The Foundational Role of Distributed Intelligence-Enabled Meters in Grid Modernization

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Utilities around the globe face unprecedented challenges in managing their distribution networks. Electric vehicles (EVs), solar power and other distributed energy resources (DERs) are changing load profiles and making demand difficult to predict. Also, labor and supply constraints have increased operating and capital costs at a time when aging infrastructure is vulnerable to more severe storms creating environmental risks. These challenges reinforce the need for intelligent meters that measure energy consumption at a faster rate and perform real-time data analytics at the edge of their distribution networks to increase customer engagement and ensure reliability—all through an open, interoperable ecosystem—that meets today's rapidly changing market.

When utilities gain visibility to the meter (and beyond), plus command and control (similar to a SCADA system) across the distribution network, they have the foundation needed to integrate DERs and maintain reliability more effectively and efficiently. This foundation is comprised of three advanced technologies:

- Data-producing sensors incorporated with intelligent meters
- Artificial intelligence (AI) for data monitoring and analytics
- Intelligently connected IoT networking with robust machine-to-machine communications

The presence of these technologies is particularly important at the very edge of the grid, where DERs and customers interface with the network and where utilities need the most visibility and flexibility. That's why distributed intelligence-enabled meters are critical to grid modernization programs.

The days of simply measuring and reporting consumption are diminishing. Distributed intelligence (DI)-enabled meters are sophisticated network sensors capable of providing valuable, high-resolution data on both upstream and downstream conditions. They are also powerful computing platforms capable of running innumerable purpose-built applications and analytics, and they are flexible communication nodes that expand the options for utility and customer connectivity.

This paper explains why DI-enabled meters deliver advanced capabilities that are critical to modernizing distribution networks.

VISIBILITY THROUGH SENSOR DATA WITH DI-ENABLED METERS

DI-enabled meters deliver this kind of visibility by measuring detailed data which can be analyzed by algorithms that disaggregate the electrical consumption of appliances and equipment in customer homes and businesses. With metrology sampling rates of up to 32kHz per second, these devices can also precisely measure voltage and current waveforms that reveal the quality of the electricity supply, including information about voltage sags, swells, harmonics and other power-quality issues. This is important as more DERs are connected to the grid causing greater unpredictability, and meters with lower sampling rates may not be able to detect issues like intermittent arcing.

Recognizing the presence of new DERs on the network will be an important first step toward successful integration. EV adoption is expected to skyrocket by 2030 to more than 60% of global sales[1], according to the International Energy Agency (IEA). Research suggests peak demand on a typical residential feeder will increase 30% when just one-quarter of the homes begin charging EVs[2]. A four-fold increase in residential solar by 2030[3], plus an increasing number of power storage systems[4] has the potential to help balance the load. However, to reliably integrate the new demand and generation—and protect equipment in the process—utilities will need visibility into the low-voltage circuits that DI-enabled meters provide. For instance, the meters on a single feeder or service transformer will be able to work in concert to calculate, monitor and even adjust net load, or let utilities know when equipment is undersized and at risk of failure.

The potential use cases for high-resolution meter data are numerous and valuable (see sidebar). Leading utilities are already using the first applications in the field to improve safety, awareness and reliability on low-voltage circuits. These applications include:

High Impedance Detection

With higher sampling rates, DI-enabled meters can detect high-impedance connections that cause customer voltage flickers, interruptions and potential fire risks. Tampa Electric Company (TECO) uses its meters to continuously monitor impedance across its low-voltage network, allowing the utility to identify problematic assets before they fail and schedule repairs as proactive capital expenditure projects, instead of reactive overtime hours.

Meter Bypass Detection

Tampering and energy diversion continues to be a major concern for utilities. This affects the utilities' bottom lines and public safety. High-resolution current and voltage data from meters at different locations on the distribution network enable utilities to determine if and where power is being stolen. Analysis of the data identifies when current is drawn on the secondary of a transformer that did not go through a meter. Itron and Tampa Electric Company (TECO) conducted a meter bypass test in Itron's DI Lab whereby the algorithms accurately identified each use-case occurrence in real time and produced 100% accuracy, with zero false positives, over the course of testing.

Active Transformer Load & Voltage Monitoring

By monitoring real-time voltage and current data from the endpoints on distribution circuits, DI-enabled meters provide unprecedented insights into the condition and loading of distribution transformers. Utilities can use the data in feedback loops to automate tap changes at the transformer and optimize the delivery of electricity while combating the growing impacts of consumer energy devices as they come online and offline.

