sas

zpryme

The Autonomous Grid

IN THE AGE OF THE

Artificial Intelligence of Things

Deploying advanced analytics and Artificial Intelligence (AI) to unlock the power of IoT devices is already transforming the utility industry. Previously[1], Zpryme explored how the utility industry was using machine learning in coordination with the network-connected devices that comprise the Internet of Things (IoT). Since then, the AI has become more powerful, and its ability to interpret the data captured from IoT devices has increased. This report explores how AI and IoT work together to deliver everything from improved threat detection to better customer engagement for utilities.

As the pace of digital technology adoption accelerates, AI and IoT will begin to fuse into an artificial intelligence of things (AIoT), where the devices deployed by utilities are able to simultaneously gather data and learn from it in real-time to improve enterprise decision making and operational efficiency. This survey examines the future state for utilities using AI and IoT, and the deployment challenges they currently face, and provides guidance on how to accelerate business value through AIoT.

Machine learning and IoT will enable utilities to better realize the next generation of the grid rapidly coming at them: a distributed system with power flows among millions of things like distributed energy resources (DERs), microgrids and in-home devices. All of which will help utilities deliver more reliable energy and greater customer choice.

"The Autonomous Grid: Machine Learning and IoT for Utilities," Zpryme, 2016

KEY FINDINGS

- 69% of utilities agree IoT is critical to the company's success, and 57% are already using IoT technology.
- 52% of utilities agree AI is critical to the company's success. 27% report that they are already using AI while only 16% have a specific and comprehensive AI strategy
- Utilities recognize the business value of using AI and IoT in conjunction but have not yet expansively deployed either technology
- 55% of utility respondents say that using AI and IoT in coordination will be crucial for the long-term viability, success, and growth of the industry.

[1] "The Autonomous Grid: Machine Learning and IoT for Utilities" Zpryme, 2016

DIGITAL TRANSFORMATION UNDERWAY

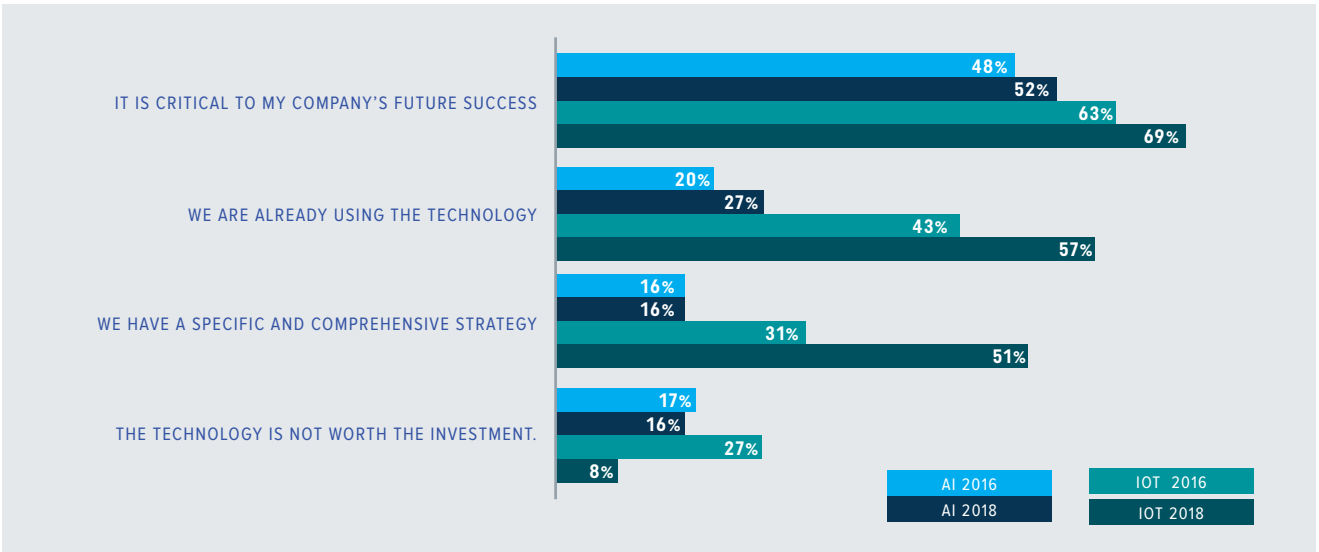
According to IoT Analytics[2], there are now more than 7 billion IoT devices and an additional 10 billion connected devices like smartphones, tablets, and laptops. These numbers are projected to grow by an additional 3 billion by the end of 2020. Prominent utility IoT devices include smart meters, line sensors, and intelligent switches. With all these connected devices gathering an ever-increasing amount of data, making this data useful is becoming an imperative.

Machine learning was first deployed by utilities to analyze large volumes of diverse IoT data. In earlier research, utilities reported that the top three benefits they were experiencing from using machine learning techniques were improved cybersecurity, better data-driven decision making, and better customer service. These business cases for machine learning were not surprising, as the advanced algorithms that drive machine learning can optimize the monitoring and control of the power grid.

While the primary use cases for machine learning at utilities were focused on network and grid control, the primary benefits for using IoT were more customer focused. Utilities reported the biggest benefits centered around customer service and driving energy efficiency. IoT devices are at the forefront of powering customer engagement, demand response, and even integrating distributed energy resources (DERs).

