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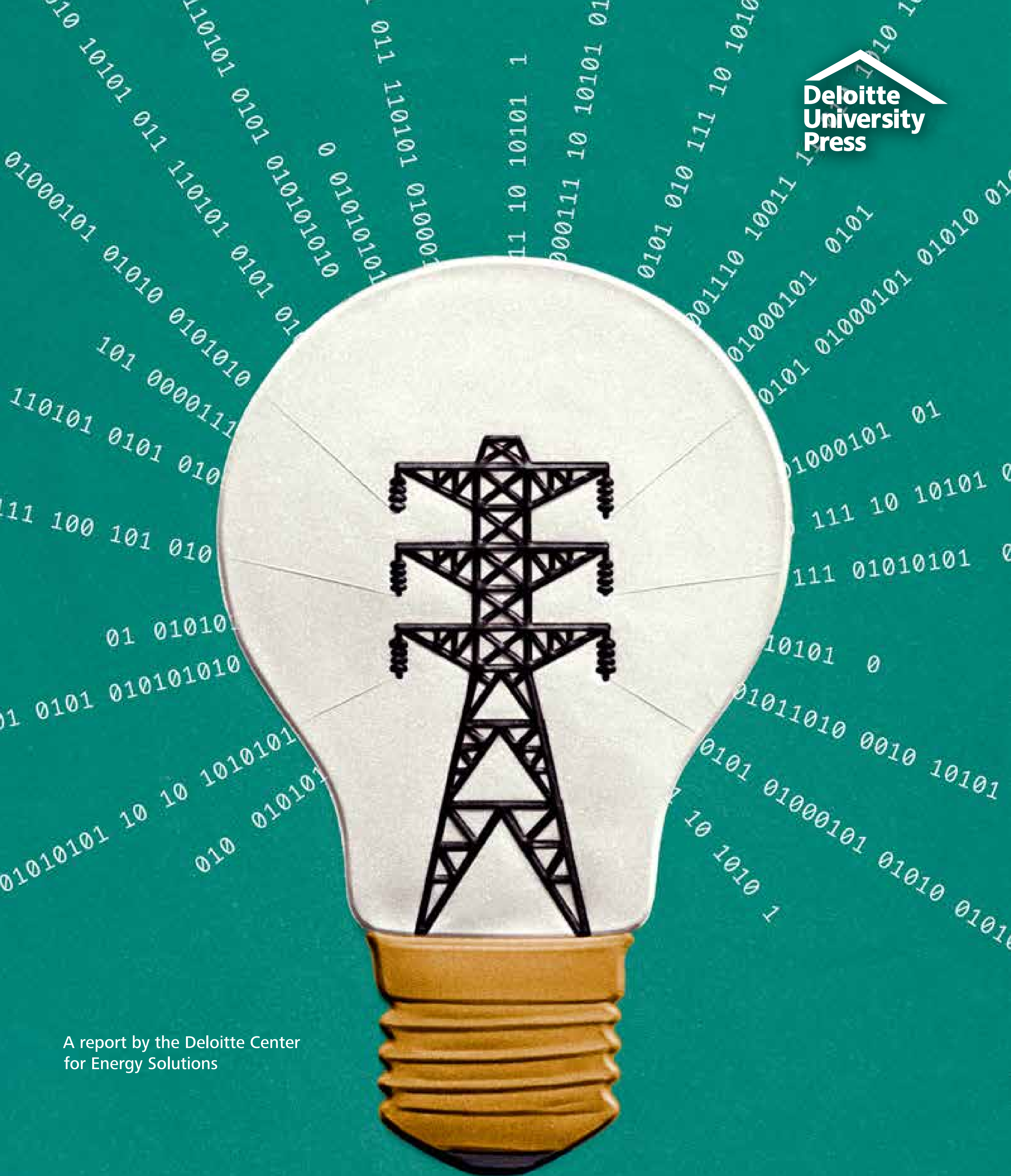

A report by the Deloitte Center for Energy Solutions

The power is on

How IoT technology is driving energy innovation

An article in Deloitte's series examining the nature and impact of the Internet of Things

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Deloitte's Internet of Things practice enables organizations to identify where the IoT can potentially create value in their industry and develop strategies to capture that value, utilizing IoT for operational benefit.

To learn more about Deloitte's IoT practice, visit http://www2.deloitte.com/us/en/pages/technology-media-and-telecommunications/topics/the-internet-of-things.html.

Read more of our research and thought leadership on the IoT at http://dupress.com/collection/internet-of-things.

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Introduction

IN 1882, Thomas Edison opened the first commercial central power station in lower Manhattan, serving a one-quarter-square-mile area, and launching urban electrification.[1] New companies arose to help develop large regional and then a national electric grid, providing the reliable power needed to unleash waves of innovation. An ever-growing demand for electricity fueled the construction of the largest machine ever built and one of the greatest engineering achievements of the 20th century: the US electric system.[2] Today, most Americans take reliable, affordable power for granted, never having known a time without it.

But the assumptions and models underpinning that reliable, affordable power are shifting. Historically, utilities have been able to invest heavily in generation and delivery infrastructure because steady growth in demand maintained affordable prices for customers and yielded reasonable returns. However, increased efficiency, conservation efforts, and alternative power sources have eroded demand growth from about 7 percent annually (1949 to 1973) to about 2.5 percent (1974 to 2013);[3] the projected growth from now until 2040 is less than 1 percent.[4] This level of growth is no longer enough to maintain the current system without raising rates. Yet, tighter emission regulations, greater reliability expectations, and the aging transmission and distribution system require more than maintenance; they need expensive upgrades and replacements. The most straightforward response— raising rates—is not always attractive, as both utilities and their regulators are charged with keeping rates affordable, and higher rates increase the competitiveness of alternatives to utility-provided power.[5]

The industry, then, must look beyond its traditional cost-of-service model[6] and focus on asset utilization and streamlining costs through operating efficiencies. Technology, particularly Internet of Things (IoT) applications, offers a range of possibilities for how electric utilities can move forward. IoT can improve the efficiency and performance of the power grid in three phases: first, by gathering data from sensors to improve the **resilience** of the grid; then through **enablement**, where utilities use that data to actively manage resources; and finally, **optimization**, where all stakeholders are able to make informed decisions about power usage and generation. Through these three phases, IoT offers some indications of how utilities can not only survive, but thrive, in this new competitive environment.

THE IOT IN THE ELECTRIC POWER INDUSTRY

The Internet of Things is a suite of technologies and associated business processes that imbues devices of all types with an ability to communicate information about their status to other systems, creating the opportunity to evaluate and act on this new source of information.