THERE'S AN APP FOR THAT

To date, several apps are available, with nearly two dozen more planned. Additionally, over 14 third parties are developing their own apps, and more than 18 third-party developers are enrolled in the Itron DI Developers program.

The applications fall into three categories.

Grid Modernization

- Active Temperature Monitoring
- Active Transformer Load Monitoring
- Active Transformer Voltage Monitoring
- EV Readiness
- High Impedance Detection
- Location Awareness
- Meter Bypass Detection
- Voltage Bellwether Monitoring

Consumer Engagement

- Smart Payment

DER Integration

- EV Awareness
- Solar Awareness
- Customer Energy Resource Control

To learn more about these DI applications, see the Itron Distributed Intelligence brochure.

[1] By 2030 EVs represent more than 60% of vehicles sold globally, and require an adequate surge in chargers installed in buildings (IEA)
[2] The potential impact of electric vehicles on global energy systems McKinsey & Company
[3] Approximately 100 million households rely on rooftop solar PV by 2030 (IEA)
[4] Global Residential Energy Storage Market by Power Rating, Connectivity, Technology, Ownership, Operation and Region - Forecast to 2028 (Research and Markets)

OPERATIONAL VALUE THROUGH ANALYTICS

Data, and the visibility it provides, are good for situational awareness and troubleshooting. But the real operational value comes from continuous monitoring and analysis of the high-resolution data. Humans aren't capable of this task, which is why Artificial Intelligence (AI) is such a promising technology for the utility industry[5].

The applications described above are made possible not by human analysis, but by machine-learning algorithms. High impedance detection, for instance, is an application that runs on a meter's computing platform. The application alerts a human working in the utility maintenance and operations (M&O) only if equipment begins trending towards failure—with no human intervention.

While AI provides a powerful tool to analyze problems like high impedance, other problems are suited to a more conventional processing strategy where grid-monitoring applications are run centrally in a back-office system or in the cloud. Distributing the computing power and analytical "intelligence" into every meter has three distinct advantages that are critically important.

Faster Control

Locating analytics closer to the challenges they address reduces network latency and increases the speed with which systems can react to changing conditions. With Active Transformer Load & Voltage Monitoring, for example, applications running on the meter have real-time access to the necessary high-resolution voltage measurements. The same application running in the cloud, or a back office, would be hampered by latency, even if it were possible to use a low-resolution data stream for Active Transformer Load & Voltage Monitoring. The same will apply for localized control of parameters set via distributed energy resource management systems (DERMS).

Simplified Data Management

DI also simplifies the challenge of managing vast amounts of data produced by sensors on a modern grid. Latency issues aside, simply backhauling and storing so much data is an enormous IT challenge. Locating analytics in the meter greatly reduces the amount of data that needs to be transmitted. It changes the paradigm from "big data" to the "right data."

Customer Engagement

Computing platforms in meters also expand the possibilities for better customer engagement. With the emergence of smart appliances, not to mention on-site solar and power-storage systems, customer expectations are increasing. Furthermore, to gain command and control over customer DERs for grid balancing purposes, utilities and their third-party partners will need customers to opt in. DI-enabled meters with computing platforms are ideal for deploying the types of customized programs needed to engage customers with valuable information.

Beyond data generation and analysis, the modern grid infrastructure relies on the flexible communications provided by DI-enabled meters to ensure interoperability.

INTEROPERABILITY THROUGH FLEXIBLE COMMUNICATIONS

Distributed data and analytical insights are practically unusable without the ability to send them to other machines and remote human operators when needed. DI-enabled meters have multi-transport capabilities and protocols that allow them to communicate in the most efficient and secure manner for the use case at hand. Four communication protocols are common in DI-enabled meters, allowing them to function as both nodes and hubs in the distribution network.

Power Line Carrier (PLC)

Meters with high-frequency, high-bandwidth PLC capabilities can rapidly exchange peer-to-peer (P2P) data and control signals with nearby meters and distribution equipment. It also gives utilities a direct method for confirming the location of devices on the distribution grid. This location awareness is key for balancing load on secondary circuits and for the efficient work of crews in the field.

Radio Frequency (RF) Mesh

RF mesh is the preferred technology for wireless Internet-of-Things (IoT) applications that do not require high bandwidth or blistering speed. RF modules in meters serve as nodes in vast webs of interconnection across service territories. Small data packets pass from node to node until they reach the target device, which could be another meter or a modem that sends the data to a centralized system via cellular or fiber connection. RF mesh is ideal for meter reading and can lay the foundation in urban settings for smart city services that require intermittent communication with things like parking meters, traffic sensors or even public garbage bins.