In the 2016 report, Zpryme found that utilities certainly saw the nascent benefits of IoT and machine learning. There is now a broader recognition of the power AI and IoT have to impact the industry; however, there is still a long way to go for these technologies to achieve their maturity. (Figure 1)

FIGURE 1:
HOW INDUSTRY PERCEPTIONS ON AI AND IOT HAVE CHANGED: 2016 TO PRESENT



[2]"State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating" IoT Analyitcs 2018

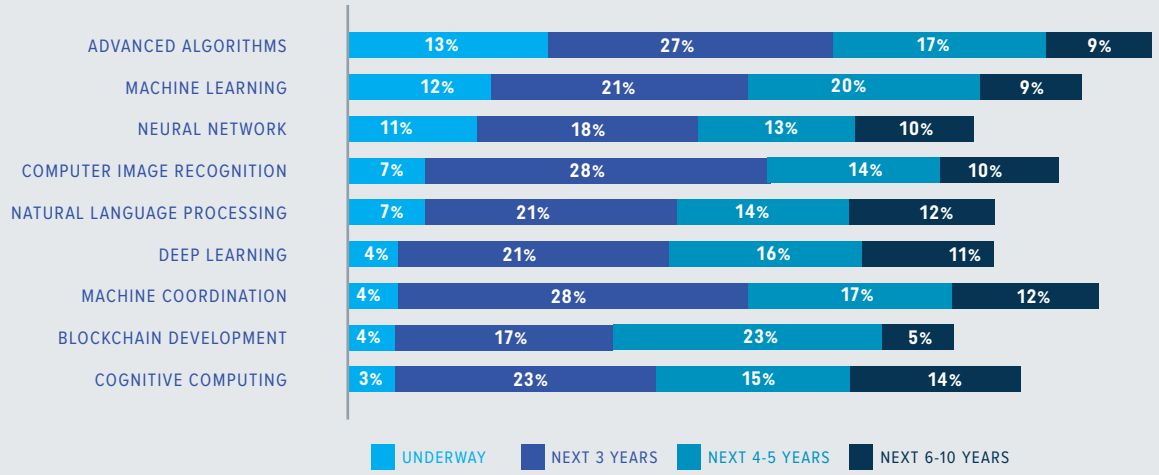
The components of AI and status of utility adoption

AI has made significant strides into the consciousness of utility professionals since the previous report in 2016. (Fig.2) AI encompasses a variety of subfields that allow for machines and software to learn, reason, and produce a human-like output.

- Machine learning automates analytical model building. It uses methods from neural networks, statistics, operations research, and physics to find hidden insights in data without explicitly being programmed for where to look or what to conclude.
- A neural network is a type of machine learning that is made up of interconnected units (like neurons) that processes information by responding to external inputs, relaying information between each unit. The process requires multiple passes at the data to find connections and derive meaning from undefined data.
- Deep learning uses huge neural networks with many layers of processing units, taking advantage of advances in computing power and improved training techniques to learn complex patterns in large amounts of data. Common applications include image and speech recognition.
- Cognitive computing is a subfield of AI that strives for a natural, human-like interaction with machines. Using AI and cognitive computing, the goal is for a machine to simulate human processes through the ability to interpret images and speech – and then speak coherently in response.
- Computer vision relies on pattern recognition and deep learning to recognize what's in a picture or video. When machines can process, analyze and understand images, they can capture images or videos in real time and interpret their surroundings.
- Natural language processing (NLP) is the ability of computers to analyze, understand and generate human language, including speech. The next stage of NLP is natural language interaction, which allows humans to communicate with computers using normal, everyday language to perform tasks.

Source "Artificial Intelligence: What it is and why it matters" https://www.sas.com/en_us/insights/analytics/what-is-artificial-intelligence.html

FIGURE 2:
PLANS FOR AI TECHNOLOGY COMPONENTS



TODAY'S MORE CONNECTED GRID

Every day, more meters are connected to the grid, more sensors are deployed in the distribution network, and more customers purchase connected devices for their homes. The speed of digital transformation is only accelerating, and utilities are increasingly recognizing that trend. Nearly 70% of utilities that participated in this survey said that IoT is critical to their company's future success, and 52% reported the same sentiment for AI. (Figure 1) Both of those numbers are up from 2016. There was also a large increase in the number of utilities reporting they are already using IoT devices; 57%, up from just 43%. AI saw a more modest 7% gain over the last two years; up to 27%.

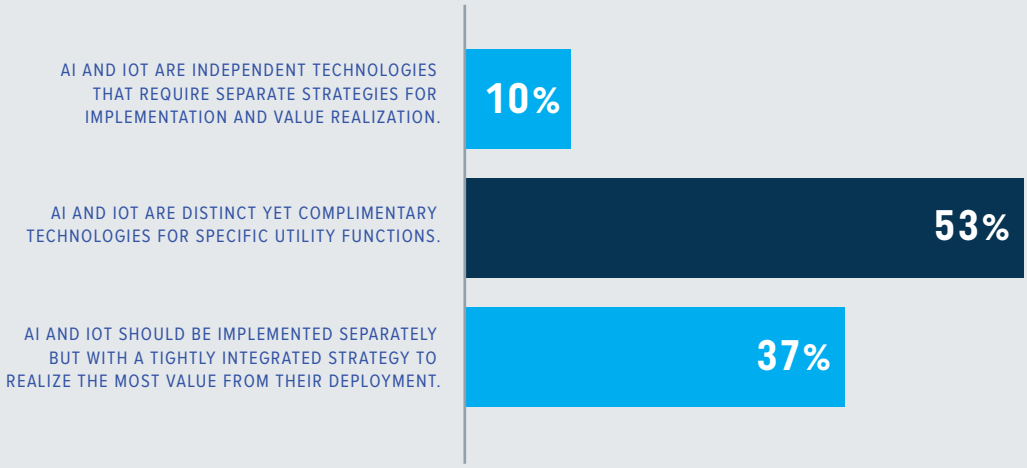
Today, utilities anticipate that the smart metering infrastructure they have put in place over the past decade will open the door for greater analytical understanding. As an electrical engineer from a utility in the northwestern United States described it, "We are using both AI and IoT for smart metering and asset health management down to the substation level currently. We have older assets, so our hope is that IoT and analytics will allow us to better understand the overall health of our system based on load and demand forecasting."

