their conventional services and

have begun to offer customized application development for grid-side services. With this array of participants in the space, it would not be surprising if the industry observes a maturing set of partnerships and alliances and some level of consolidation. Recent acquisitions by several of the large T&D vendors in this space indicate that this is the start of a trend in grid-side applications.

4) Systems integrators will have increasing influence on utility smart-grid decisions, but the integration challenge will continue.

While most utility and vendor attention has recently focused on implementing AMI and grid applications, attention is now turning to systems integration. As larger deployments get under way and move from the pilot stage to full deployment, and as AMI and grid services are being integrated, there is an increasing need to ensure that information—the lifeblood of smart-grid investments—is delivering what is expected at reasonable costs and within predictable time frames.

There is a clear challenge here: Data needs will multiply as meter read intervals become narrower and grid operations data are retrieved through a more extensive and intelligent network of sensors. This raises the complexity to unprecedented levels. The role of systems integration and information delivery is critical. Precisely because this is new territory, utilities often see it as a virtual "black box." This is leading to a boon for systems integrators (SIs). Not only is there a key role for engineering and field-force systems integration, but linking these systems to customer information and billing systems and business decision systems also is critical. One manifestation of the change is the discussion on the need for utilities to have a "super" data mart. In addition to the large information technology (IT) consulting firms, back-office IT providers are also entering into the space to provide services.

At utilities, SIs will have increasing influence in smart-grid investment decisions. There are two basic models in which utilities are engaging SIs. Some utilities are going down the path of bundling an AMI and systems integration contract together and selecting a consortium led by an SI as a prime. The alternative is to separate out the SI role and let that partner play a key role in helping the utility determine the rest of its smart-grid deployment plan. By helping to define key areas of functionality in the business cases, assisting with vendor selection, and driving pilot design as well as deployment, SIs are positioned to step beyond the traditional integration role into the downstream aspects of utility smart-grid decisions.

The "black box" nature of integration needs and the increasing reliance on SIs does provide the foundation for a healthy margin in this part of the smart-grid value chain. For many SIs, this is a new revenue stream that could be very large, since winning a smart-grid partnership deal potentially locks in multiple years of support and integration. The complexity of the data needs positions an SI in a particularly strategic position vis-à-vis the utility.

Before the SI is engaged, utilities need to scope out the role of systems integration with careful consideration and ensure they have an established view of the IT budget for systems integration to support smart-grid activities. Given the "black box" nature of the activity, it is not uncommon to see IT expenditure estimates significantly revised over the course of pilots and deployments.

5) The spotlight will move from demand management and grid-side applications to the "enabling" functions.

HAN and grid applications get attention now, but in the near future, the focus will shift to functions typically perceived as those that the smart grid simply enables. Specifically, these functions include the integration of wind, distributed PV, cogeneration, and EVs (both grid-to-vehicle and vehicle-to-grid), as well as the necessary forms of distributed storage that these alternative energy technologies bring with them.

A number of factors are driving the need to more explicitly understand how these applications are enabled by the smart grid. The push toward renewable portfolio standards (RPS) will underscore the need for grid integration at an unprecedented scale. The increasing activity around EVs is raising questions from policy, automotive, and utility stakeholders about the infrastructure needed. In addition, utilities are being more deliberate in linking energy efficiency resource standard (EERS) targets to the share that will come from smart grid-based demand management. Underscoring all of this is the push toward carbon emission reductions.

These factors drive the urgency to understand the value of the smart grid as a direct enabler of these applications. However, utilities have not been actively thinking about this area. Most business cases treat the value of this enabling function as a qualitative afterthought. Often at utilities, investment in renewables and supporting integration needs is filed through by a different group than those individuals or the specific team that is driving smart-grid development. More importantly, the value of the smart grid's role is not completely understood and is often met with a range of reactions, including skeptical views of what, exactly, is "smart" and the challenge of valuing the enabling function.

Properly valuing the enabling role is actually a boost for a utility's smart-grid business case. The overall package of benefits delivered increases substantially as environmental targets rapidly become measurable from the

PUC perspective. If the costs of carbon are explicitly monetized in some way in the near future, this can provide a "hard" basis for linking carbon benefits to the enabling functions. In addition, without the aspect of integrating alternative as well as modular sources of energy into the grid, the smart-grid business case lacks the decentralized vision that it has often been touted to have.