The electric utility industry's use of IoT applications has closely followed the arc of technology availability. While seldom on the bleeding edge, utilities have always leveraged available technology to optimize and control assets, increase safety, control the grid, and keep the lights on. Two examples of IoT usage in the electric power industry are supervisory control and data acquisition (SCADA) and advanced metering infrastructure (AMI).

SCADA: The IoT's roots in the industry stretch back to the early 1950s. Then, the use of SCADA allowed the centralized monitoring and control of far-off generation and transmission systems. SCADA is composed of sensors and actuators communicating with and controlled by a central master unit, and provides a user interface through a human-machine interface. The system captures time-stamped data for later analysis.

AMI: AMI is a two-way communication system of smart devices on both the utility and customer sides of the meter. Consisting of home area networks, in-home displays, energy management systems, smart meters, communications networks, and data management systems, AMI is a key component of the "smart grid."

Advances in computing, databases, and analytical tools now allow the rapid application of predictive and prescriptive analytics to large volumes of SCADA, AMI, and data from other commercial and consumer IoT devices.

Harnessing innovation to create and enhance value

THE unprecedented convergence of forces reshaping the electric power industry—from moderating demand and aging infrastructure to environmental mandates and the proliferation of distributed energy resources (DER)—requires an increasingly flexible and robust grid. The grid is evolving from a one-way system where power flows from centralized generation stations to consumers, to a platform that can detect, accept, and control decentralized consumption and production assets so that power and information can flow as needed in multiple directions. This common industry vision is known as the "intelligent grid."

This intelligent grid builds on the industry's innovative heritage of increasing interconnectedness using sensors, "smart" devices, and networked operations.[7] Achieving it will require a myriad of technologies, including numerous IoT applications. At the heart of these advances are exponential technologies like sensors, robotics, and advanced analytics, which together form advanced, interconnected systems capable of quickly analyzing large amounts of data (see sidebar). These critical systems are the sensory organs, nerves, and brains capable of giving our electric system the flexibility and agility necessary to enable ideas like a self-healing grid and plug-and-play generation—an intelligent grid.

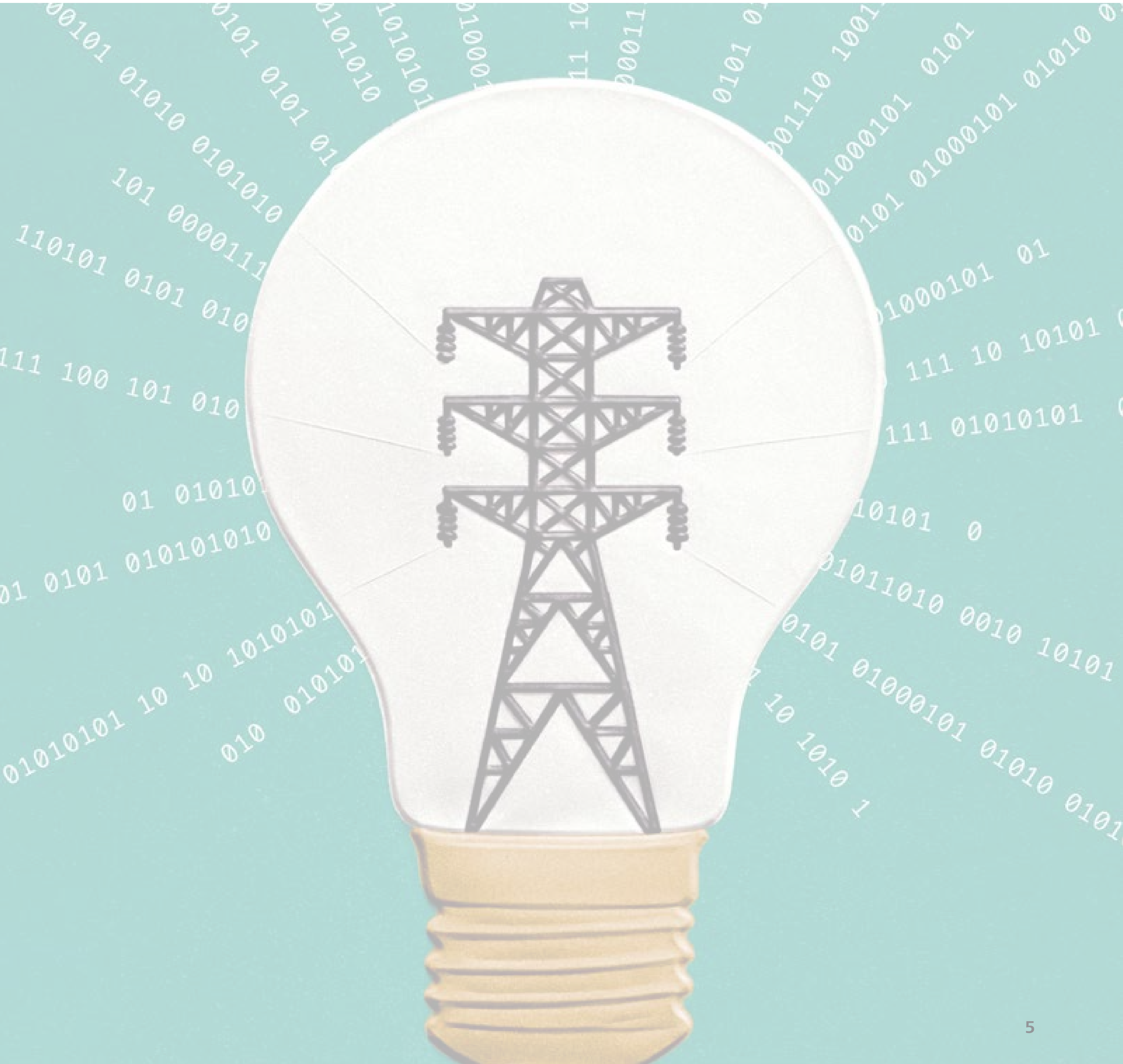
EXPONENTIAL TECHNOLOGIES

Exponential improvement in core digital technologies is fueling accelerated innovation. The cost-performance curve of three core digital technology building blocks—computing power, data storage, and bandwidth utilization—has been improving at an exponential rate for many years. As the rate of improvement accelerates, we are experiencing rapid advances in the innovations built on top of these core "exponential" technologies. The current pace of technological advance is unprecedented in history.