While the deployment of IoT and AI are both up, our research shows more acceleration in IoT adoption, likely due to three driving factors. First, there is a global shortage of data scientists in all industries and particularly in the utility sector. Secondly, the most hyped products— in this case, the physical products related to IoT— can be an easier capital investment than unseen AI algorithms, even if algorithms are the "brains" of the entire operation. Finally, many utilities are still in the early phase of digitalization, which requires the deployment of devices to measure as much data as possible. Eventually, as the amount of data accumulates, they will need to put it to more actionable use across the enterprise.

Nearly 70% of utilities that participated in this survey said that IoT is critical to their company's future success.

While it is easy to understand the bias for deploying IoT devices, it will ultimately require a strategic approach of using AI to analyze the data from these technologies to deliver the highest ROI. The one area of stark concern is the reported lack of a comprehensive strategy for deploying AI, 16%. (Figure 1) In comparison 51% reported a strategy for IoT deployment. Since connected IoT devices were available long before the computing capacity made AI a reality, this division is understandable. The gap is likely to close quickly as utilities realize how AI and IoT collaborate in the modernization of utility operations.

FIGURE 3:
OPINIONS OF HOW AI AND IOT SHOULD WORK TOGETHER TO MODERNIZE UTILITY OPERATIONS



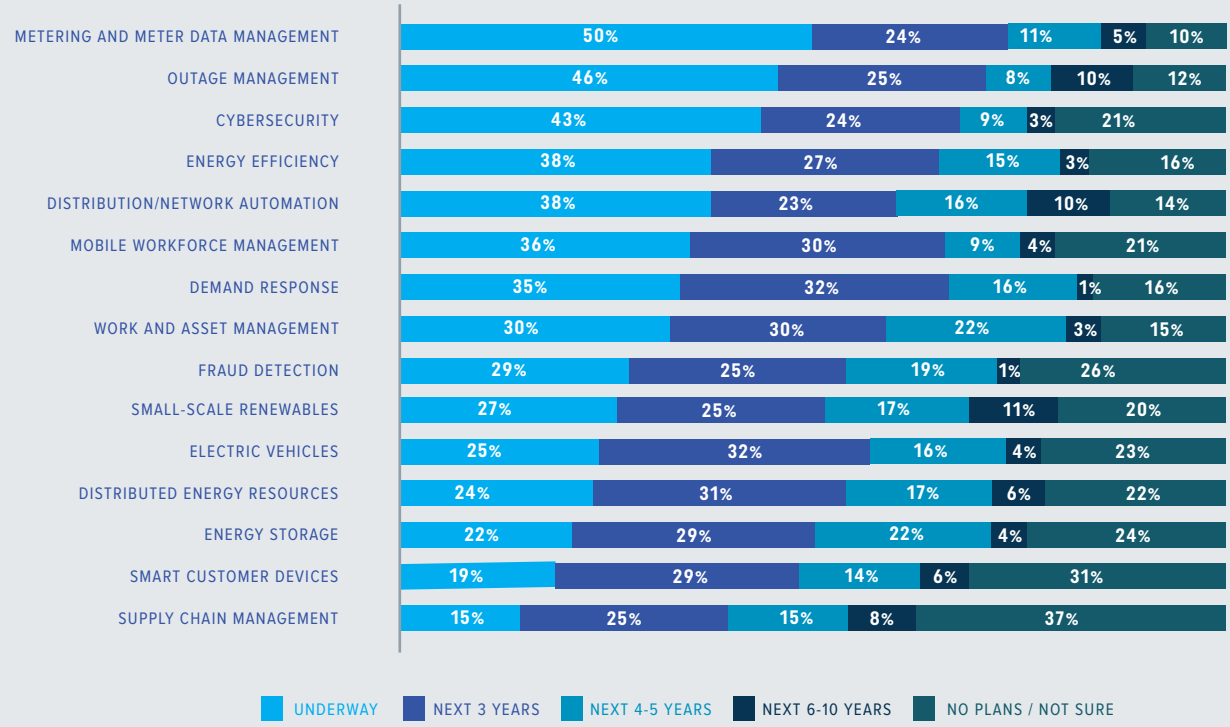
*NOTE: % OF RESPONDENTS WHO SELECTED "SOMEWHAT AGREE" OR "STRONGLY AGREE"

Over half of respondents (53%, Figure 3) believe AI and IoT are distinct yet complementary technologies for specific utility functions. Only 10% believe that they require separate strategies for implementation and value realization. This is promising, as a lack of coordination could delay the industry's ability to see the full benefits of either technology.

