Distributed Intelligence: Creating the Future for Utilities

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New challenges for the utility industry are presented every day. Continued innovation has created a plethora of new and exciting opportunities for the utility industry in every commodity. For electricity, multi-directional power flows in the LV network, created by photovoltaics, electric vehicles, storage penetration and consumer service expectations—driven by digital economy revolution and players like Google, Amazon and Apple—have driven many changes in to utility market.

These opportunities are a catalyst for new business models based on energy balancing, reactivity and customer focus. As a result, utilities need new tools to retain a position as a provider and enabler for energy consumers.

UTILITIES AND COMMUNITIES IN TRANSITION

Over the past several years, powerful trends have emerged that are affecting infrastructure investments and decision making by utilities and communities. More than just grid modernization, there are critical events that affect core utility infrastructure. Aging capital assets such as transmission lines, transformers, distribution assets and grid security are affecting utilities capital decisions. Include the impact of environmental issues such as severe weather, resource sustainability and wildfire management, and this creates large unplanned impacts on core utility infrastructure. Include pandemics, which have a huge impact on utility workforce, and modern utilities have a difficult set of issues facing them.

All these observations and changing customer expectations have created an environment where utilities must evolve, change and upgrade infrastructure, business models and operational strategies to survive. These conditions are driving grid modernization and new use cases. The result of ignoring these indicators is bankruptcy and reorganization of the utility.

Some factors that are currently affecting how utilities operate now, and in the future, include:

» The rise of renewable distributed generation (and utility use of renewables) to create a more dynamic and non-dispatchable source of energy

» An increase in the number of prosumers and rates that create multi-directional low voltage networks, including programs such as solar buyback and using EV batteries for peak flattening

» Rapid urbanization with increased population density is driving the need for more apartments and less single-family home ownership. There is also an emphasis on sustainability and low-impact living.

» Consumers demanding choice in their electric providers, renewable energy and pricing plans, etc.

In addition, the evolving digital economy is creating consumer expectations of immediacy through contributors such as:

» Amazon Prime: same-day delivery

» Amazon and Google: "digital assistants" that provide instant information based on searching the internet

» T-Mobile, AT&T and Verizon: instant access to anybody who has a cell phone as well as SMS where text exchanges happen instantly

The examples above are part of building instant gratification expectations and the expectation of "right here, right now". Our world is becoming the "instant" society where waiting is not tolerated—and is an inconvenience.

These events are building a new community model that drives customer's expectations, and the utilities that support them, into new business areas, rate models and use cases.

With access to every consumer in its territory, how can utilities play a central role in this evolving model? Today, the utility serves their base load and peak loads using traditional, centralized generation capabilities and supplementing with power purchases from the wholesale market. Incorporating decentralized generation from prosumers is just beginning to evolve in the utility operational model.

THE CHANGING GRID

As the prosumer evolves, and decentralized generation becomes more prevalent, the rise of microgrids becomes more prevalent. Microgrids are those islands of generation servicing a small, connected group of consumers. Microgrids add a level of resiliency to the grid by continuing to operate during a main grid outage. The utility will need to define the requirements for microgrid connectivity and re-connectivity to the main power grid. This creates the opportunity for a value-added rate/tariff of how the utility serves the microgrid and its connectivity to the utility grid.

Utilities and communities can work together through public-private partnerships and other means to provided advanced services and revenue streams to each other and to citizens. Services such as EV charging, water data collection and billing, water conservation and streetlight controls are examples of these advanced services.

A report by the Rocky Mountain Institute on "Navigating Utility Business Model Reform"[1] discusses many of the issues facing utilities as new regulatory policies begin to roll out across the country. The report outlines four areas that are driving change:

1. Adjustments to the Cost-of-Service Model

2. Leveling the Playing Field

3. Retirement of Uneconomic Assets

4. Reimagined Utility Business

Each of these four areas of reform, and the use cases associated with them, creates a significant change for how utilities need to think about future planning. Adjustments to the Cost-of-Service model encompasses major changes to how utilities interact with their customers. Revenue decoupling, multi-year rate plans and performance-based incentives are all examples of regulatory changes that drive a major shift in utility business models and consumer expectations.