—John Hagel III, et al., *From exponential technologies to exponential innovation*, Deloitte University Press

The hype surrounding new technologies makes identifying the right investments difficult.[8] And an evolving regulatory policy continues to influence the equation. It is more than likely that utility planners will have to stem rate growth and increase grid flexibility by focusing capital planning, performance management, and operations on innovative ways to increase asset utilization, system reliability, and operating margin. IoT technologies are playing, and will continue to play, a key role.

The challenge is charting a path to achieve the intelligent grid vision. Meeting this challenge requires tuning out the noise about industry disruption in order to identify and seize the opportunities that IoT technologies enable. To realize the full potential of IoT technologies, we need to understand how to create and capture value from information. The Information Value Loop (IVL) provides a framework to guide us (see figure 1). It helps identify where information bottlenecks exist and what technologies can relieve them to create value. In sum, the IVL can help utilities develop a roadmap to achieve their intelligent grid visions.



The Information Value Loop

THE suite of technologies that enables the IoT promises to turn almost any object into a source of information about that object. This creates both a new way to differentiate products and services and a new source of value that can be managed in its own right. Realizing the IoT's full potential motivates a framework that captures the series and sequence of activities through which organizations create value from information: the Information Value Loop.

Note first that the value loop is a *loop*: An action—the state or behavior of things in the real world—gives rise to information, which then gets manipulated in order to inform future action. For information to complete the loop and create value, it has to pass through the stages of the loop, each stage enabled by *specific technologies*. An *act* is monitored by a *sensor*, which *creates* information. That information passes through a *network* so that it can be *communicated*, and *standards*—technical, legal, regulatory, or social—allow that information to be aggregated across time and space. *Augmented intelligence* is a generic term meant to capture all manner of analytical support, which collectively is used to *analyze* information. The loop is completed via *augmented behavior* technologies that either enable automated autonomous action or shape human decisions in a manner that leads to improved action.

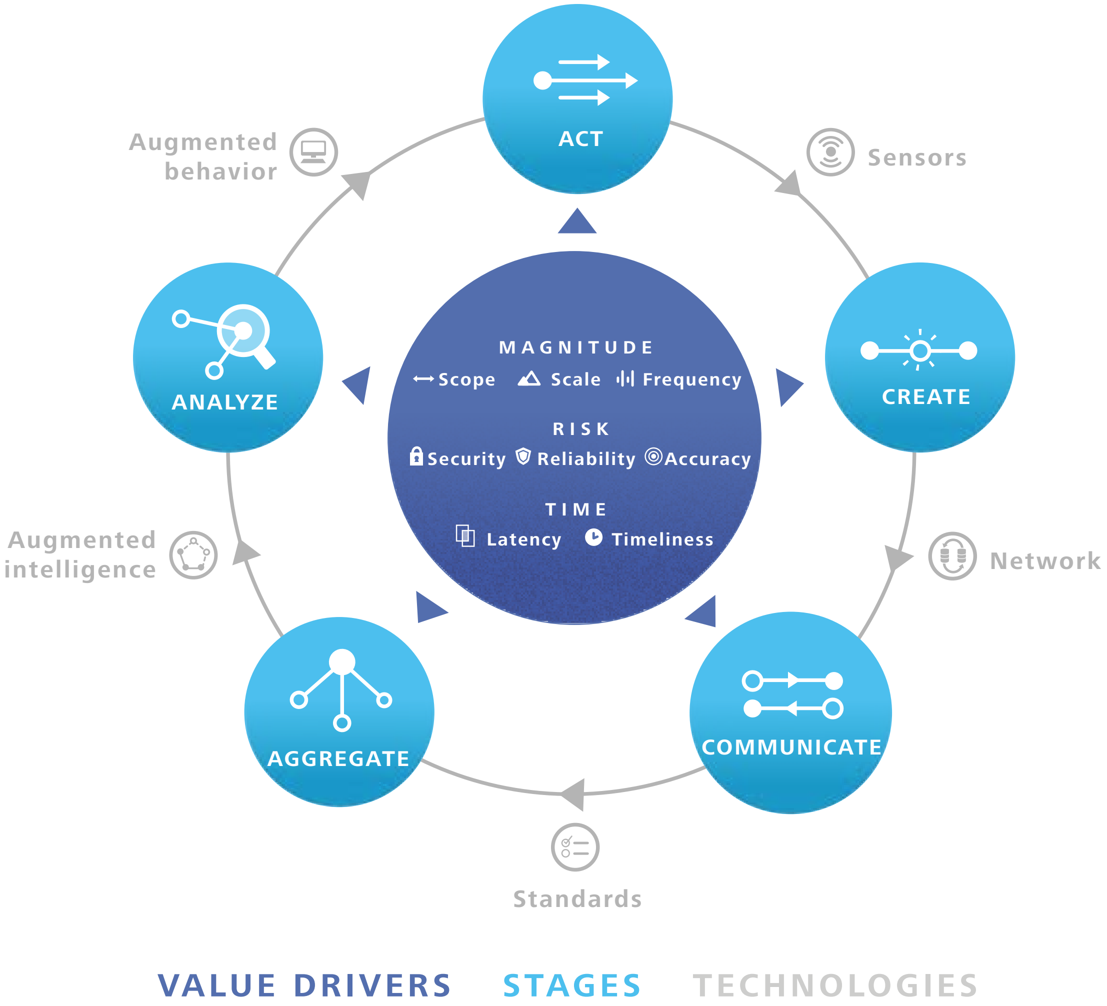
The amount of value created by information passing through the loop is a function of the value drivers identified in the middle. Falling into three generic categories—magnitude, risk, and time—the specific drivers listed are not exhaustive, only illustrative. Different applications will benefit from an emphasis on different drivers.

Exploring the Information Value Loop

The IVL provides a guide to identify business value and capture that value through action.[9] It maps the flow of information through five stages: create, communicate, aggregate, analyze, and act. It is important to realize that information must complete the loop before any value inherent in that information can be captured through informed action. Even though one or more of the IVL stages may be minimized, each stage must be traversed before value can be extracted. This point is important and deserves exploration to illustrate the interaction of IVL stages, technologies, and value drivers.

Information bottleneck: Information flow can be inhibited by insufficiencies in IVL stages or technologies. For example, implementing poorly planned or executed data standards can seriously impact value capture by not allowing action based on accurate or complete

Figure 1. The Information Value Loop



Source: Deloitte analysis.

Graphic: Deloitte University Press | DUPress.com

information aggregation and analysis. In this case, information can flow completely around the loop, but the value that can be captured may be minimal.