HOW UTILITIES ARE USING AI AND IOT

With the hype of IoT finally settling into reality, you might think that devices spanning the energy value chain would be internet connected and highly sensored. Think again. Two years after our initial report, the industry has made slow and steady progress in deploying IoT in support of major programs, but we are still on the cusp of expansive proliferation. Metering is still the top use case, followed closely by other grid-side applications.

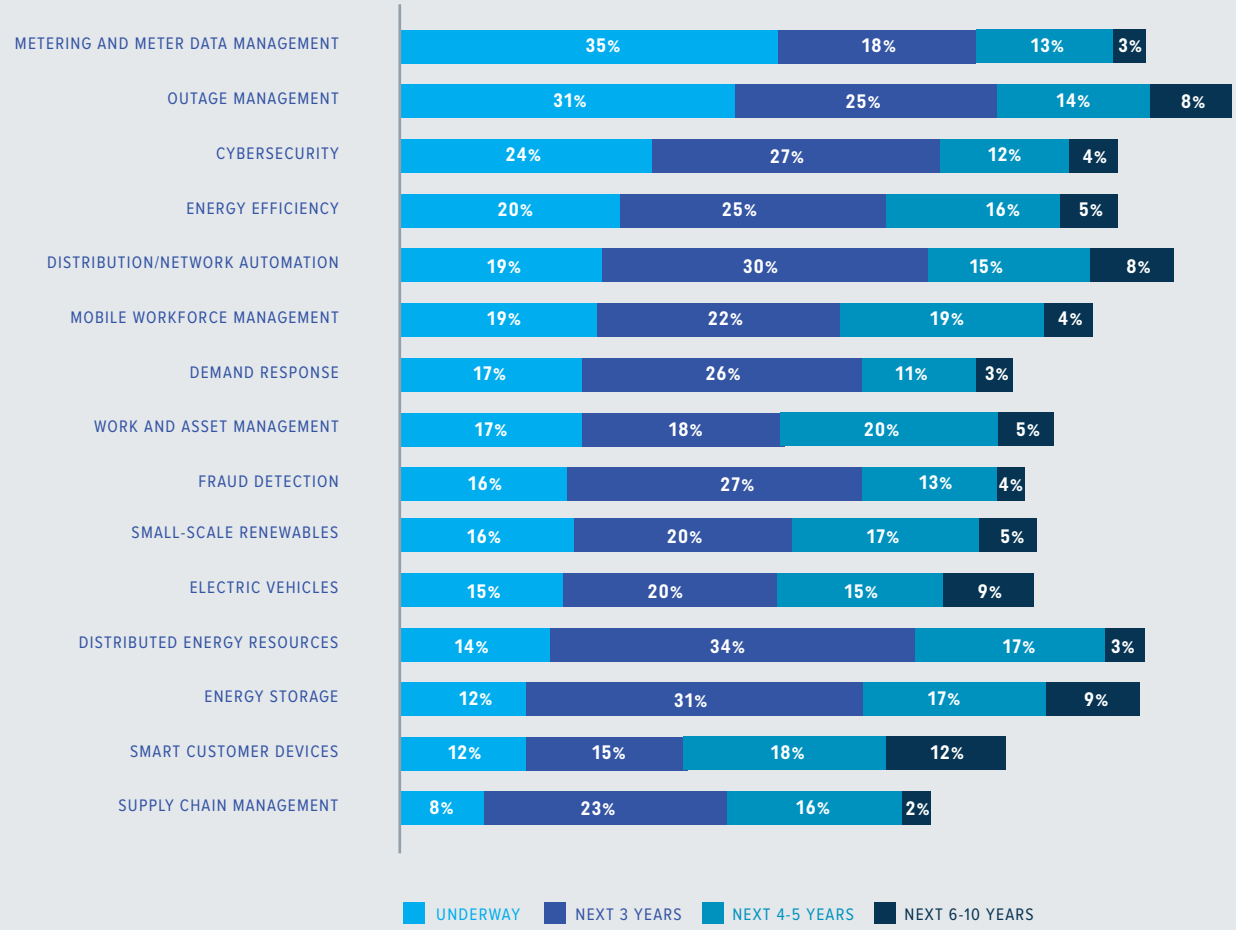
FIGURE 4:
PLANS FOR IOT SUPPORTED PROGRAMS AND APPLICATIONS



Today's investments are more focused on optimizing the grid, but the future expansion plans are focused on the customer. Figures 4 and 5 show the progress that utilities are making in deploying IoT devices and applying artificial intelligence to optimize programs and gain real-time insights. At the end of 2018, more utilities have deployed IoT technology than AI. However, there is commonality in the areas of focus. Metering/meter data management (50% and 35%), outage management (46% and 31%), and cybersecurity (43% and 24%) are currently the programs where utilities have made the most progress.

While most utilities are not currently using AI and IoT in tandem, there are some exciting examples from companies that are leading the way. "Our focus has been automation and analytics," said one survey respondent. "We are using our AMI program to create an asset failure prediction model that is helping us make better decisions. However, we still have a long way to go as an organization to ensure that our people have been trained to make data available for everyone who needs it. The hardest thing is managing the data when there's petabytes available. The key is to get in a system where people can get the data from disparate sources."