As these changes become part of the utility business model, consumer energy services (value-added services that the utility provides for the consumer) become part of the consumer's menu of choices. These services may include leasing solar to the consumer or providing an energy arbitrage for those deregulated markets. Today, these services are being created by independent, non-utility companies that are filling in the consumer energy services space. Examples include solar plant providers that install solar panels on consumers' homes in return for tax credits or EV charging companies that provide public EV charging stations. All are opportunities for the utility, when enabled by regulatory bodies.

These opportunities are driving change to occur in this space, and it is just the beginning. IoT technology has created an enabler to help us move from the old energy model to a new energy model.

DECARBONIZATION & RENEWABLE GENERATION

More dynamic, less predictable generation fleets. Cleaner gas mixes and increased focus on safety.

ACCELERATION OF PROSUMER MODELS

A fluid, multi-directional low voltage network.

RAPID URBANIZATION & DEVELOPMENT

Increasing population density. Emphasis on sustainability and resiliency.

DIGITAL ECONOMY-DRIVEN CONSUMER EXPECTATIONS

"Right here, right now."

Factors Affecting Utility Infrastructure & Vision

With proper planning and execution, IoT tech enables utilities to stay relevant and provide real value to their stakeholders. But, it is the vertically integrated platform, outcomes and solutions that support that platform, not the technology itself, that makes this possible. Some of the key opportunities where utilities can use IoT to create valuable outcomes are:

» **Improving safety for consumers and field crews:** the utility's core mission has been to provide safe, reliable and resilient power. This remains true for both consumers and the field crews that keep the lights on. Smart sensors can proactively identify safety concerns.

» **Opening new business models:** In the old model, utilities made significant investment in capital equipment and then earned a return on it by providing energy to their customers. Now, their customers are generating and storing their own energy, and are focused on using less of it. That traditional model is slowly going away, creating new opportunities for utilities to become an energy management services provider: support distributed generation, but provide grid services as needed/desired. This opens the opportunity for Distributed Energy Management to enhance grid sustainability and reliability.

» **Enabling transactive services:** Utilities and cities alike are becoming platform providers that enable third parties and end consumers to connect to a common, integrated platform. Utilities, for example, can enable consumers to be buyers and sellers of electricity, depending on the system's needs, customer needs and capabilities, and price factors that can incent the customer to be an energy taker or provider, including inter-customer transaction (this requires new thinking and regulation change).

BASE AND PEAK LOAD SERVICES
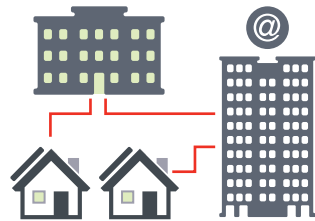
CONNECTING GRID ISLANDS
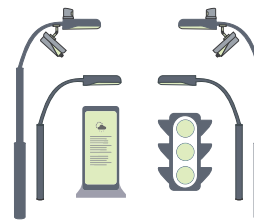
CONNECTED COMMUNITIES

CONSUMER ENERGY SERVICES

New Utility Community Models

» **Engaging and equipping prosumers:** Consumers can control their loads in response to prices and/or signals from a grid operator, as well as owning their own generation or storage. And they can choose to use those products or offer them to the grid. This is a new relationship for utilities and their customers.

For smart communities, this means providing an application enablement platform that utilizes the same network and back-office application platform. Communities worldwide are increasingly adopting open data models that enable them to share data with third-party providers. Third-party providers likewise need an easy way to access this data so it can be incorporated into their applications.

» **Enhancing resilience and reliability:** The increasing frequency of severe weather events, coupled with greater consumer expectation for "always-on" services, makes reliability a top priority.