Value drivers: The technologies and stages of the IVL may be fully operational and well-implemented, but the value of the information captured may differ due to differing value drivers. For example, consider magnitude: There is some value in a single smart meter generating a "power out" message that is communicated around the IVL for action. But there is much more value in one million smart meters reporting their power status through the IVL for aggregation and analysis, generating a service area view for outage remediation after a storm. In this case, the two scenarios are operating in exactly the same loop using the same technologies; the value driver—magnitude—is the only difference.

The path toward an intelligent grid

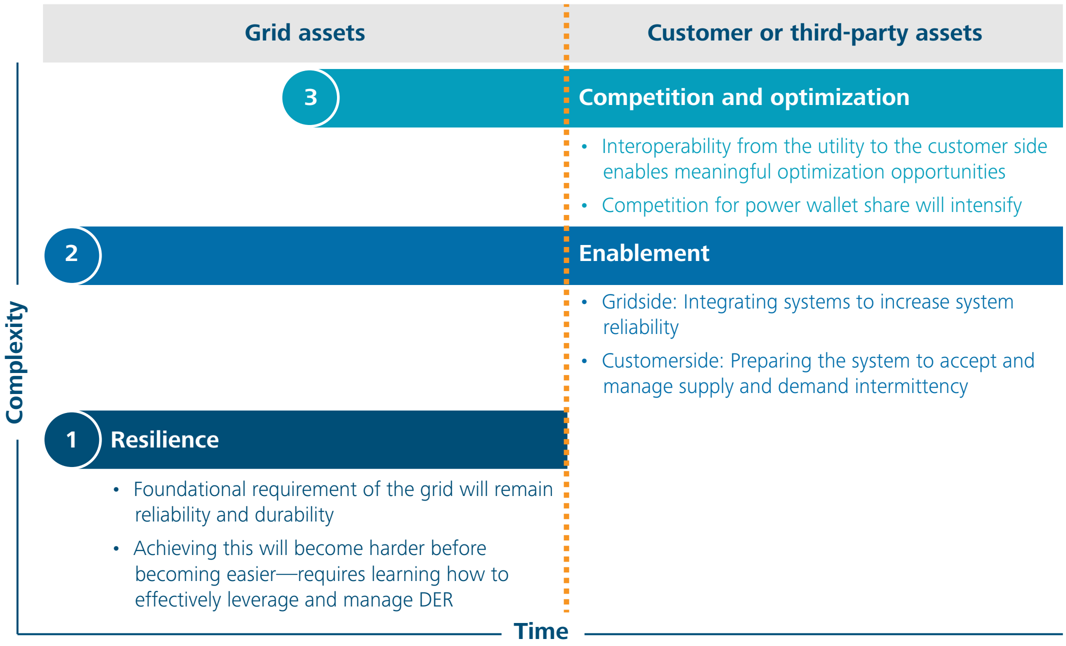
GIVEN the available choices and dynamics affecting grid modernization, the IVL is useful for analyzing decision points along the path to a more intelligent, IoT-enabled grid. The IVL is a tool to evaluate IoT investment options by determining where and how value can be created. The planning processes leading up to the deployment of AMI is a good example. The original business cases for AMI focused on its point-of-sale advantages. However, smart meters are more than point-of-sale devices—they are grid sensors that support demand response, voltage management, outage management, accelerated restoration, and overall operational efficiency. Soon after many utilities deployed AMI, operators discovered benefits within the meter data streams. What was intended to be a customer-service asset is being used by system operators to more effectively operate the electric delivery system.[10] Had utilities applied the IVL framework to the original AMI business cases, they likely would have included additional opportunities to more rapidly capture a wider range of benefits.

Described in terms of the value loop, AMI initially focused on the right side of the loop—sensor, network, and standards technologies and the create, communicate, and aggregate stages. Minimal attention was given to the left side of the loop—augmented intelligence and behavior technologies and the analyze stage. This limited the value of the business cases used to rationalize the deployment of AMI and perhaps delayed the realization of value beyond that of point-of-sale functionality.

Applying the IVL effectively requires a vision for realizing the intelligent grid. Our view is that the electric grid should modernize in three phases, which we refer to as the **resilience**, **enablement**, and **competition/optimization** phases (see figure 2). The IoT technologies and business opportunities represented by the three phases are additive and will likely occur at varying paces across the country depending on a number of factors, including regulatory and political motivation, the retail price of electricity, and customer preferences. However, each application of the IVL to an IoT technology in a modernization phase is unique and should be evaluated independently.

The following sections outline the three phases of grid modernization, highlight specific examples of IoT technologies that could be leveraged within each one, and follow the paths of relevant information around the IVL to create value.

Figure 2. The three phases of grid modernization



Graphic: Deloitte University Press | DUPress.com

Phase 1: Resilience

Background

The initial phase of grid modernization is **resilience**. Resilience is about grid reliability and durability, a goal made more difficult by the growing trend toward decentralized energy resources.[11] As a result, reliability cannot be assured merely by keeping existing facilities running and within operating parameters. Rather, resilience requires knowledge of the state of the grid that can come only from the ubiquitous deployment of a wide variety of networked sensors and control devices across the grid communicating via standards-based protocols. Ultimately, the distribution grid will need the flexibility and agility to accommodate all types of distributed energy resources or DER (see sidebar). However, without the necessary standards in categories like data, communications, network, and security, a resilient system is unlikely.

The legacy power delivery system is one-way. Large power stations located outside of population centers produce power, which is shipped in bulk across transmission lines to cities and industrial locations, where distribution systems then deliver power to customers. Because the current system generally has no ability to store electricity, grid operators are constantly balancing the amount of centrally generated electricity injected into the system with demand. The introduction of large numbers of decentralized, uncontrolled, and unmonitored generators could threaten this balance, degrade power quality, or even potentially endanger the grid and the public. Creating a system that can move power efficiently and safely in any direction based on fluctuating internal and external factors and resources increases system complexity and operational risk for utilities. Retrofitting the system for two-way power flows and the introduction of DERs creates significant hardware, software, and data management challenges. The scope, scale, and frequency of the information required to operate safely, securely, economically, and in an environmentally friendly manner is significant. Making sense of all this information so that operators can maintain the system requires common communications and operating standards.

