The Architecture for an Integrated Grid

New Architecture of Software, Tools, and Test Beds to Integrate Millions of Grid Devices

By Garrett Hering

A century-and-a-half following the opening of Thomas Edison's laboratory and Alexander Graham Bell's invention of the telephone, the Internet of Things could truly integrate electric power and telecommunications, unlocking the potential of distributed energy resources and other emerging technologies.

EPRI's Integrated Grid initiative is working in diverse areas to integrate solar photovoltaics, storage, electric, smart meters, and other distributed devices at what is sometimes termed the "edge." For utility operations and planning, this offers immense potential to enhance grid efficiency, security, and sustainability—and to expand services and customer choices.

But for the grid to become truly integrated, all of its software and hardware must communicate and coordinate their operations. This is where "architecture" becomes instrumental.

EPRI's Technology Innovation program launched research to create an "Architecture for an Integrated Grid," providing a common language and set of rules for interacting systems and devices. This will lay the foundation for an information and communication technology infrastructure that enables compatibility and functionality of devices across the grid, including computer-based enterprise systems; utility-owned transmission, distribution, and generation assets; and customer-owned distributed energy resources.

"There are millions of interconnected devices on the grid today, but they are not integrated," said EPRI Technical Leader Karen George. "They do not speak the same language."

Today utilities use proprietary, legacy information and communications infrastructures that require custom-engineered solutions for each new system. This leads to "accidental architectures" that impede access and the flow of data needed for reliable grid operations, explained George.

From 'Accidental' to Intentional

EPRI's research is intended to provide software, tools, and test beds that help the electric power industry transform its various accidental architectures into one that is uniform, intentional, and nonproprietary.

"We are creating the architecture for the integrated grid," said George. "It's like the connectors in a Legos set. It enables everything to fit together."

"The idea is to enable utilities to adapt their existing systems and devices, to foster innovation of new applications, to enhance overall cyber security and communications, and to integrate distributed resources," added Matt Wakefield, director of EPRI's Information, Communication, and Cyber Security program.

All four EPRI research sectors are involved, along with other research initiatives such as the Smart Grid Interoperability Panel, the Grid 3.0 initiative, and the Wi-SUN Alliance.

In all, about three dozen organizations, initiatives, and companies are participating in the research, including utilities, technology vendors, laboratories, universities, government, and industry groups.

"For us to be successful in developing and implementing a common language, we need broad industry collaboration and adoption," said Wakefield.

The Five Pillars

EPRI's Architecture for an Integrated Grid project consists of five interrelated pillars at various stages of development:

- **Pillar One: The Enterprise Interoperability Platform**. The hub of the architecture, this network of software and computer hardware enables utility information and communications infrastructures to integrate legacy, new, and future systems. The EPRI-developed Common Information Model facilitates this interoperability. Research focuses on computing across different communication buses.
- **Pillar Two: Open Application Platform**. Similar to the way smart phones serve as platforms for apps, this computer-based platform will enable electric meters and other utility devices to "learn new tricks" after being installed, explained EPRI Principal Technical Leader Ed Beroset. With meters, for instance, utilities could load apps for power quality monitoring, billing data collection, and outage notification. For meters and other equipment, EPRI is helping vendors use advances in microprocessors and software to turn their products into platforms for innovation.
- **Pillar Three: Open Telecommunications**. Similar to how Wi-Fi and Bluetooth support communication among phones, computers, and other consumer products, EPRI is working with vendors to enable wireless, wired, and power-line-carried data transfer among grid devices and enterprise systems. In 2016, EPRI will complete a set of software to improve grid communications across the integrated grid architecture.

- **Pillar Four: Cyber Security**. The expansion of electronic data collection and exchange on the grid creates potential security vulnerability. EPRI will develop approaches that provide cyber security for the enterprise interoperability and open application platforms. This year, EPRI is working with the Smart Grid Interoperability Panel to enhance cyber security for its Open Field Message Bus initiative.
- **Pillar Five: Distributed Energy Resources**. EPRI is developing software and other tools to integrate distributed energy resources. For example, EPRI's OpenDERMS software enables utilities to manage distributed resources with data from smart inverters, providing an interface with grid operations.

EPRI has launched laboratory and field demonstrations of software, tools, and test beds to examine how each pillar supports the architecture.

Loading Apps onto Smart Meters

In 2015 at EPRI's Knoxville laboratory, researchers demonstrated that an EPRI-designed electric meter could support an application to verify the meter's proper operations.

"That's especially important after hurricanes, ice storms, or other severe weather that causes blackouts, because sometimes parts of the grid are reassembled a bit differently during restoration," said Beroset.

Later this year, EPRI will update the application programmable interface used in the demonstration meter and integrate it into a commercial device.

Communication Collaboration

Also in 2016, EPRI will complete software to improve communications across the integrated grid architecture. EPRI is developing the software with the Wi-SUN Alliance and has begun testing its application with advanced metering infrastructure and distributed energy resources.

Using this software, EPRI is working with vendors to achieve interoperable communication networks enabling data exchange among utilities, various models of meters, distributed energy resources, and distribution automation. With this open communications platform, third-party software programmers also can contribute enhancements.

"This would be a major step in creating an open architecture for an integrated grid because currently vendors of meters and other devices use proprietary interfaces that are not interoperable," said Wakefield.

Wearables Integrated with the Grid

EPRI has developed and demonstrated a prototype of a wearable Raspberry Pi computer for utility maintenance workers. A line worker, for instance, can use it to record still images or video of damaged transmission equipment, along with its geospatial coordinates. The device then generates maintenance work orders that are sent to an open-source workflow management software (called OpenWMS) via an interface supported by EPRI's Common Information Model.

The wearable computer—an important data-exchange building block for enterprise interoperability—can be used for work scheduling and other applications.

This fall, the team will update OpenWMS to support additional routine service messages. Many possible applications are under consideration.

"There's a lot of potential for worker safety," said George. Wearable computers could include sensors to measure invisible threats such as an electrical charge in a fence. Maintenance workers could use wearable computers to view augmented reality images of underlying utility infrastructure when visiting customer sites.

Vendors of wearable computers are using EPRI's cloud-based test harness to confirm that message formatting is accurate. This enables vendors to focus on the specifications and pricing of their devices.

Managing Distributed Energy Resources

As with smart meters and other grid devices, the different manufacturers and models of solar and other distributed energy resources challenge seamless communications. To address this, EPRI uses its OpenDERMS tool.

"OpenDERMS helps to aggregate the services of individual distributed resources and translate their different languages into one cohesive language," said George. "Utilities can't control deployment of these resources, but OpenDERMS can help manage them."

This year, EPRI is further developing the interoperability of OpenDERMS. Using the Common Information Model and another set of standards called MultiSpeak, EPRI is equipping OpenDERMS to receive web service messages so that it can manage and integrate communications between enterprise systems and distributed energy resources.

EPRI has used the test harness to validate these messages. As with vendors of wearables, knowing that communication is seamless enables distributed energy resource vendors to focus on their products.

EPRI will support utilities in applying OpenDERMS to grids in their service territories.

The Architecture for an Integrated Grid will enable the electric sector and society to benefit from the connected systems and devices in the emerging Internet of Things—an outcome that would surely impress Edison and Bell.

Key EPRI Technical Experts

Karen George, Matthew Wakefield, Ed Beroset