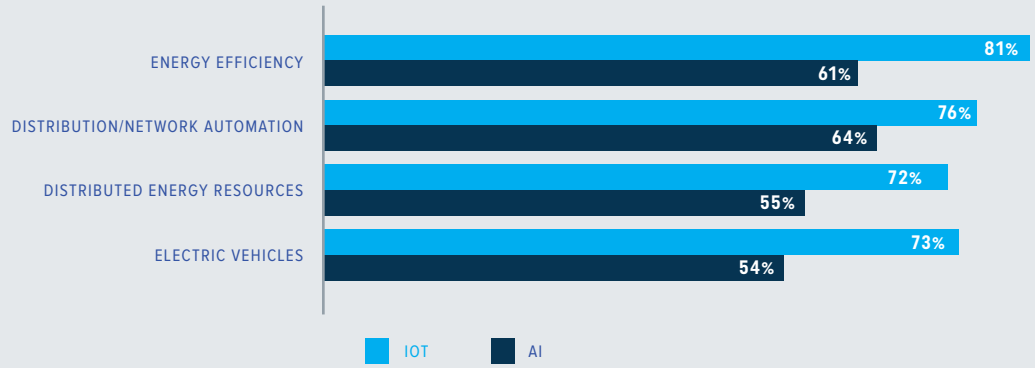
FIGURE 5:
PLANS FOR AI SUPPORTED PROGRAMS AND APPLICATIONS



CROSSING THE AIOT CHASM

The innovators and early adopters are already actively using AI and IoT for AMI and OMS systems. However, the next phase will be the hurdle of widespread usage by utilities across the enterprise. Even as the speed and effectiveness of IoT and AI technologies improve and they are increasingly adopted by utilities, there remains a series of challenges to address for the fully-integrated AIoT benefits to be realized.

FIGURE 6:
PROGRAMS AND APPLICATIONS SUPPORTED BY IOT OR AI IN THE NEXT FVE YEARS



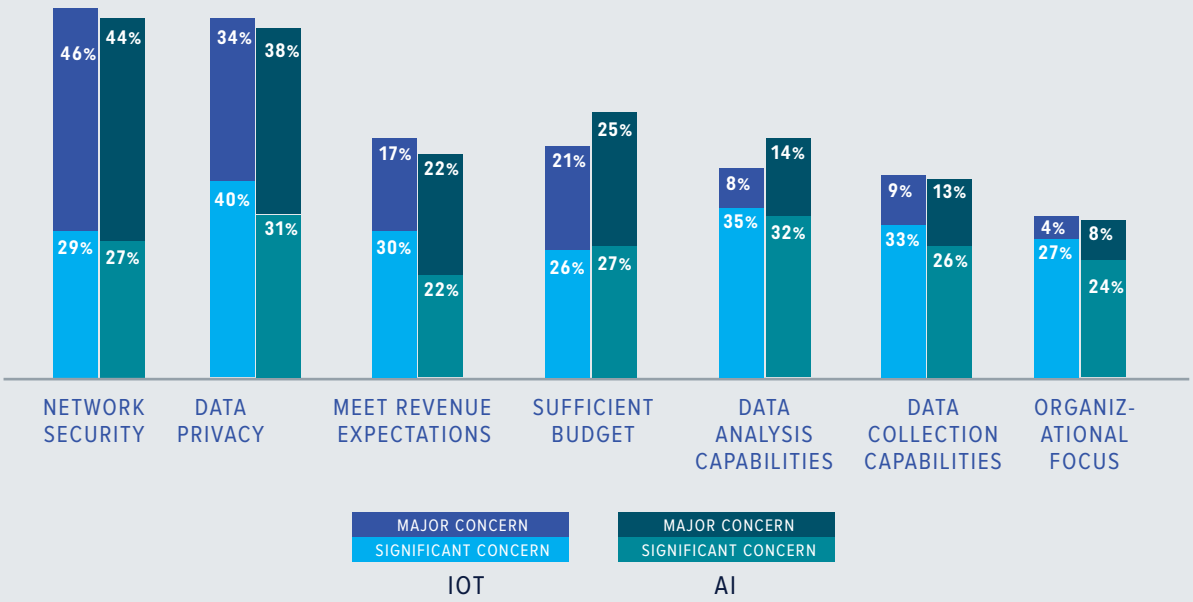
Looking over the five-year time horizon, the opportunities for IoT and AI become more pronounced. AIoT will be at the forefront of improved outage management systems, advanced demand response, and distributed energy resource management systems. These technologies will be at the forefront of the next wave of "green" utility modernization efforts. Utilities have significant plans to use IoT and AI in the next five years in the following programs; Energy efficiency (81% and 61%), Distributed automation (76% and 64%), DR (83% and 60%), DER (72% and 55%), and EVs (73% and 54%).

"The biggest challenge is integration with our old assets. That's an IT problem because they need to figure out how to utilize the software to better manage them, and it's an OT problem because they need to acquire the right resources."

- Electric Distribution Manager from northeastern US utility

Our research found that, for both IoT and AI, network security was the most pressing concern. (Figure 7) These results were in line with what we saw in the 2016 survey and reflect an ongoing awareness and focus in the industry of the need to protect data and combat the threats associated with cybersecurity. Security challenges will almost certainly not diminish over the next few years; however, as malicious actors become more sophisticated, the increasing power of AI to combat these threats might go some way to mitigating these concerns. AI and machine learning will be at the forefront of advanced threat detection for both grid management and customer data privacy. Utilities can use software to monitor these discrete systems for abnormal communication patterns or activity and automatically quarantine suspicious activity, while simultaneously alerting IT staff. As we see in Figures 4 and 5, cybersecurity is one of the most significant areas where IoT and AI technologies are currently deployed.