Technical challenge

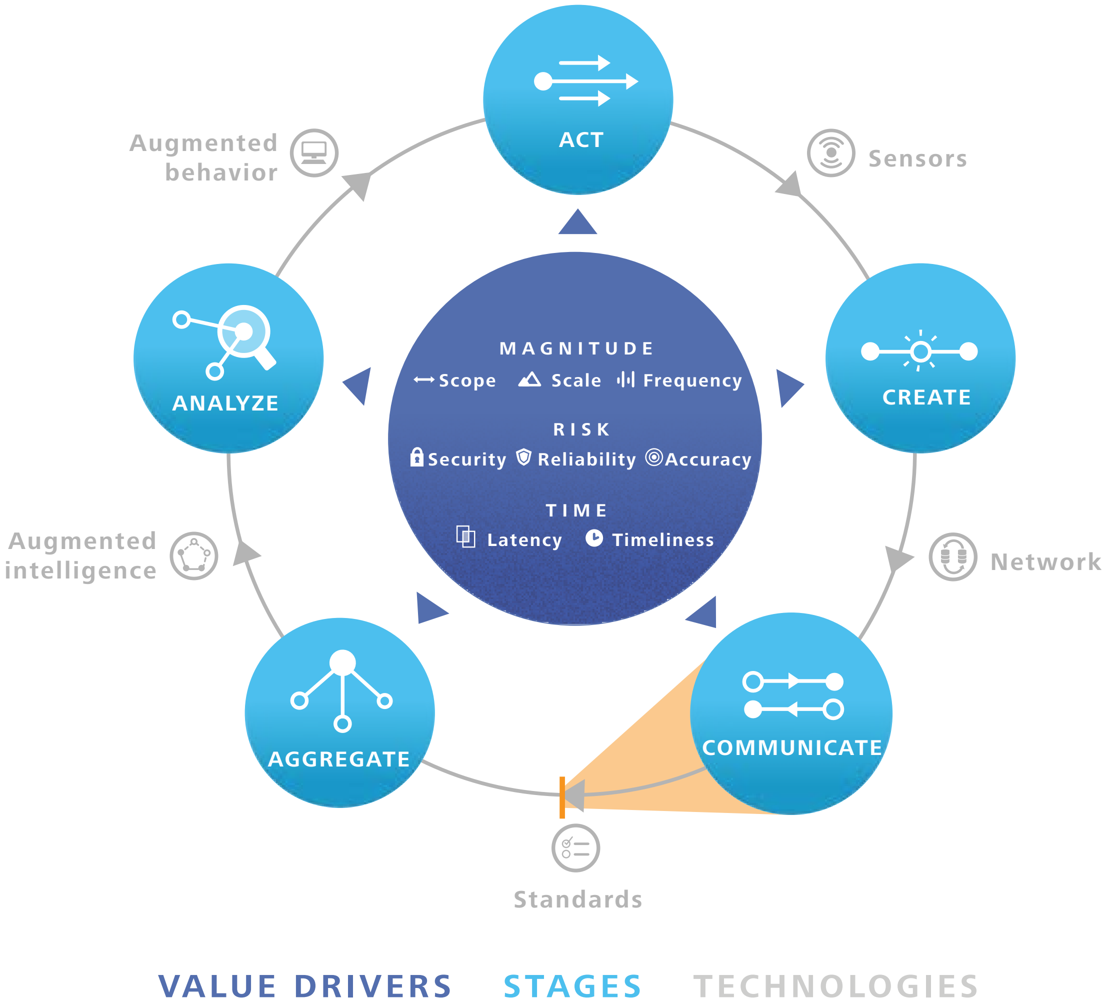
The state of California is pushing beyond its original renewable energy portfolio target of 30 percent in 2020 to 50 percent by 2030.[12] A core component of this is the addition of 12,000 MW of power from DERs by 2020. A device critical to integrating DERs on this scale with the grid is the power inverter, which transforms electricity from direct current to alternating current so that it can be injected into the grid for consumption. However, these products lack the external control functions and communications standards necessary to facilitate mass integration into the grid. From an operational perspective, this lack of standards limits the number of DERs that can be interconnected without risking safety and grid stability.

Thus, an IVL bottleneck exists between the "communicate" and "aggregate" stages at standards technology (see figure 3). A lack of common standards makes it extremely difficult to aggregate data, while nonstandard control and monitoring signals make widespread DER difficult to integrate into the grid.

Potential IoT solution

However, solutions to this challenge may be emerging. Adding IoT technology to an inverter can enable intelligent automated local actions and standards-based monitor-ing and control of the device, making it a "smart inverter." Indeed, the California Public Utility Commission Rule 21 Smart Inverter Working Group was formed in 2013. On December 18, 2014, the group adopted the

Figure 3. The bottleneck for phase one: Resilience



Source: Deloitte analysis.

Graphic: Deloitte University Press | DUPress.com first smart-inverter recommendations.[13] The group continues its work today, supporting the ambitious targets of California's Renewable Portfolio Standard.

Creating a common set of functions and communications requirements for smart inverters addresses the need for information about a DER's status and available capacity on the grid at any given time. It also creates the connectivity needed to control and manage these resources. Value drivers include:

- **Magnitude**. The value unlocked by these standards is proportional to the velocity and accuracy of the information about DERs that is available to operators, aggregators, and others to build a real-time view of grid status and available capacity.

- **Risk**. Smart-inverter standards limit risk by creating a reliable and accurate data stream on which personnel working on the lines can count to reduce safety hazards and on which operators can rely to maintain grid reliability.

- **Time**. Selecting standards that meet the latency requirements of the utility and other data users is essential. Automating the management of DERs requires the receipt of accurate data within the decision cycle time, often measured in milliseconds, to maintain system stability and safety.

Implications for utilities and other industry stakeholders

Collectively, these value drivers generate a number of benefits beyond preserving grid resiliency, including reduced interconnection costs. Smart-inverter standards can also turn DERs into local voltage support resources for grid operators to leverage. These standards may enable aggregators to create opportunities for owners of DERs of all sizes to participate in the electric wholesale market and maximize the value of their individual investments while protecting grid stability. At the same time, utilities could productize interconnection and DERs to pursue revenue opportunities by leveraging a potential competitive advantage.

Phase 2: Enablement

Background

The second phase is **enablement**, in which the aggregation and analysis of collected data enable augmented intelligence and new insights into grid operations and customer interactions. This phase is all about the formation of a platform capable of interconnecting all manner of resources, utility- and third-party-owned, including consumption and production assets that may operate intermittently. Enablement is about more than the technical aspects; while they are beyond the scope of this paper, it also includes customer, regulatory, and procedural influences, all factors required to achieve a plug-and-play system.