Wi-Fi

Wi-Fi is the communication technology linking smart-home technology. With Wi-Fi capability, an electric meter is not only able to communicate directly with power-hungry appliances like refrigerators and water heaters, but also able to supply real-time information to customers regarding time-of-use (TOU) rates or other efficiency or demand response (DR) programs. Perhaps most importantly, Wi-Fi will enable the integration of customer owned DERs with a utility's network. DI-enabled meters will be communication hubs for utilities to exchange data and control signals with smart solar inverters, EV chargers and power storage systems. The data will allow utilities to have better demand forecasting and the control will enable coordinated load balancing to protect grid assets and ensure reliable power delivery.

Cellular

Cellular technologies also play a key role in connecting DI-enabled meters as both a backhaul option for RF mesh networks and for direct point to point communication to the meter itself. The ability to leverage existing telecommunication infrastructure makes cellular-enabled meters ideal for use cases such as spot deployments for opt-in or pilot activity, as well as bellwether monitoring. In addition, cellular technology enables utilities to utilize existing standards-based networks as a complement to their RF mesh networks, providing flexibility for rural or remote locations where RF mesh is not cost effective. In addition, some utilities may choose to take advantage of cellular networks for their entire deployment, or even potentially build out utility-owned private LTE networks. This approach is often necessary in markets where the provision of metering services is "contestable" and the metering is owned and operated by a different supplier from property to property.

[5] Why artificial intelligence is a game-changer for renewable energy (Ernst & Young)

ITRON'S PERSPECTIVE ON DISTRIBUTED INTELLIGENCE-ENABLED METERS

Through grid modernization, Itron's utility customers aim to solve two major challenges on the distribution grid:

» Increasing capacity to meet rising demand

» Managing the growing complexity of connected devices and two-way power flows

Based on their unique situations, utilities will approach the challenges with different strategic and capital priorities. However, when it is time to invest in the DI-enabled meters, our customers will want to ensure they get the strongest return on their investments and enough technological headroom for long-term growth. As a result, development at Itron prioritizes the following in a single meter.

Distributed Intelligence

To enable a dynamic and resilient grid, meters must be capable of independent data analysis. They must have a high enough sampling rate to effectively monitor local grid conditions and enough computing power to interpret and confirm observations. Plus, they must be configurable to implement operational decisions and/or alert human attention. Itron is committed to providing high-speed, high-quality data using market leading measurement technology to enable advanced DI outcomes.

Seamless and Secure Networking

To enable the safe and efficient flow of data and the interoperable command and control of assets, meters must be seamlessly and securely networked with one another, and with other devices and equipment across the distribution grid. As a result, Itron is committed to the use of open standards, support interoperable communication technologies and end-to-end integrated security solutions.

Ecosystem Collaboration

The challenges facing utilities will require innovation from across the entire industry. No single vendor will be able to generate all the necessary solutions. Itron meters are open platforms for utilities to use in collaboration with other vendors, partners and third-party application developers. Innovation is unpredictable, and we want our meters to bring flexibility, not limitations to our customers.

Operational Efficiency

With the growing complexity of connected devices in a distribution network, having an integrated meter-to-cash solution with distributed intelligence functionalities streamlines the operational efforts needed for utilities to monitor their distribution network without multiple devices.

The combination of powerful Linux-based computing, multi-transport communications and a collaborative ecosystem of innovation ensures that utilities have the resources and flexibility to develop the modern grid that best suits the needs of their customers and stakeholders.

Meter with the Outcome in Mind

Itron's DI-enabled meters are designed to be foundational elements in a diverse ecosystem of intelligent devices and sensors working in collaboration at the edge of utility networks to analyze high-resolution data, make decisions and act in real time to transform energy and water delivery systems, empower consumers and businesses, and make communities more livable and sustainable (see the paper, "Distributed Intelligence: Creating the Future for Utilities")

Focused on delivering the cost-effective metering solutions our utility customers need, Itron recognizes that our responsibility does not end with the design and manufacturing of devices, because the devices themselves are only valuable through strategic integration with utility operations. With DI-enabled meters, functions such as high impedance detection, meter bypass detection and transformer load monitoring will enable utilities to better manage their distribution network at the edge and be better equipped for the energy transition associated with today's rapidly changing markets.

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