FIGURE 7:
CONCERNS REGARDING AI AND IOT TECHNOLOGIES AND INVESTMENTS



While network security and data privacy are of paramount concern, the CIO of a northwestern US utility described the biggest challenges they are facing as organizational and data collection focused, "The tools we are currently using are not mature enough, which makes it hard to aggregate data from different sources and share that data effectively across the enterprise to make our decision-making."

An Advanced Metering Program Manager at a southwestern US utility echoed this sentiment, "The biggest challenge: this is not something that is pre-baked, we're building it as we go. We must understand what constitutes normal. We must monitor the device and constitute what is normal. There is never a zero level. What is baseline data? We find that device usage changes on a seasonal basis."

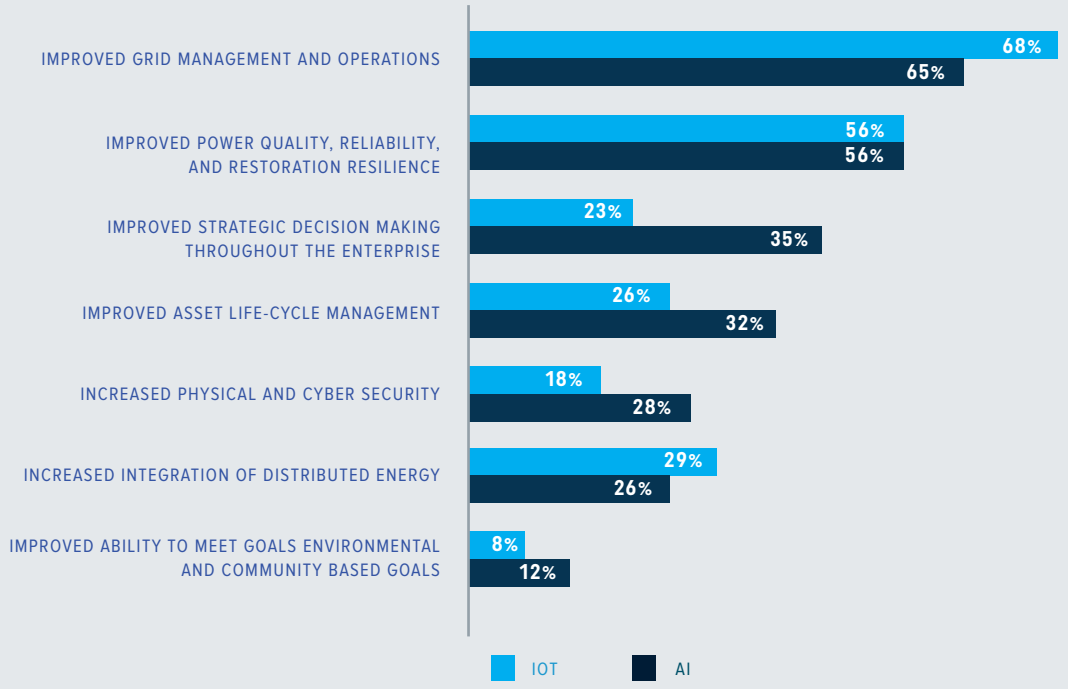
In addition to the security and organizational concerns for both IoT and AI, there is a smaller uncertainty around meeting revenue expectations, sufficient budget, and having the institutional ability to properly analyze the escalating volume and diversity of IoT data. The concerns regarding meeting revenue expectations and the ability to properly analyze the data are not unexpected. As new technologies are adopted there is always a challenge to ensure that the right people and processes are in place to ensure a sufficient ROI.

Having a suitable budget was a top concern for AI, but it was still significantly lower on the priority list than network security and data privacy. Looking 3-5 years into the future, utilities will need to prioritize AIoT from a budgetary perspective to ensure they are able to deploy the technology effectively and to attract and retain top analytics talent.

HOW AI AND IOT BECOMES AIOT

As the regulatory demands change and the business model for utilities continues to evolve, there is a greater need for using technology to assist in the transformation. Therefore, it was not surprising that the largest benefits utilities see from using IoT and AI are improvements in grid management and operations. (Figure 8) IoT at the customer level in the home will simultaneously allow for not only better customer engagement, but a greater understanding of how demand and distributed energy resources will impact grid operations. Utilities also expect both AI and IoT to assist in the improvement of power quality, reliability, and outage management.