Terms such as "self-healing grid" create promising images of autonomous systems with limited human-in-the-loop processes. System faults are mitigated through a combination of automated switching, dispatch of DERs, coordinated demand response, and management without intervention by operators in the control room. Some of this is possible today. Solutions such as feeder automation[14] and demand-response management[15] are a reality. Integrating such technologies into central monitoring and controls requires an application that can manage these systems of systems. Each of the current solutions broadcasts data to aggregation points, and humans must act as information integrators and decision-makers. The role of humans in these solutions is sub-optimal, since most of the physical properties of the grid require millisecond decision cycles to avoid inefficient or unsafe configurations of electrical circuits or distribution equipment.

Technical challenge

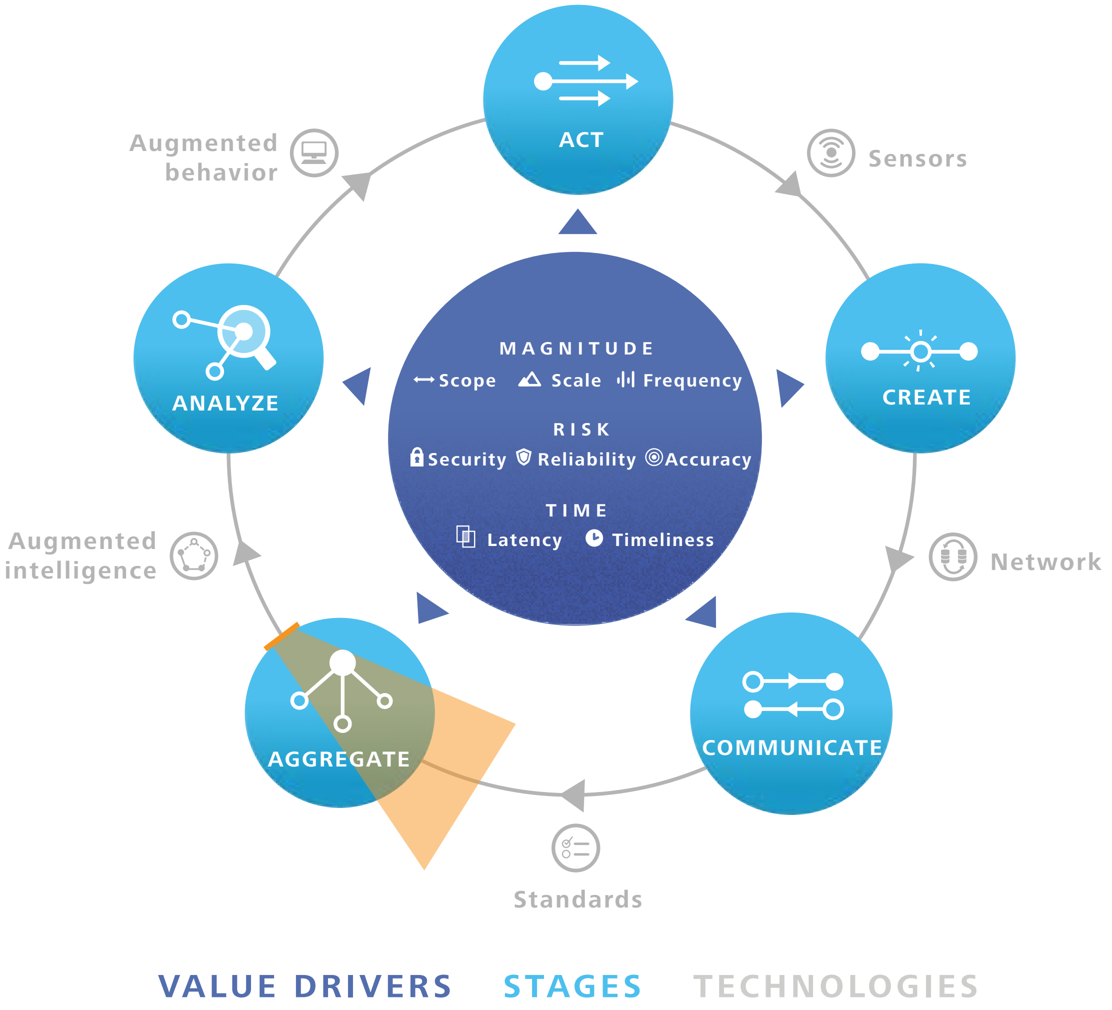
Distribution system operators need control points that eliminate the need for human interaction and can handle the increasing number of IoT-enabled devices and applications within the grid. These control points must manage customer- and third-party-owned assets as well as utility assets. The rapid rise of grid complexity and the accompanying operational systems is quickly outpacing the grid operator's ability to quickly and effectively assess a situation, create a plan of action, and execute that plan. The various operations systems that must be consulted to operate the grid are often independent, stand-alone systems with little or no ability to programmatically exchange data. This creates a bottleneck in the IVL at the aggregate stage (figure 4).

Relieving the bottleneck in aggregating data from these diverse sources allows analysis and augmented behavior based on a more holistic situational awareness. This heightened situational awareness is necessary to optimize distributed resources and the embedded IoT technologies to increase overall grid efficiency.

Potential IoT solution

Advanced Distribution Management Systems (ADMS) are an IoT technology that solution providers are developing to achieve this level of situational awareness. An ADMS is an integrated software application that takes advantage of new and existing applications to create a unified monitoring and control system. This control system is required to maintain reliability, leverage all manner of

Figure 4. The bottleneck for phase two: Enablement



Source: Deloitte analysis.

Graphic: Deloitte University Press | DUPress.com embedded systems and distributed resources, and safeguard property and people from the variability inherent in a modern grid.

ADMS is important to achieving the intelligent grid, evident through the potential that exists across all three value loop drivers.

- **Magnitude**. The amount of aggregated information required for an intelligent grid is considerable. The data comes from systems such as SCADA, asset management, work management, meter data management, demand response, weather, customer information systems, interactive voice response, and outage management. Relieving this aspect of the bottleneck is central to realizing the functionality of an intelligent grid.

- **Risk**. An intelligent grid requires secure, reliable, and accurate access to the large amounts of data produced by the numerous IoT assets deployed throughout the grid. An ADMS is only as good as the data available. Therefore, data security, reliability, and accuracy are paramount to realizing the value of an ADMS. This may require some businesses to look backward at their foundational systems and network infrastructure. For example, to maximize an ADMS's value, the accuracy within GIS systems or a communications system's reliability may require attention. However, successful implementation and operation of an ADMS increases distribution operational security by providing a holistic security purview rather than a system-centric perspective.