» **Delivering a 3D ROI:** Utilities and cities are investing in critical communication infrastructure that can be used to enable new services for connected communities. As utilities and communities evaluate new services, they are embracing value beyond traditional economic ROI, including environmental and social benefits of solutions.

[1]Cross-Call, Goldenberg, Guccione, Gold & O'Boyle. *Navigating Utility Business Model Reform.* November 2018. https://rmi.org/insight/navigating-utility-business-model-reform

Instead of a traditional generation/transmission/distribution model, distributed energy resources (DER) such as solar and wind, are driving significant investment in grid modernization to provide greater awareness, control and flexibility of these new distributed, decentralized energy systems. In a decentralized power system, utilities must account for bi-directional power, transaction management and storage.

THE TECHNOLOGY INVASION

As the use of microprocessors in smart phones and IoT devices drives down cost of advanced microprocessors, it becomes more cost effective to integrate these devices into meters. This is a direct outcome of Moore's law[2] and its intersection with the Rodgers Adoption Curve[3]. The use of powerful microprocessors in meters creates the capability for high-frequency sampling and additional processing power to run local analytics. The evolution of the meter from a single-focus device that only collects consumption data, to a device with an embedded operating system, has created a powerful endpoint. This combination enables the meter to function as a real-time network monitoring and control device, a powerful and flexible engine for user engagement and development of efficient operational processes.

The utility has the key advantage of having prime real estate on the side of every customer's home. With an advanced meter on every home premise, capable of high-frequency data capture and on-site analysis, the utility has the ability to provide its customers with significant insights, information and actions that decrease the consumers' costs and increase the utility's efficiency and metrics. Examples of this include high impedance detection and load disaggregation to more advanced capabilities such as location awareness and active demand response. New market opportunities could open neighborhood energy markets and power trading within microgrids. The value that can be unlocked using distributed intelligence capabilities will be enabled by the coming regulatory changes above and the utility's vision of the future.

Meeting the challenge of servicing these new markets requires a broad and comprehensive vision that provides choice to the consumer and utility. An open architecture that supports a vibrant ecosystem of solution providers will be key in the success of this vision. Enablement of a partner ecosystem is critical to ensure reactivity, continuous innovation and the opportunity to support a business and operations model that encourages innovation.

EMPOWERING BUSINESS TRANSFORMATION

The changing market is creating a difficult trend for utilities to navigate. There is the trend for residential and small commercial customers to demand greater value and a more personalized experience from their energy provider, creating higher regulatory hurdles for utility rate cases. Large commercial customers are demanding more ability to control their own consumption and spend on energy, pushing a more decentralized grid to support emerging microgrids where commercial (and some prosumers) distributed energy resources combine to create localized energy networks that can disconnect from the grid and operate autonomously.

As the new regulatory model becomes more prevalent, consumers—both large and small—are no longer bill payers, they are stakeholders. Their activities are driving the utilities' direction. Residential consumers are buying more electric cars and by 2040, it is estimated that 50% of new cars will be electric vehicles. This requires the right infrastructure to charge, manage and maintain these cars and the load they create on the electricity grid. Large commercial customers are asking for higher power quality at lower prices. They are becoming transmission customers, and building their own substations, power generation and power control systems, where they can design grids to meet their specific needs.

These changes have large implications on how utilities manage capacity and account for energy transactions. These are a broad, complex set of challenges that requires a long-range vision and extensible capabilities that will enable management of distributed assets and new technologies across multiple domains and geographies.

INTELLIGENCE THAT EMPOWERS

Our strategy is to deliver the right information in the right place at the right time so our utility customers can meet the demands of their evolving markets and new regulatory business models. By enabling smart meter technology that exists at the edge of the network, using intelligent connectivity and smart devices, an active grid with intelligent connectivity is created to support this new market paradigm.

Our Distributed Intelligence (DI) vision goes beyond the meter and extends to a broad ecosystem of devices that can be connected to create a vibrant, active grid enabled by intelligent connectivity that creates capability at the edge of the grid. Capability that applies analysis, decision making and action where it is best utilized for the most valuable outcome. We are enabling DI for the broad collective of use cases in smart communities.