FIGURE 8:
EXPECTED BENEFITS FROM AI & IOT APPLICATIONS

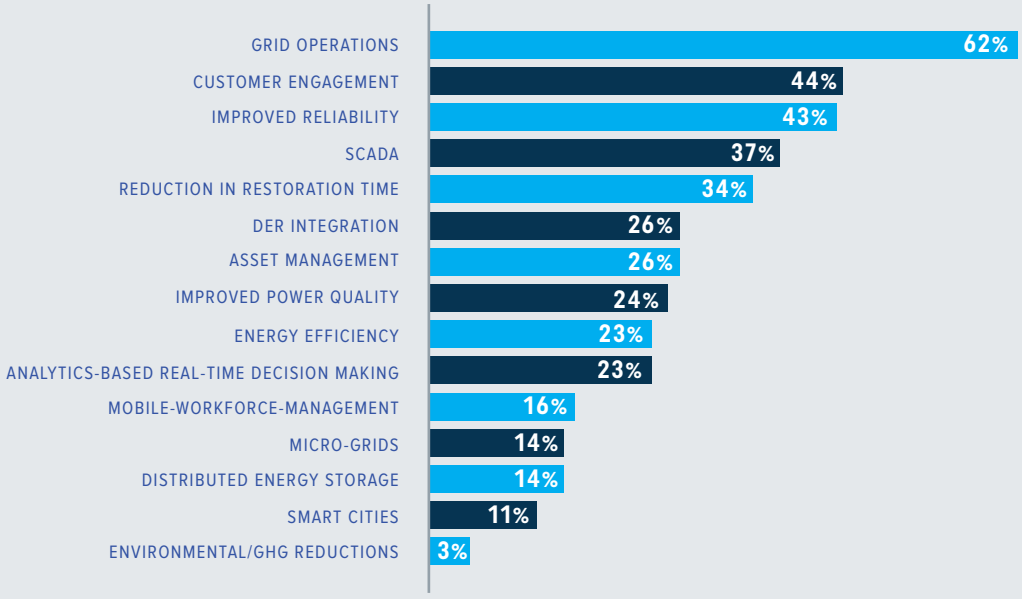


*NOTE: % OF RESPONDENTS WHO SELECTED AN ANSWER IN THEIR TOP 3

Most utilities still lack a coordinated strategy for using AI and IoT together. However, with the increasing complexity of grid management, the higher customer experience demands, and the proliferation of DERs, utilities will need to put large amounts of data to work. Keeping a distributed grid balanced will require a speed of analysis (far beyond that of humans alone) and decision-making that can only be accomplished through a fusion of intelligent devices and artificial intelligence. The coming autonomous grid requires AIoT to effectively manage variable DER integration and demand.

When asked about the primary uses or planned uses for AI and IoT in coordination, the top response from utilities by a wide margin was grid operations, reflecting the broader understanding that the volume and diversity of data captured in an intelligent system requires AI-driven analytics to manage it and to harvest insights that may be hidden from the human eye. (Figure 9) Utilities saw customer engagement as the second most important use for the fusion of AI and IoT, which is not unexpected either, considering the new distributed grid will provide customers more control over their energy choices and usage. The increased understanding of customers based on their data will allow utilities to focus simultaneously on grid management and customer centricity.

FIGURE 9:
PRIMARY OR PLANNED USES OF AI AND IOT TOGETHER



*NOTE: % OF RESPONDENTS WHO SELECTED AN ANSWER IN THEIR TOP 5

As AIoT-driven modernization occurs, utilities expect to see a reduction in restoration times and the ability to make better decisions throughout the enterprise. Using IoT devices in the home and throughout the grid will allow AI to strategically analyze the myriad of different systems and find connections between them to improve outcomes. This should invariably lead to better engagement as energy efficiency and renewable programs spark a new connection between the utilities and their customers.

There are many examples of utilities using data and devices to improve customer engagement and workforce management. An Advanced Metering Program Manager at a southwestern US utility shared a program they have and are currently working to expand upon. “We actually have a program where the customer can send us pictures of what they see. We’re looking at AI for image recognition, to help make faster decisions, and to point out issues in day-to-day operations of our company.”

Utilities have made significant strides in the past two years going from pilots to fully implementing IoT and AI programs. However, as the volume and diversity of data grows at an almost exponential rate, the business case for turning that data into strategic operational decision making will drive utilities towards machine learning, advanced algorithms, and other components of AI.

FIGURE 10:

AREAS WITH GREATEST IMPROVEMENT FROM TIGHTLY COUPLED AI AND IOT STRATEGY

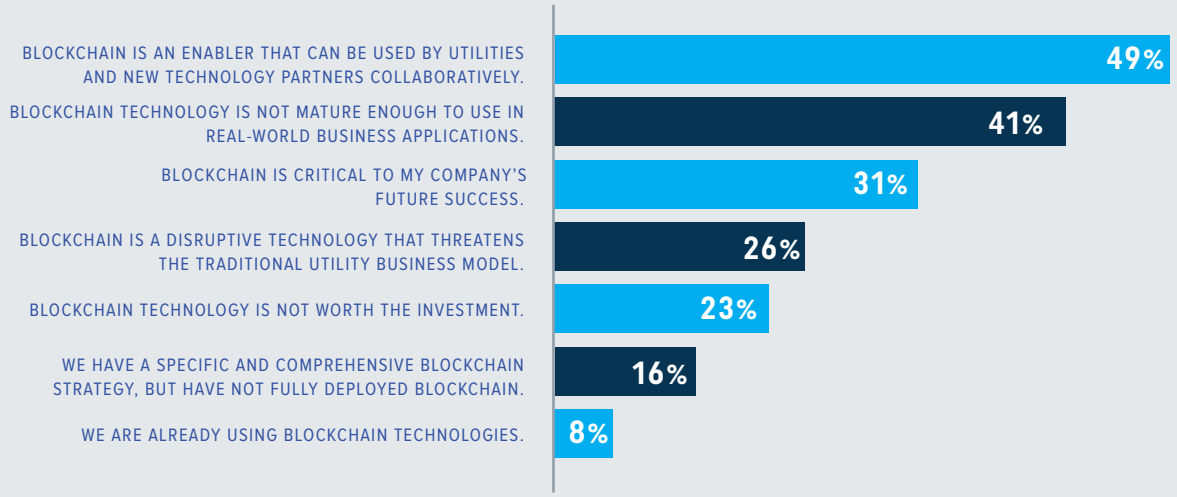
*NOTE: % OF RESPONDENTS WHO SELECTED A "4" OR "5" ON A SCALE OF 1 TO 5 [1=LEAST IMPROVED, 5=MOST IMPROVED]