- **Time**. Aggregating all of this requires a network of networks with adequate bandwidth to meet the latency requirements for safe and reliable system operations. If an ADMS cannot coordinate subsystem operations within the decision-time requirements of the physical system, then it leaves value on the table.

Implications for utilities and other industry stakeholders

For utility operations, an ADMS's collective value is substantial. To capitalize on this potential, some utilities are working with application providers to develop an ADMS collaboratively; others may want to consider doing so. The potential value that such a system unlocks could represent the turning point where the concept of an intelligent grid becomes a reality. An ADMS can provide utilities with the intelligence to focus on detailed asset optimization and operating margin improvements. At the same time, such a system provides operators with the intelligence needed to integrate customer and third-party resources confidently.

Implementing an ADMS opens a new world of opportunities. For example, with an ADMS in place, outage response could automatically dispatch a crew to a specific set of assets at an exact location on the grid. Reliable remote diagnosis of the problem would decrease the time and cost of restoration. The challenge may very well be for utilities to set specific performance outcomes for an ADMS investment, assign accountabilities, and then manage the deployment to capture value.

Phase 3: Competition/ optimization

Background

The final phase opens new methods of optimization, which, in turn, enable the utility to better support and thrive in newly competitive business landscapes and markets. Using the data and insights generated in the enablement phase, grid stakeholders are able to make informed business decisions. Interoperability across the meter from the utility to the customer enables new optimization capabilities and a more efficient use of resources. Cooperation and competition increase system efficiency, provide options, and drive value to all internal and external utility stakeholders. Here, all stakeholders including utilities, competitors, and customers are able to change their behaviors based on enhanced intelligence and sound data. These behaviors will be adjusted based on the introduction of exponential technologies that advance efficiencies and weed out less effective solutions.

Technical/business challenge

Embedded supply and demand resources are growing in number, and the owners of these DERs will require that the utility work with them to optimize the utilization of their resources. At the same time, societal and regulatory trends are driving utilities to lower costs and provide cleaner power. Stakeholder perspective drives decisions on asset optimization targets and methods. For example, a utility, a residential customer, and a technology company facility manager may all have different grid optimization priorities. At the same time, many utilities are facing an explosion of grid complexity and optimization challenges; many are being asked to facilitate and participate in new business and operational environments.

For example, the New York Public Service Commission is transforming the state's utility regulatory system with its "Reforming the Energy Vision" plan, based on creating a marketplace with a comprehensive catalog of energy products and services for all customers.[16] This mandate has the effect of making the utility a participant in a new competitive and cooperative landscape. These new market dynamics will pose serious business decision challenges for utilities. Capital expenditure decisions that were previously clear-cut will now have to take a multitude of new factors into consideration.

Potential IoT solution

An intelligent platform such as an ADMS, composed of various IoT technologies and solutions, can provide the necessary grid intelligence to facilitate stakeholder perspective-driven optimization decisions. Animating an effective market requires equal transparency for all market participants and powerful optimization tools to maximize and protect investments. One piece of information that each utility will need to provide to support the market and make its own investment decisions is locational system performance. This intelligence enables decisions about what assets are needed and where. For the utility, it means a feeder-level profitability assessment tool is needed to evaluate which investments make sense and which are better suited for the market to satisfy.

The need for these new analytical tools represents a bottleneck at the analyze stage, which exists because legacy thinking assumes the utility will invest in all grid assets, rather than analyzing alternatives and choosing the optimal path (see figure 5).

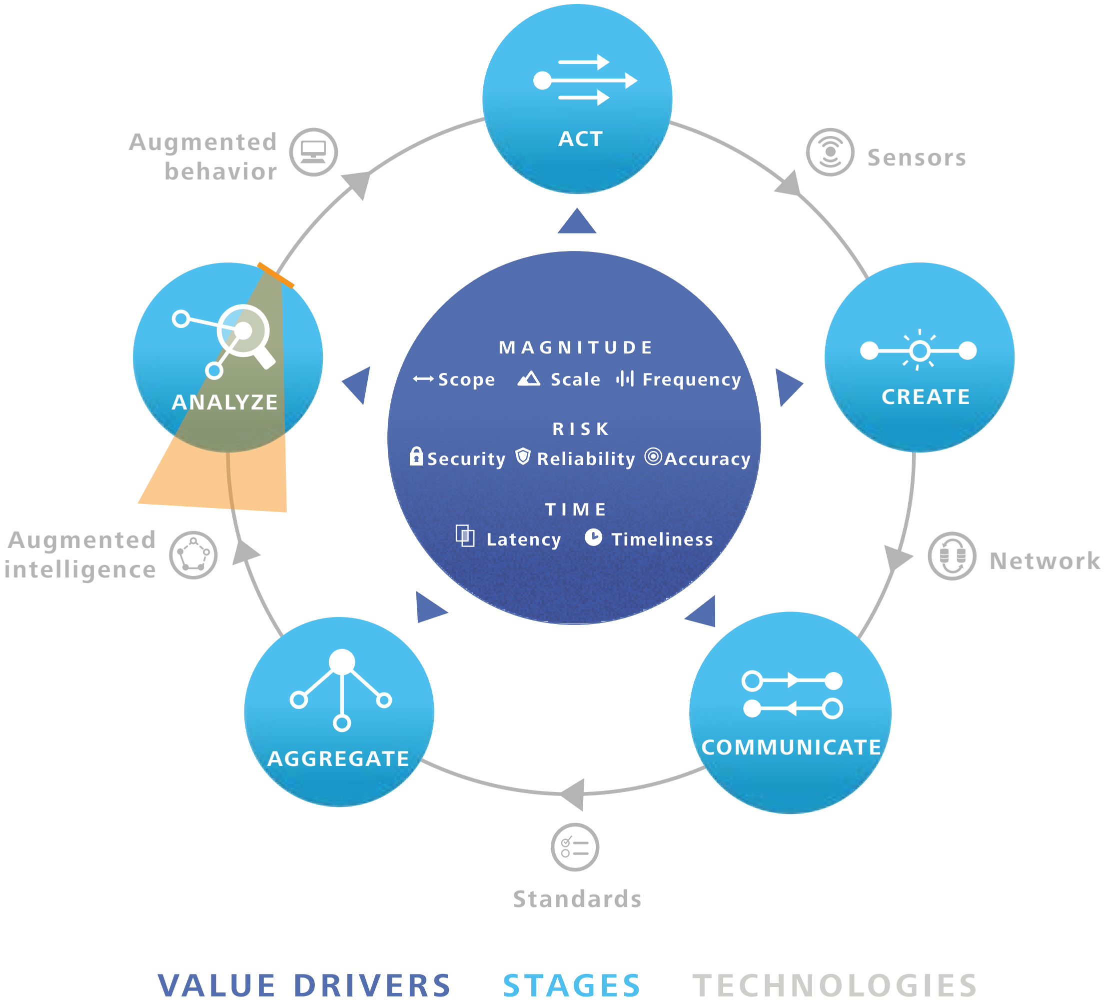
IoT-enabled tools are needed to provide utilities with the decision criteria to determine when, where, and what investments in the grid are profitable versus when to encourage others to make investments, leading to an overall "ecosystem" of players in and around the grid.