Distributed Intelligence-enabled Use Cases

While this complex challenge has many opportunities, we are focusing on three areas:

» **Gas safety and water conservation:** autonomous action taken at the smart IoT device—methane, pressure and temperature sensing—allows gas valves to close without human interaction

» **Grid management and smart cities:** enables intelligence in aftermarket devices by retrofitting them with a comms module and utilizing an Itron IoT Edge Router to act at the router level

» **Utility grid optimization and consumer services enablement:** creates more efficiencies in the delivery of energy to prosumers, enabling grid resiliency and redundancy by incorporating DERMS and extending infrastructure life

Can this vision realistically be implemented into a viable solution that scales to meet the demands of the new market requirements? Yes.

[2]*Technology Adoption Lifecyle*, https://en.wikipedia.org/wiki/Technology_adoption_life_cycle
[3]*Moore's Law*, Brittanica, https://www.britannica.com/technology/Moores-law
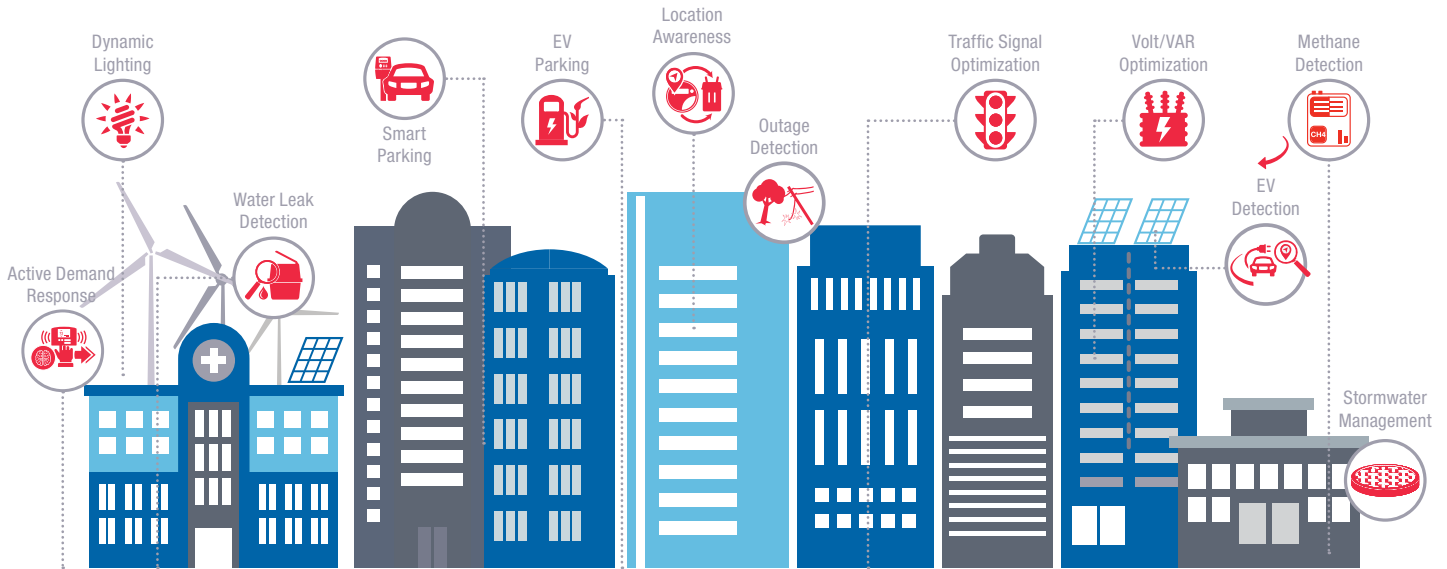
BUILDING BLOCKS FOR THE FUTURE

A key pillar to building a broad solution, our Distributed Intelligence platform applies analysis, decision making and action where it is best utilized for the most valuable outcome.