6) The choice of front-end communications technology will get even more complicated.

Choosing the most suitable communications technology at the local and wide-area network level has plagued utility decision makers, regulators, and vendors since automated meter reading (AMR) functionality was developed. The initial debate surrounded the transition from mobile to fixed. The current debate is among broadband, RF, and PLC. While different perspectives on this issue continue, the latest round of large IOU deployments has favored RF providers.

The next wave of communications decisions is going to center on three competing technologies. The first group is the current set of technologies that are continually improving to deliver increased bandwidth, latency ability, and Internet protocol (IP) capabilities. Second, there is the advent of advanced telecommunications technologies, primarily in the form of 3G, GPRS, and WiMax. The future of these technologies is a hotly debated issue. Proponents of telecom-based technologies point to the adoption of these technologies in parts of Europe as a sign of future developments (e.g., GPRS in Nordic countries). Those arguing against the technologies point to the penetration levels in the United States—both currently and in the longer time frame, as in the case of WiMax. The debate about whether private or public networks will prevail will take several years to play out, but utilities need to do their homework while PUCs ask the questions.

The third, emerging model that alters the debate significantly focuses on customer interaction and service provision through an Internet connection. In this model, the meter essentially is replaced with a data server at the home that acts as a "virtual meter." This links up with a customer's computer as the interface and provides the requisite HAN functionality while sending back the appropriate metering data that the utility needs from the customer. If such a model were to be adopted, issues concerning physical disconnect and broadband access would need to be addressed. This would be a particularly attractive model in competitive retail markets in which retailers can use AMI and HAN services to improve their retailing value proposition to win and retain customers. Of course, issues about data confidentiality and data usage also need to be ironed out in these retail situations. Retailers in Germany are already beginning to introduce these technologies.

The challenge for utilities will be to continue smart-grid deployments with the recognition that the technology game will continue to change. This is an unavoidable facet of the smart-grid industry, but rather than postponing decisions entirely, there is a way to construct optionality in deploying the smart-grid with limited risk. The role of the PUC in providing support for obsolescence is also critical, and the recent precedent established by the U.S. Congress, which in October 2008 approved a measure that lets utilities depreciate investments in smart-grid technologies over ten years instead of 20, provides some indication of where regulatory support is headed.

7) Margins are not going to commoditize "downstream" in the near term.

There has been growing concern from AMI and grid products and services vendors that the smart-grid value chain will rapidly commoditize within the next couple of years. In other words, AMI and grid technologies will become increasingly standardized as utility demand drives both the scale and interoperability of applications, and margins will start shrinking. As this happens on the downstream grid and meter side, the contention is that margins migrate toward more complex functionality, such as systems integration and data management.

There are a number of factors that will prevent commoditization of the downstream aspects of the smart grid. AMI, HAN, and grid application providers can maintain a threshold of interoperability and still differentiate on other product specifications. For example, for a number of AMI providers, the push into IP is setting a perceived standard on interoperability, but margins on the AMI solution have remained intact. Similarly, as multiple grid vendors provide volt/var applications, additional services and features can be added in to maintain differentiation. Likewise, when it comes to demand response, the innovation in products and services that is happening now has resulted in a variety of offerings, many of which preserve the interoperability feature (e.g., ZigBee, HomePlug) but are actually not that easy to compare with one another. Margins will stay local to the segments of the value chain as long as vendors establish a balance between perceived interoperability and adequate differentiation of services. On top of this, the ability to modularize and customize features to meet customer needs will ensure margin capture.

8) Proof is in the pudding: Ultimately, the success of the large deployments under way will pave the way for all smart-grid adoption.

It's important to end on a practical note grounded in the here and now: Ultimately, smart-grid adoption will be shaped by the success of the current deployments under way broadly in California, in Texas, and at some targeted utilities in several other states, as well as in Ontario, Canada. Both utilities and vendors are nervously watching. The success of these deployments will ultimately determine whether utilities and regulators take a bullish or bearish position on smart-grid deployment. p&e