Locational system-performance evaluation drives profitability decisions down to the circuit level. This approach makes sense for the utility because it aligns costs, benefits, and risks better than a system-level approach to investment planning.

- **Magnitude**. Value is created by bringing together specific data to determine profitability at a granular level. The availability of this data today is disparate or nonexistent. By defining, gathering, and combining this data, utility business performance can be tracked at a more detailed level.

- **Risk**. The risk of inaccurate information could be detrimental to a utility's financial performance. A utility's financial performance effectively drives the confidence management has in its decision criteria and

Figure 5. The bottleneck for phase three: Competition/optimization



Source: Deloitte analysis.

Graphic: Deloitte University Press | DUPress.com

the confidence that regulators, customers, and shareholders have in the utility. Without that confidence, behavior is not likely to change.

- **Time**. The timeliness of the data is important. Investment decisions require timely data to create value for the utility.

Implications for utilities and other industry stakeholders

Like the decentralization of the grid, a more granular profitability lens increases awareness and decision agility. For example, a pocket of rooftop solar owners at the end of a distribution line are experiencing power reliability and quality problems. The solar owners may be motivated to invest in localized storage solutions to maximize their solar investment and to ensure power stability at their location. The utility will also be motivated to reinforce the line to minimize potential damage to equipment and outages up and down the line. Both approaches improve the customer's power reliability, but one may provide more of a utility profit opportunity than the other. If the utility has the information to make a profitability decision for the line in question, a clear choice may present itself. In this case, the utility might find it is more profitable not to invest heavily in reinforcing the line but, rather, to support and encourage the localized storage solution.

And the utility may offer to facilitate, finance, install, and/or maintain that storage solution as a way to enhance customer value and capture new revenues.

Making profitability decisions at the circuit level will be new and challenging for utilities and regulators. However, the IoT-enabled smart grid, coupled with new business perspectives, will make it possible for the utility to unlock greater efficiencies as well as offer potential for new revenue opportunities.

Beginning the journey

WHILE the innovations of the IoT are made possible by technological advancements, it will take more than technology to achieve these visions for the future. Innovation by its nature challenges accepted practices, and this requires adjusting the capability mix as well as the components within capabilities. Deloitte defines a capability as *a purposeful combination of technology, talent, processes, decision flows, and decision rights*.[17] For example, inbound customer service is a common capability seen in most utilities and other companies.

So far, our focus has been on technology. But it is important to recognize that capturing the full value of IoT investments will require more than effective technology procurement and implementation; it will likely require "architecting" a new operating model. One of the more difficult capability dimensions to adjust is the skills matrix of a business. Unlike redesigning a process or procuring a new technology, shifting to a different mix of talent can take years, depending on current workforce constraints, institutional will, and even political winds.

The utility workforce of the future is needed now

For technology to be useful, a company needs employees that can use the technology. One bottleneck that exists across all stages of the value loop and across all phases of electric utility transformation is the need for a utility workforce that understands the implications of IoT technology and has the mindset to create, absorb, and adapt to the resulting augmented intelligence/behaviors. While many observers have commented on aging workforce issues in the electric utility industry, the IoT poses the additional challenge of attracting, developing, and retaining the next-generation workforce, a workforce that is comfortable with the pace, magnitude, and risk of IoT-driven changes.

Next-generation utility staff need to know not only the physics of the grid but also the operation of sophisticated monitoring, control, and analytical systems. The rising number of systems involved in the grid means troubleshooting faults will involve marshaling multidisciplinary teams composed of everyone, from data scientists to linemen. In addition to the technical skills required, the leadership skills to organize, direct, and inspire complicated teams are a new imperative. This may require a transformation of how learning is done within the utility. In short, the workforce of the future is a critical success factor for today's development of the intelligent grid.

Many utilities see this as a recruiting opportunity to reignite career interest in the industry. It is a chance to offer those entering the workforce opportunities to learn cutting-edge skills and be a part of an industry that is modernizing rapidly. In many cases, the skills needed to support the new and sophisticated back-office and operational systems are in extremely high demand in other industries. Utilities also have a geographic challenge in being distributed across the country and having to compete for the workforce of tomorrow with high-demand locations such as San Francisco or New York. For many utilities, this kind of recruiting competition is not part of their culture, meaning that leadership must think about the company's talent brand, its tie to the company's brand, and how to use this as a recruiting advantage. In short, utilities must compete strongly for the skills required to support ever-more complex core utility systems.

Conclusion

Creating a grid for the future

INNOVATION is part of the electric utility heritage. Tapping into this tradition is essential to meet today's challenges and create a more intelligent grid.

The IoT offers exponential technologies that utilities can deploy and leverage to find new ways to explore and extract incremental value from the intelligent grid. However, the path forward is not always clear. The Information Value Loop provides a structured framework to help understand how to create and capture value from information in order to more clearly define the road ahead. Applying the value loop to electric utilities, we see three key phases in the further adoption of and value realization from IoT technology:

- The first and most foundational phase is **resilience**, in which the fundamentals of grid reliability and durability are based on the ubiquitous deployment of grid sensors connected via standards-based protocols.

- The second phase is **enablement**, in which the aggregation and analysis of collected data enable utilities to actively manage a wide variety of devices both using and generating power within the grid.

- The third and final phase introduces new methods of **optimization and competition** by using the data generated from the previous phases to allow all stakeholders to make informed decisions about power usage, generation, and future investments.

Every electric utility must evaluate its own path to value realization through IoT technology based upon its starting point and a thorough evaluation of "what's next?" It is important that management does not focus entirely on technology—rather, technology needs to be considered and planned for within the context of a utility's capability model. The utility's barriers to the adoption of these new IoT tools can be high, but the risk and cost of not pursuing them is greater.

Endnotes

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