The first step is the ability to create, access, control, analyze and deliver power while monitoring and reacting to local events. Power delivered or created locally must be stable, reliable and dispatchable. Distributed Intelligence creates the platform that is required to enable Active Demand Response, Outage, Volt/Var Optimization and a myriad of other key use cases. Our DI platform enables these concepts to become reality.

Meters have gone from measuring only consumption to becoming an embedded Linux computer in every device. Now there is a Linux computer on the side of most homes and business (where regulators have the foresight to allow AMI and advanced technology projects) available in the form of a meter.

Dynamic Lighting

Location Awareness

EV Parking

Traffic Signal Optimization

Volt/VAR Optimization

Methane Detection

Smart Parking

Outage Detection

EV Detection

Water Leak Detection

Active Demand Response

Stormwater Management

Evolving Smart Communities

With this shift in technology, utilities have access to high-resolution data at the endpoint or meter. That enables the capability to look at waveform data for electric, interval usage for water and gas, and potentially load disaggregation for gas and water.

Adding peer-to-peer communications between meters and devices creates the ability for devices to compare information and status. By enabling peer-to-peer capabilities, devices can use "bee-hive"-like communications, where one device can tell another device that an event is occurring, and the other device can validate or invalidate the event as it applies to them and pass that information to other devices. That information is aggregated into an event or non-event depending on the collective outcome.

With the complexity of the information provided, and the broad nature of the solution, having an open and vibrant ecosystem of partners and solution providers creates more opportunity for the consumer to capture the value of this technology shift. An example might be power brokering between neighbors in a microgrid or retail power market. Another example is providing real-time communications that give utilities the ability to provide more grid reliability such as management of distributed energy resources during a critical peak event.

Having this capability at the edge of the utility network, especially the electric network, creates an opportunity to develop advanced solutions that meet the needs of smart cities, prosumers and future regulatory requirements.

After evaluating these markets and our customers' requests, we have created distributed intelligence applications and begun distribution of these apps to key electric customers. We have created apps that enhance our customers' ability to serve their customers.

Each of these apps address some of the common use cases that electric utilities manage every day. These apps provide enhance value to the utilities and the customers they serve. The apps listed below are the building blocks for a utility's evolution to meet the new market challenges.

» **High Impedance Detection:** The High Impedance Detection DI app provides detection of high-impedance connections (poor electrical connections) in the low voltage (LV) secondary distribution. High-impedance connections cause customer voltage flicker, interruptions and potential fire risk. Early detection allows maintenance work to be scheduled rather than corrected through one-off trouble calls and for the condition often to be resolved before impacting customers.

» **Meter Bypass Detection:** The Meter Bypass Detection DI app provides detection of bypass tampering at the electricity revenue meter where jumpers are placed around the meter to steal electricity.

» **Location Awareness:** The Location Awareness DI app provides the electrical location of every meter on the distribution grid, including transformer, phase and feeder. This information is used by multiple DI apps and is also delivered to the back office for update and validation of GIS connectivity, improved outage response, feeder phase balancing and multiple other grid applications.

» **Load Disaggregation:** The Load Disaggregation DI app provides disaggregation of the whole premise electric load into the individual electric appliances and loads within the premise, in the form of time series load profiles for the individual loads. This information can be used for numerous customer and utility operations applications and programs.

Distributed intelligence empowers forward-looking utilities to evolve new business models using these key applications and build their own applications. Distributed intelligence, delivered in conjunction with intelligent connectivity—on an industry-leading IoT-based network and rich ecosystem of multi-service use cases—allows this evolution to occur. This facilitates future planning to align with their customer's needs and the changing market driving their business model. Delivering key information to the right place and at the right time will improve grid efficiency, reliability and safety, transform customer service and decrease operational costs. Insight, innovation, enablement and trust will be the pillars for utilities to succeed in navigating the new business models. Itron distributed intelligence empowers the business transformation necessary for utilities to succeed and be in the k**now** about their customers and their grid.