When this necessary convergence occurs, utilities are expecting many areas of their business and industry to improve. (Figure 10) The top areas are future energy industry success, viability, and growth (55%), enterprise-level operational efficiency (53%), and customer engagement and brand management (53%). AIoT is the connective tissue for all these improvements. AI and IoT will enable utilities to better realize a distributed energy system, more reliable energy and greater customer choice. Only through simultaneous improved customer engagement and enterprise-level operational efficiency can individual utilities drive long-term financial growth and success.

BLOCKCHAIN. WHAT ROLE DOES IT PLAY?

Blockchain has been grabbing headlines over the past few years, and the potential impacts on the delivery of energy have not gone unnoticed by the utility industry. There is a wide spectrum of beliefs regarding the potential power of blockchain, ranging from having no impact, to potentially starting an energy revolution. What is clear is that blockchain belongs in a discussion of AI and IoT, not just because it is a new technology, but because as consumer IoT devices become more common, blockchain has the potential to be a reliable, low-cost way for financial or operational transactions to be recorded and validated across a distributed network with no central point of authority. We explored utility expectations for blockchain and when the technology could start impacting the industry. (Figures 11 and 12)

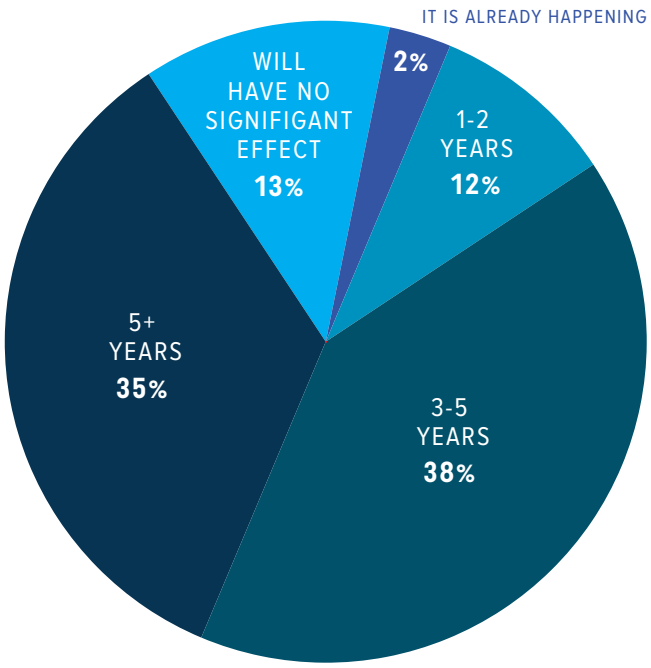
FIGURE 11:
AGREEMENT ON STATEMENTS REGARDING BLOCKCHAIN



*NOTE: % OF RESPONDENTS WHO SELECTED "SOMEWHAT AGREE" OR "STRONGLY AGREE"

49% of utilities agree blockchain is an enabler that can be used by utilities and new technology partners, but 41% believe it is not mature enough to use in real-world business applications. Only 8% of utilities say they are already using blockchain technology.

FIGURE 12:
TIMELINE FOR BLOCKCHAIN TO HAVE SIGNIFICANT IMPACT ON HOW AI AND IOT WORK TOGETHER



52% of utilities believe blockchain will have a significant impact in the next 5 years.

This impact will be felt as the industry becomes more distributed and the convergence with AIoT becomes apparent.

RECOMMENDATIONS

1. Develop a coordinated strategic roadmap that is centered around using AI to maximize the benefits of IoT data.

2. Create a digitally-enabled workforce. AI and IoT require skilled people and processes to execute effectively. Training the existing workforce and hiring top quality data professionals will be essential for utilities to thrive.

3. Because success with AIoT will require the power of an ecosystem, utilities should develop relationships inside and outside the industry to take advantage of AIoT expertise. Utilities should also explore other industries and how they leverage IoT and AI. Simultaneously, utilities can benefit from connecting with other utilities to find out what's working, challenges others have faced, and how they worked through them. Utilities can make certain that those key points are then continuously addressed.

4. Develop a change management and communication plan that emphasizes the importance of digital transformation to employees, customers, policy-makers, vendor partners, and regulators.

DEMOGRAPHICS

- **Utility type:**
  IOU (45%), municipal (30%), cooperative (15%), district/federal (10%)
- **Services provided:**
  Electric (95%), Gas (35%), Water (28%), and Wastewater (15%)
- **Headquarter location:**
  United States: midwest (24%), northwest (16%), southeast (14%), southwest (11%), mountain (10%), and northeast (9%). international (16%),
- **Organization annual revenue:**
  >US $1B (40%), US $100M to US $500M (26%), US $500M to US $1B (17%), <US $100M (17%)
- **Primary role:**
  Engineering (44%), Operations (24%), IT (24%), Other (8%)
- **Level of responsibility:**
  Professional staff (41%), Mid-management/manager (35%), Senior management/director (18%), Administrative (3%), Executive/C-level (3%)